

Seed Cotton Yield, Economics and Nutrients Uptake of Bt Cotton (*Gossypium hirsutum* L.) Hybrids as Influenced by Different Plant Spacings under Irrigation

S. R. ANAND, RAMESH BABU, P. ASHOKA AND R. SMITHA

*Department of Agronomy, University of Agricultural Sciences, College of Agriculture
 GKVK, Bangalore 560065, India
 E-mail : anismi3@gmail.com*

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 MECH-184 Bt recorded significantly higher seed cotton yield, gross returns, net returns and B : C ratio (2,615 kg/ha, Rs 47,793/ha, Rs 27,558/ha and 2.26, respectively). Among spacings, 75 × 30 cm spacing recorded significantly higher seed cotton yield and gross returns (2,389 kg/ha, Rs 41,857/ha, respectively). Whereas, net returns were significantly higher with 90 × 45 cm (Rs 20,441/ha) spacing. MECH-184 Bt with 75 × 30 cm spacing registered significantly higher seed cotton yield and gross returns while net returns were significantly higher in MECH-184 Bt with 75 × 60 cm (Rs 28,650/ha) spacing. Uptake of N, P and K in all the hybrids increased with decrease in plant spacing from 90 × 60 cm (18,518 plants/ha) to 75 × 30 cm (44,444 plants/ha). MECH-184 Bt removed significantly higher NPK at all the spacings compared to other two hybrids.

Key words : Cotton yield, Nutrient uptake, Economics, Plant spacing.

Cotton (*Gossypium hirsutum* L.) is a leading commercial crop grown for its valuable fiber. India ranks number one in the world accounting for 20% of the total area planted under cotton. However, even with highest area under cotton, nine million hectares, India ranks only third position with only 13% in production of cotton (Anon. 2007). India's average yield is only 319 kg/ha lint as compared to world average of 603 kg/ha. Cotton is highly susceptible to insects especially to the larvae of lepidopteron pests, which is impacting cotton production. Fifty percent of the total insecticides consumed in the country are used only for cotton crop. The total loss due to damage to cotton crop is estimated to be more than Rs 1200 crores. The chemical control to suppress these insect pest are proving ineffective as these pests have developed high level of resistance for most of such chemical used for the control of bollworm complex. Such a high level of resistance requires repeated application of insecticides leading to heavy expenditure, crop failures, and vicious cycle of debt for farmers. Therefore, it has been argued that adoption of Bt cotton could help in protecting the crop against potentially the most damaging bollworms and thus re-

duce the risk of crop failures. 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 namely, MECH-184 Bt, MECH-162 Bt and MECH-12 Bt for and RCH-2 Bt for commercial cultivation in recent years. Among the various cultural practices plant spacing is one of the most critical factor that influences seed cotton 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 exploit potential yields which helps in improving the economic condition of the farmers.

Methods

Field experiment was conducted during *kharif* season of 2004-2005 under irrigated conditions at the Agriculture College Farm, Raichur on medium black soil having 229.4, 25.5 and 358.0 kg/ha available N, P₂O₃ and K₂O, respectively with pH of 8.29 and organic content of 0.62%. There were 18 treatment com-

Table 1. Seed cotton yield (kg/ha), cost of cultivation (Rs/ha) and gross returns (Rs/ha) of cotton hybrids as influenced by different plant spacings. H₁—MECH-184 Bt, H₂—RCH-2 Bt, H₃—Bunny. S₁—75 × 30 cm, S₂—75 × 45 cm, S₃—75 × 60 cm, S₄—90 × 30 cm, S₅—90 × 45 cm, S₆—90 × 60 cm.

Treatments	Seed cotton yield (kg/ha)				Cost of cultivation (Rs/ha)			
	H ₁	H ₂	H ₃	Mean	H ₁	H ₂	H ₃	Mean
S ₁	2821	2540	1507	2389	24,376	24,376	18,766	22,539
S ₂	2695	2456	1710	2287	20,636	20,636	17,740	19,703
S ₃	2587	2316	1581	2161	17,816	17,916	16,807	17,546
S ₄	2755	2497	1746	2343	22,436	22,436	18,009	20,793
S ₅	2642	2378	1637	2219	19,086	19,086	17,056	18,409
S ₆	2417	2143	1473	2011	16,956	16,956	16,446	16,786
Mean	2615	2389	1659	2235	20,234	20,234	17,454	19,301
	SE ±		CD at 5%		SE ±		CD at 5%	
Hybrids (H)	28		113		212		834	
Spacing (S)	36		104		249		721	
S at the same H	62		181		432		1250	
H at the same or diff S	64		185		448		1295	

Table 1. Continued.

