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Yield and quality of late sown Bt Cotton (*Gossypium hirsutum* L.) as influenced by different plant spacings, fertilizer levels and NAA applications under irrigation

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ABSTRACT

A field experiment was conducted on vertisol to study the yield and quality of late sown Bt cotton as influenced by different plant spacings, fertilizer levels and NAA applications under irrigation during 2006-07 at College of Agriculture, Raichur farm, University of Agricultural Sciences, Dharwad. The results of the investigation indicate that seed cotton yield was highest with 90 x 30 cm spacing (2479 kg ha^{-1}), 150 per cent RDF (2420 kg ha^{-1}) and three sprays of NAA (2488 kg ha^{-1}). The yield parameters such as number of bolls per plant, boll weight and seed cotton yield per plant were significantly higher with 90 x 60 cm, 150 per cent RDF and three sprays of NAA. Fibre quality parameters such as mean fibre length, ginning percentage, lint index were not significantly influenced by spacing levels, fertilizer levels, and NAA sprays. Interaction effect were found to be non significant.

Key words : Yield, Bt cotton, Spacing, Fertilizer levels, NAA sprays

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fibre crop of India contributing 85 per cent of raw materials to the textile industry. India ranks first in area and third in production after USA and China with an average productivity of 462 kg lint ha^{-1} which is very low compared to world's average productivity of 682 kg lint ha^{-1} (Khadi, 2007). Optimum time for sowing of hybrid cotton is upto July second fortnight. Delay in sowing beyond normal time becomes inevitable due to partial or total failure of rains and/or late release of canal water in *Kharif* season (Satyanarayana Rao and Janawade, 2006). The research studies indicated a 28.9 per cent reduction in cotton yields when sowing was delayed by a month (Basavanneppa *et al.,* 2001). Under such conditions it is necessary to find out suitable agronomic practices for enhancing the cotton productivity. The present investigation was conducted to study the yield and quality of late sown Bt cotton as influenced by different plant spacings, fertilizer levels and NAA applications under irrigation.

MATERIALS AND METHODS

Field experiment was conducted during 2006-07 at College of Agriculture, Raichur, farm on black clay soil. The experiment was laid out in a split- split plot design. There were 18 treatment combinations with plant spacings (population levels), 90 cm x 30 cm (37,036 plants/ha), 90 cm x 45 cm (24,691 plants/ha) and 90 cm x 60 cm (18,518 plants/ha) in main plots, fertilizer levels (100 % and 150 % RDF) in sub plots and growth regulator sprays control (water spray), NAA @ 10 ppm - two sprays at flower commencement and full blooming stage and NAA @ 10 ppm - three sprays at squaring, flower commencement and full blooming stage in sub-sub plots replicated three times. The recommended dose of fertilizer (RDF) for cotton comprised of 150:75:75 NPK kg ha^{-1}. Bt cotton (Bunny Bt) was sown on 25th September 2006, a delay of 45 days from optimum schedule.

RESULTS AND DISCUSSION

Compared to other field crops, cotton is more flexible to wide variations in plant densities because of its indeterminate growth habit and ability to produce vegetative and fruiting branches. Planting at an optimum plant density for efficient interception of radiant energy to the crop surface is an important consideration to improve the productivity of cotton under given set of environmental conditions.

In the present investigation, response of Bt cotton was assessed at varied plant densities or spacing levels (18,518 plants ha^{-1} with 90 x 60 cm spacing, 24,691 plants ha^{-1} with 90 x 45 cm spacing and 37,036 plants ha^{-1} with 90 x 30 cm spacing) under irrigation of late sown situations. Cotton crop grown with 90 x 30 cm spacing produced 2479 kg of seed cotton yield ha^{-1} which was significantly higher than that with 90 x 60 cm spacing (2101 kg ha^{-1}) but was at par with 90 x 45 cm spacing

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(2343 kg ha^{-1}). The plant spacing of 90 x 60 cm resulted in significantly lower seed cotton yield. Increase in seed cotton yield with 90 x 30 cm spacing was 5.8 and 18.0 per cent over 90 x 45 and 90 x 60 cm spacings, respectively (Table 2 and Fig. 1). Sisodia and Khamparia, (2007) also have obtained higher seed cotton yield with higher plant population.

The final seed cotton yield is the manifestation of yield contributing characters. Total number of bolls harvested per plant was significantly influenced by different spacings (Table 1). Number of bolls harvested per plant was significantly reduced with spacing of 90 x 30 cm (28.30) compared to 90 x 45 cm (32.22) and 90 x 60 cm spacings (36.17). Though the plants with 90 x 60 cm (18,518 plants ha^{-1}) 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. Where as, the number of bolls per plant with 90 x 30 cm (28.30) was lower compared to 90 x 60 cm (36.17) spacing, but the loss in number of bolls per plant was compensated through higher plant population per hectare.

