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Effect of Plant Spacings on Yield and Quality Parameters of Bt Cotton (*Gossypium hirsutum* L.) Hybrids in Thunga Bhadra Command Area under Irrigation

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Abstract

A field experiment was carried out during *kharif* season of 2004-05 to study the response of Bt cotton hybrids to different plant spacings under irrigation. The results revealed that among hybrids, MECH-184 Bt registered significantly higher seed cotton yield (2,815 kg/ha), seed cotton yield per plant (108.7 g), mean boll weight (4.10 g), number of good opened bolls per plant (23.99) and total number of bolls harvested per plant (32.72). Significantly higher uniformity ratio (47.83), bundle strength (24.43 g/tex) were noticed by MECH-184 Bt over other two hybrids. However, significantly higher elongation percentage was noticed with Bunny (6.7) followed by RCH-2 Bt (6.1) and MECH-184 Bt (5.9). Staple length, micronaire value and maturity ratio did not differ significantly with hybrids. Among spacings, seed cotton yield was significantly higher with 75 × 30 cm (2,389 kg/ha) spacing, while yield per plant mean boll weight, number of good opened bolls per plant and total number of bolls opened per plant were significantly higher with 90 × 60 cm spacing (119.4 g, 4.42 g, 23.48 and 32.54 respectively). Different plant spacing did not influence quality parameters of cotton hybrids.
Key words : Bt cotton, Quality, Irrigation, Spacings, Yield.

Cotton provides a livelihood to more than 60 million people in India by way of support in agriculture, processing, and use of cotton in textiles. Cotton contributes 29.8% of the Indian agricultural gross domestic product, and nearly nine million hectares of land in India were used to produce 14.2 million bales of cotton lint. Indian cotton production is third in the world in quantity, although the productivity is substantially low. The major reason for this low productivity is damage caused by insect pests notably *Helicoverpa armigera*, commonly referred to as American bollworm. Nearly Rs 12 billion worth of pesticides are used in India to control just the bollworm complex of cotton. Mahyco (Maharashtra Hybrid Seed Company), in collaboration with Monsanto, has introduced Bt cotton technology into India. Bt cotton carries the *Cry1Ac* gene derived from the common soil bacterium *Bacillus thuringiensis* var *kurstaki*, which results in the expression of the *Cry1Ac* protein that confers resistance to the bollworm complex.

The cotton projection made in India for 2010 AD is around 23.0 million bales of lint to meet the anticipated domestic and export requirements (kairon and Venugopal 2000). To fulfill this projected requirement, the cotton production has to be increased by 15.0% and it has to come mainly from increased productivity. The area under this crop has been declining enormously over the past decade. This is due to low productivity for various reasons. Of these, pest menance especially bollworm plays an important role in success or failure of cotton crop. Cotton farmers often incur monetory losses on account of higher cost of cultivation which is due to the higher cost towards control of pests mainly bollworms. Under this context, in India genetically modified cotton hybrids resistant to bollworms have been developed. Monsanto in collaboration with Mahyco and Rasi Seeds have released Bt cotton hybrids viz., MECH-184 Bt, MECH-162 Bt and MECH-12 Bt and RCH-2 Bt for commercial cultivation. Among the various cultural practices plants spacing is one of the most critical factors that influence the growth, fruiting and yield of cotton. Though, cost of seeds is higher in Bt cotton hybrids, there is a urgent need to find out suitable Bt cotton hybrids for TBP command area and to find out the optimum plant spacing to

Table 1. Seed cotton yield (kg/ha), yield per plant (g) and mean boll weight of cotton hybrids as influenced by different plant spacings. H_1—MECH-184 Bt, H_2—RCH-2 Bt, H_3—Bunny. S_1—75×30 cm, S_2—75×45 cm, S_3—75×60 cm, S_4—90×30 cm, S_5—90×45 cm, S_6—90×60 cm.

Treatments	Seed cotton yield (kg/ha)				Yield per plant (g)				Mean boll weight (g)			
	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean
S_1	2821	2540	1507	2389	75.8	70.5	54.9	67.0	3.575	3.36	3.40	3.50
S_2	2695	2456	1710	2287	105.5	81.6	65.6	85.4	4.05	3.62	3.75	3.80
S_3	2587	2316	1581	2161	128.6	107.3	83.6	106.5	4.70	4.20	4.25	4.25
S_4	2755	2497	1746	2343	85.7	78.6	65.1	76.4	3.85	3.56	3.55	3.65
S_5	2642	2378	1637	2219	120.4	98.5	76.8	98.5	4.16	4.10	4.05	4.10
S_6	2417	2143	1473	2011	136.2	125.7	96.3	119.4	4.52	4.36	4.38	4.42
Mean	2615	2389	1659	2235	108.7	94.3	73.8	89.80	4.10	3.86	3.89	3.95

	SE ±	CD at 5%	SE ±	CD at 5%	SE ±	CD at 5%
Hybrids (H)	28	113	0.53	2.09	0.04	0.17
Spacing (S)	36	104	0.56	1.63	0.05	0.16
S at the same H	62	181	0.98	2.83	0.10	NS
H at the same or diff S	64	185	1.04	3.01	0.10	NS

exploit potential yield which helps to increase the productivity of crop and to improving the economic condition of the farmers.