Treatments	Gross returns (Rs/ha)			Mean
	H ₁	H ₂	H ₃	
S ₁	50,850	45,810	28,912	41,857
S ₂	48,590	44,208	27,360	40,122
S ₃	46,566	41,688	25,296	37,722
S ₄	49,770	44,946	27,936	40,996
S ₅	47,556	42,804	26,192	38,550
S ₆	43,506	38,574	23,568	35,216
Mean	47,793	43,005	26,544	39,187
	SE ±		CD at 5%	
Hybrids (H)	128		502	
Spacing (S)	163		471	
S at the same H	183		817	
H at the same or diff S	288		832	

binations consisting of two Bt cotton hybrids and one non-Bt (H₁ - MECH-184 Bt, H₂ - RCH - 2 Bt and H₃ - Bunny non-Bt) in main plots and six different spacings (S₁-75 × 30 cm, S₂-75 × 45 cm, S₃-75 × 60 cm, S₄-90 × 30 cm, S₅-90 × 45 cm, and S₆-90 × 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 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 prices of the inputs that were prevailing at the time of their use were considered for working out economics of the various treat-

ment combinations. Net returns/ha was calculated by deducting the cost of cultivation from gross income/ha. Benefit cost ratio was worked by dividing gross returns (Rs/ha) with cost of cultivation (Rs/ha).

Results and Discussion

Performance of Hybrids

MECH-184 Bt recorded significantly higher seed cotton yield (2,655 kg/ha) over RCH-2 Bt (2,389 kg/ha) and Bunny cotton hybrid (1,661 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. 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

Table 2. Net returns (Rs/ha), B : C ratio and uptake of N, P and K (kg/ha) in plant at harvest of cotton hybrids as influenced by different plant spacings. H₁—MECH-184 Bt, H₂—RCH-2 Bt, H₃—Bunny, S₁—75 × 30 cm, S₂—75 × 45 cm, S₃—75 × 60 cm, S₄—90 × 30 cm, S₅—90 × 45, S₆—90 × 60 cm. DAS—Days after sowing.

Treatments	Net returns (Rs/ha)				B : C ratio				Nitrogen			
	H ₁	H ₂	H ₃	Mean	H ₁	H ₂	H ₃	Mean	H ₁	H ₂	H ₃	Mean
S ₁	26,474	21,434	10,146	19,310	2.08	1.87	1.54	1.83	148.2	149.3	154.7	150.7
S ₂	27,874	23,572	9,620	20,355	2.35	2.14	1.54	2.01	135.3	131.4	135.1	133.9
S ₃	28,650	23,688	8,489	20,276	2.59	2.31	1.50	2.13	123.2	116.2	114.7	118.0
S ₄	27,334	22,510	9,927	19,924	2.21	2.00	1.85	1.92	141.3	138.2	146.2	141.9
S ₅	28,470	23,718	9,136	20,441	2.49	2.24	1.53	2.08	128.2	122.3	121.2	123.9
S ₆	26,550	21,618	7,122	18,430	2.56	2.27	1.43	2.08	120.1	110.7	108.5	113.1
Mean	27,558	22,756	9,056	19,821	2.26	2.18	1.51	1.98	132.7	128.0	130.1	130.3
		SE ±	CD at 5%	SE ±	CD at 5%	SE ±	CD at 5%					
Hybrids (H)		259	1017	0.05	0.19	0.14	0.57					
Spacing (S)		234	677	0.11	NS	0.65	1.89					
S at the same H		406	1172	0.19	NS	1.13	3.28					
H at the same or diff .S		452	1306	0.18	NS	1.05	3.03					

Table 1. Continued.

Treatments	Phosphorus				Potassium			
	H ₁	H ₂	H ₃	Mean	H ₁	H ₂	H ₃	Mean
S ₁	28.7	26.7	27.3	27.4	188.3	186.2	189.48	187.3
S ₂	19.2	18.3	21.3	19.6	172.8	170.3	172.36	171.6
S ₃	13.8	11.8	18.2	14.6	159.6	153.2	158.85	157.2
S ₄	25.8	22.2	24.2	24.0	179.0	181.8	182.46	181.1
S ₅	16.8	13.1	16.2	15.4	165.3	159.8	165.26	165.4
S ₆	12.5	14.0	10.5	11.0	151.3	148.0	149.70	149.7
Mean	19.4	17.0	19.6	18.7	169.3	166.5	169.3	168.4
		SE ±	CD at 5%	SE ±	CD at 5%			
Hybrids (H)		0.22	0.87	0.33	1.32			
Spacing (S)		0.39	1.14	0.39	1.13			
S at the same H		0.68	1.98	0.68	1.96			
H at the same or diff S		0.66	1.92	0.70	2.04			

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 and seed index (Table 1).

Effect of Spacings

The seed cotton 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 (Table 1). The final seed cotton yield is the result of yield per plant,

mean boll weight, number of good opened bolls per plant and total number of bolls harvested per plant. This was due to differential plant densities obtained with different spacings under study. Though the plants with 90 × 60 cm spacing produced higher number of bolls per plant, it could not compensate for the loss in number of plants per hectare and thus recorded lower seed cotton yield per hectare. Similar results were also reported by Venugopal (2004).

Interaction effects were significant on seed cotton yield. Seed cotton yield was significantly higher with MECH-184 Bt at 75 × 30 cm spacing (2,821 kg/ha) which was on par with 90 × 45 cm (2,642 kg/ha), 90 × 30 cm (2,755 kg/ha) and 75 × 45 cm spacing (2,695 kg/ha) compared to RCH-2 Bt with different spacings

(Table 1). The plant size was smaller in MECH-184 Bt, while RCH-2 Bt was bushy with more crop spread. This was reason for higher seed cotton yield in MECH-184 Bt at closer spacings.

Economics

Significantly higher cost of cultivation was noticed in MECH-184 Bt (Rs 20,234/ha) and RCH-2 Bt hybrids (Rs 20,234/ha) compared to Bunny (Rs 17,454/ha). Higher cost of cultivation in Bt cotton hybrids may be attributed to seed cost as it is three times more than that of Bunny hybrid (Tables 1 and 2). Net returns (Rs 27,558/ha) and benefit cost ratio (2.26) were significantly higher in MECH-184 Bt than RCH-2 Bt (Rs 22,756/ha and 2.18, respectively) and bunny (Rs 9,056/ha and 1.51 respectively). This is mainly due to higher yield in MECH-184 Bt. Further there was less expenditure incurred in controlling insect pests in Bt hybrids. The number of plant protection sprays was same against sucking pests in all hybrids. But in Bt hybrids, plant protection measures were not taken against bollworms, which forms major cost of cultivation in cotton production. These results are in accordance with the findings of Kubsad et al. (2004). Whereas, the lowest B : C ratio and net returns were obtained in Bunny (Rs 9,371/ha and 1.51, respectively), because of higher cost involved in bollworm control. In Bunny hybrid four sprays were given in spite of low incidence of bollworms during the year of experiment, whereas no sprays were given against bollworms control in Bt hybrids. In spite of timely plant protection measures against bollworms, Bunny recorded lower seed cotton yield per hectare. The lower seed cotton yield and more cost involved in boll worm control resulted in lower net returns in Bunny. Similar trend was also observed in gross returns. Significantly higher gross returns (Rs 47,793/ha) was obtained with MECH-184 Bt cotton hybrid followed by RCH-2 Bt (Rs 43,005/ha) compared to Bunny (Rs 26,544/ha). This was mainly due to higher seed cotton yield produced by Bt hybrids (Table 2).

Different spacings caused significant differences in net returns. Plant spacing of 90 × 45 cm recorded significantly higher net returns (Rs 20,473/ha) and it was at par with 90 × 30 cm (Rs 19,924/ha), 75 × 60 cm (Rs 20,276/ha) and 75 × 45 cm (Rs 20,355/ha) spacings (Table 2). This was mainly attributed to lower cost of

cultivation and higher seed cotton yield per hectare compared to 90 × 60 cm spacing, Kubsad et al. (2004) also recorded similar results. Even though, the seed cotton yield were higher with 75 × 30 cm spacing (2,011 kg/ha) compared to 90 × 45 cm spacing (2,219 kg/ha), the closer spacing (75 × 30 cm) recorded significantly lower net returns (Rs 19,310) than 90 × 45 cm spacing (Rs 20,441) mainly because higher cost of cultivation involving higher seed cost of Bt hybrids.