Methods

Field experiment was conducted under irrigation during *kharif* season of 2004-2005 at the Agriculture College Farm, Raichur on medium black soil having 229.4, 25.5 and 358.0 kg/ha available N, P_2O_5 and K_2O respectively with pH of 8.29 and organic matter content of 0.62%. There were 18 treatment combinations consisting of two Bt cotton hybrids and one non-Bt (H_1—MECH-184 Bt, H_2—RCH-2 Bt and H_3—Bunny non-Bt) in main plots and six different spacings (S_1–75×30 cm, S_2–75×45 cm, S_3–75×60 cm, S_4–90×30 cm, S_5–90×45 cm, and S_6–90×60 cm spacing) in sub-plots. The experiment was laid out in split plot design and replicated thrice, common RDF of 150 : 75 : 75 N P K kg/ha along with FYM 10 t/ha were

Table 2. Number of good opened bolls per plant, bad opened bolls per plant and total number of harvested bolls per plant in cotton hybrids as influenced by different plant spacings. H_1—MECH-184 Bt, H_2—RCH-2 Bt, H_3—Bunny, S_1—75 × 30 cm, S_2—75×45 cm, S_3—75×60 cm, S_4—90×30 cm, S_5—90×45 cm, S_6—90×60 cm.

Treatments	Number of good opened bolls per plant				Number of bad opened bolls per plant				Total number of bolls harvested per plant			
	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean
S_1	18.73	19.23	7.10	14.00	10.42	12.03	16.08	12.84	29.15	31.26	23.18	26.53
S_2	22.39	18.00	9.52	16.63	9.14	10.20	15.24	11.52	31.53	28.20	24.76	28.16
S_3	28.20	20.86	14.35	21.13	7.29	9.50	13.61	10.13	35.49	30.36	27.96	31.27
S_4	19.08	16.30	8.07	14.48	10.20	11.30	16.00	12.50	29.28	27.60	24.07	26.98
S_5	24.86	18.43	12.20	18.48	8.66	10.73	19.00	11.13	33.52	29.16	31.20	29.62
S_6	30.68	23.38	16.38	23.48	6.71	8.33	12.15	9.06	37.39	31.71	28.53	32.54
Mean	23.99	18.70	11.42	18.03	8.73	10.34	14.51	11.19	32.72	29.04	25.78	29.18

	SE ±	CD at 5%	SE ±	CD at 5%	SE ±	CD at 5%
Hybrids (H)	0.14	0.58	0.14	0.55	0.22	0.87
Spacing (S)	0.34	1.00	0.12	0.37	0.32	0.94
S at the same H	0.60	1.75	0.62	1.64	0.56	1.63
H at the same or diff S	0.56	1.64	0.24	1.71	0.56	1.62

Table 3. Uniformity ratio (%), bundle strength (per tex) and Elongation (%) in cotton hybrids as influenced by different plant spacings. H_1—MECH-184 Bt, H_2—RCH-2 Bt, H_3—Bunny. S_1—75×30 cm, S_2—75×45 cm, S_3—75×60 cm, S_4—90×30 cm, S_5—90×45 cm, S_6—90×60 cm.

Treatments	Uniformity ratio (%)				Bundle strength (per tex)				Elongation (%)			
	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean	H_1	H_2	H_3	Mean
S_1	48	47	46	47.00	26.7	23.4	23.4	27.5	5.9	6.2	6.3	6.1
S_2	47	46	46	46.33	24.7	23.0	22.5	23.4	5.9	6.0	6.7	6.2
S_3	48	47	45	46.66	23.2	21.9	21.1	22.0	6.4	6.4	6.9	6.5
S_4	49	47	46	47.33	23.3	24.5	21.2	23.0	6.1	6.0	7.1	6.4
S_5	49	47	44	46.66	24.9	22.7	21.3	22.9	5.7	6.4	6.5	6.2
S_6	46	47	45	46.00	23.6	22.7	21.3	22.5	5.8	5.9	6.7	6.1
Mean	47.83	46.83	45.33	46.66	24.43	23.32	1.80	23.0	5.96	6.1	6.7	6.2
	SE ±		CD at 5%		SE ±		CD at 5%		SE ±		CD at 5%	
Hybrids (H)	0.147		0.57		0.14		0.58		0.07		0.30	
Spacing (S)	0.67		NS		0.80		NS		0.13		NS	
S at the same H	1.175		NS		0.13		NS		0.22		NS	
H at the same or diff S	1.083		NS		1.27		NS		0.22		NS	

applied to all treatments. The crop was sown on 30 July 2004 with a plot size of 9.0 m × 5.4 m. The irrigations were given at an interval of 25—30 days. The total seed cotton picked from the net plot of each treatment in different pickings was used for working out seed cotton yield per hectare. The bolls picked from five tagged plants of each treatment were counted during all pickings. To obtain number of bolls picked per plant, total number of bolls picked was divided by number of plants. The result was expressed as number of bolls harvested per plant. The total seed cotton picked from the net plot of each treatment in different pickings was used for working out seed cotton yield per hectare. Fiber tufts weighing one mg were taken in duplicates from each treatment and fed to the Pressley Tester, which gives reading in 1b per mg. This pressley strength index was multiplied by 5.36 and fiber strength was expressed as g per tex. Maturity ratio was determined with the help of micrinaire instrument by airflow method. A quantity of 3.24 g lint was fed to the instrument and compressed air was allowed to pass through the samples with or without spacer. The difference between the two readings referred against a standard table gives the maturity ratio.