Uptake of Nutrients

Nitrogen uptake was significantly higher with MECH-184 Bt (13.7 kg/ha), while RCH-2 Bt (126.0 kg/ha) recorded significantly lower uptake of nitrogen compared to Bunny (130.1 kg/ha). Significantly higher N uptake by plants was recorded with plant spacing of 75 × 30 cm (150.7 kg/ha) as compared to all other plant spacing (Table 2). Significantly higher P uptake by plant was observed in Bunny (19.66 kg/ha) and it was on par with MECH-184 Bt (19.42 kg/ha) and significantly lower P uptake was observed in RCH-2 Bt (17.03 kg/ha). Significantly lower P uptake was noticed with plant spacing of 90 × 60 cm (11.00 kg/ha). K uptake differed significantly amongst hybrids (Table 2). Uptake of K by plants was significantly higher with MECH-184 Bt (169.35 kg/ha) and Bunny (169.35 kg/ha) as compared to RCH-2 Bt (166.58 kg/ha). Significantly higher K uptake by plants was noticed with plant spacing of 75 × 30 cm (187.37 kg/ha) as compared to other plant spacing levels. Uptake of N, P and K by cotton plants was significantly higher in MECH-184 Bt followed by RCH-2 Bt (Table 2). This is because of higher magnitude of total dry matter accumulation in MECH-184 Bt hybrid at 90, 120 DAS and at harvest and efficient absorption of nutrients (Table 2). This higher nutrient uptake is one of the reasons for observed variation in seed cotton yield in MECH-184 Bt. The observations made during the present investigation are in line with the findings of Krishnan and Christophar (1987).

Interactions

MECH-184 Bt recorded significantly higher net returns with 90 × 45 cm spacing (Rs 28,470/ha). Even though, MECH-184 Bt gave higher seed cotton yield with closer spacing of 75 × 30 cm, but its net returns

were significantly lower as compared to 90 × 45 cm (Table 1). This was because of higher seed cost which was inturn due to higher plant density with closer spacing of 75 × 30 cm (44,444 plants/ha) when compared to lower plant density with 90 × 45 cm spacing (24,629 plants/ha). Significantly lower net returns and B : C ratio were recorded with Bunny with all the plant spacings. This was mainly attributed to lower seed cotton yield and more incidence of bollworm, which involved more cost of cultivation in Bunny as compared Bt hybrids. The present investigation indicated that cultivation of MECH-184 Bt with 90 × 45 cm spacing was found profitable in TBP command area in black soil under irrigation.

Uptake of N, P and K in all the hybrids increased with decrease in plant spacing from 90 × 60 cm (18,518 plants/ha) to 75 × 30 cm (44,444 plants/ha). MECH-184 Bt removed significantly higher NPK at all the spacings compared to other two hybrids. This was attributed to higher dry matter production and higher seed cotton yield recorded in this hybrid (Table 2).

References

- Anonymous. 2007. *USDA report*. Cotton Corp. of India. 1—5 pp.
- Khadi B. M., I. S. Katageri, V. N. Kulkarni and A. M. Adigannavar. 2002. Evaluation of Bt cotton hybrids in transitional track of Karnataka. Pp. 87. *In Nat. Sem. on Bt cotton scenario with special reference to India*. 23 May 2002. Dharwad, India.
- Krishnan P. K. and L. Christopher. 1987. Different levels, time and method of application of nitrogen and potassium on the uptake of nutrients and soil nutrient status in cotton. *Madras Agric. J.* 84 : 330—334.
- Kubsad V. S., V. Rudra Naik, H. L. Halemani, C. P. Mallapur, C. P. Mansur and B. C. Kolhar. 2004. Productivity of desi cotton genotypes as influenced by spacings and fertilizer levels. Pp 112—115. *In Int. Symp. on strategies for sustainable cotton production—A global vision 2. Crop production*. 23—25 Nov 2004. Univ. Agric. Sci., Dharwad, India.
- Venugopal K. 2004. Changing paradigms (avenues/ approaches) in cotton production technologies for improving productivity and fiber quality of cotton. *In Int. Symp. on strategies for sustainable cotton production—A global vision 2. Crop production*. 23—25 Nov 2004. Univ. Agric. Sci., Dharwad, India.