Results and Discussion

In the present study among hybrids MECH-184 Bt was found to be superior and recorded significantly higher seed cotton yield (2,615 kg/ha) over RCH–2 Bt (2,389 kg/ha) and Bunny cotton hybrid (1,659 kg/ha). The yield increase in MECH-184 Bt over RCH-2 Bt and Bunny increase was to an extent of 11.1 and 60.0%, respectively (Table 1). These results are in conformity with findings of Khadi et al. (2002). Seed cotton yield is governed by several factors, which have direct influence on seed cotton yield and yield components viz., number of good opened bolls per plant, number of bad opened bolls per plant, mean boll weight, total number of bolls harvested per plant (Tables 1 and 2). Seed cotton yield per plant (108.0 g), mean boll weight (4.10 g), number of good opened bolls per plant (23.38) and total number of bolls harvested per plant (32.72) were significantly higher in MECH-184 Bt compared to RCH-2 Bt (94.0 g, 3.86 g, 18.70 and 29.79, respectively) and Bunny (65.5 g, 3.89 g, 11.46, 25.78, respectively). This is mainly attributed to the reason that Bt hybrids have *Cry1AC* protein in plant system. This *Cry1AC* protein kills the cotton bollworms. Because of these, hybrids have greatest potential to produce number good opened bolls per plant and total number of bolls per plant. These results are in agreement with the earlier findings (Anon. 2002).

The seed cotton yield was significantly higher with 75 × 30 cm spacing (2,392 kg/ha) compared to

90 × 60 cm (2,011 kg/ha) and it was on par with 90 × 30 cm (2,343 kg/ha) and 75 × 45 cm spacing (2,293 kg/ha). The yield increase in 75 × 30 cm, 90 × 30 cm and 75 × 45 cm over 90 × 60 cm spacing was to an extent of 18.9, 16.5, and 13.7% respectively. The higher seed cotton yield with 75×30 cm spacing was due to more plant population per hectare compared to other spacings. Similar results were also reported by Venugopal (2004). Even though yield per plant (54.9 g), mean boll weight (3.50 g), number of good opened bolls per plant (14.00) and total number of bolls harvested per plant were significantly lower with 75×30 cm spacing compared to other spacings, it recorded significantly higher seed cotton yield mainly because of higher plant population per hectare (44,444 plants/ha). Though the plants with 90×60 cm spacing produced higher yield per plant (96.3 g), mean boll weight (4.42 g), number of good opened bolls per plant (23.48) and total number of bolls per plants (32.54), it could not compensate fot the loss in number of plants per hectare and thus recorded lower seed cotton yield per hectare. Where as, these yield parameters were lower with 75×30 cm spacing compared to 90×60 cm spacing, but the loss in number of bolls per plant was compensated through higher plant population per hectare (Tables 1 and 2). The findings of Samani et al. (1999) are also line with results of present studies.

Interaction effects between hybrids and different plant spacing were found to be significant. MECH-184 Bt with 75×30 cm spacing recorded significantly higher seed cotton yield (2,821 kg/ha) which was at par with 90×30 cm, 75×45 cm and 90×45 cm (2,735, 2, 695 and 2, 642 kg/ha respectively) compared to RCH-2 Bt with different spacings. This was due to higher yield per plant, mean boll weight, number of good opened bolls per plant and total number of bolls harvested per plant. With 90×60 cm spacing, MECH-184 Bt recorded significantly higher seed cotton yield per plant (136.28 g) number of good opened bolls per plant (30.68) and total number of bolls per plant (37.39) compared to other two hybrids (Tables 1 and 2).

Quality Parameters as Influenced by Hybrids and Plant Population Levels

The quality parameters like uniformity ratio, bundle strength and elongation per cent differed significantly with hybrids. Significantly higher uniformity ratio (47.83) was noticed by MECH-184 Bt over RCH-2 Bt (46.83) and Bunny (45.33). Significantly higher bundle strength (24.43 g/tex) was noticed with MECH-184 Bt compared to other two hybrids. However, significantly higher elongation percentage was noticed with Bunny (6.7) followed by RCH-2 Bt (6.1) and MECH-184 Bt (5.9). Staple length, micronaire value and maturity ratio did not differ significantly with hybrids. These results are in line with the findings of and Halemani et al. (2004). Different plant spacing did not influence quality parameters of cotton hybrids. This may be attributed to varietal inbuilt ability and spacing has no bearing on quality of fiber (Table 3).

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