However, variation in plant density caused significant difference in seed cotton yield per plant. Seed cotton yield per plant was higher with 90 x 60 cm spacing (126.09 g plant^{-1}) as compared to 90 x 30 cm (83.32 g plant^{-1}) (Table 1). This was due to the favourable effect of yield components like higher boll number, boll setting percentage and mean boll weight in low plant population (18,518 plants ha^{-1}) with 90 x 60 cm spacing compared to high plant population (37,036 plants ha^{-1}) with 90 x 30 cm spacing. Increased yield per plant obtained with 90 x

Table 1 : Number of harvested bolls per plant, boll weight (g), seed cotton yield (g plant^{-1}) and boll setting percentage in Bt cotton as influenced by management practices under late sown conditions

Treatments	Number of harvested bolls plant^{-1}	Boll weight (g)	Seed cotton yield (g plant^{-1})	Boll setting percentage 120 DAS
Plant spacings (S)				
S_1- 90 x 30 cm (37,036 plants ha^{-1})	28.30	3.57	83.32	46.08
S_2- 90 x 45 cm (24,691 plants ha^{-1})	32.22	4.09	114.36	47.30
S_3- 90 x 60 cm (18,518 plants ha^{-1})	36.17	4.55	126.09	50.11
S. E. ±	0.56	0.07	2.33	0.44
C.D. (P=0.05)	2.22	0.30	9.16	1.74
Fertilizer levels (F)				
F_1- 100% RDF	30.74	3.92	104.37	45.52
F_2- 150% RDF	33.72	4.22	111.48	50.13
S. E.±	0.32	0.02	1.90	0.35
C.D. (P=0.05)	1.11	0.09	6.58	1.21
Growth regulator sprays (G)				
G_1- Control (water spray)	30.64	3.96	103.69	45.20
G_2- NAA @ 10 ppm (2 sprays)	31.94	4.06	108.22	48.01
G_3- NAA @ 10 ppm (3 sprays)	34.12	4.19	111.86	50.27
S. E.±	0.45	0.04	1.71	0.58
C.D. (P=0.05)	1.28	0.10	3.49	1.71
Interactions				
S x F				
S. E.±	0.55	0.04	3.29	0.60
C.D. (P=0.05)	NS	NS	NS	NS
S x G				
S. E.±	1.12	0.09	3.49	1.01
C.D. (P=0.05)	NS	NS	NS	NS
F x G				
S. E.±	0.92	0.07	2.85	0.83
C.D. (P=0.05)	NS	NS	NS	NS
S x F x G				
S. E.±	1.59	0.12	4.94	1.43
C.D. (P=0.05)	NS	NS	NS	NS

NS = Non significant

60 cm spacing at the lowest plant density (18,518 plants ha^{-1}) was inadequate to compensate the loss in the plant population and thus resulted in lower seed cotton yield. Though the number of bolls per plant and yield per plant was higher in 90 x 60 cm, the beneficial effect was offset due to less number of plants per unit area (ha.). The mean boll weight also followed same trend (Table 1). Many research workers have also reported lower values of yield attributes of cotton with higher plant spacings (Satyanarayana Rao and Janawade, 2006 and Sisodia and Khamparia, 2007).

In the present investigation, seed cotton yield differed significantly due to fertilizer levels (Table 2 and Fig 1). The seed cotton yield increased significantly with increase in fertilizer levels upto 150 per cent and it was 2195 and 2420 kg ha^{-1} at 100 and 150 per cent RDF, respectively. The extent of increase in seed cotton yield was 10.2 per cent over 100 per cent RDF. Application of 150 per cent RDF was found to be optimum for Bt cotton under irrigated condition compared to present recommended level of NPK (100 per cent). Krishnegowda (2004) also observed significant response of Bt cotton to 150 per cent RDF application under irrigation.

Table 2 : Seed cotton yield (kg ha^{-1}) in Bt cotton as influenced by management practices under late sown conditions

Treatments		G_1	G_2	G_3	Mean (S)
S_1	F_1	2215	2352	2513	2360
	F_2	2413	2596	2784	2598
	Mean	2314	2474	2648	2479
S_2	F_1	2126	2236	2319	2227
	F_2	2320	2369	2687	2459
	Mean	2223	2302	2503	2343
S_3	F_1	1750	2062	2183	1998
	F_2	2007	2165	2441	2204
	Mean	1879	2113	2312	2101
Mean (G)		2138	2297	2488	
Sub plot mean (F)		F_1	2195	F_2	2420
For comparing the means of		S.E. ±		C.D. (P=0.05)	
Spacing (S)		35.24		137.97	
Fertilizer (F)		28.37		98.22	
Growth regulator spray (G)		49.34		144.03	
Interactions					
S X F		49.15		NS	
S X G		85.47		NS	
F X G		69.78		NS	
S X F X G		120.87		NS	

S_1 – 90 x 30 cm S_2 – 90 x 45 cm S_3 – 90 x 60 cm
F_1 – 100 % RDF F_2 – 150 % RDF
G_1 – Control (water spray) G_2 – NAA @ 10 ppm (2 sprays)
G_3 – NAA @ 10 ppm (3 sprays)

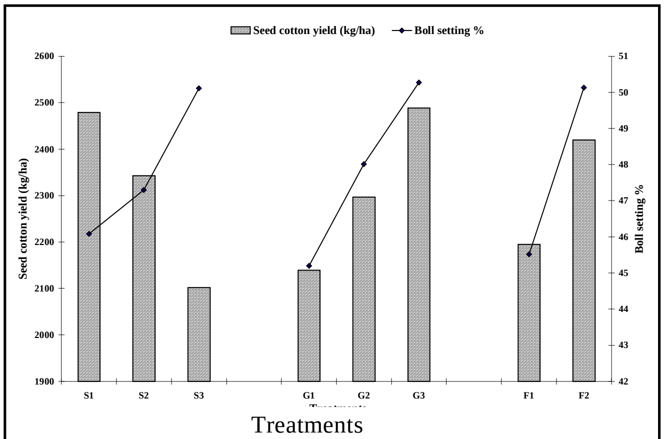

Fig. 1 : Seed cotton yield (kg/ha) and boll setting percentage in Bt cottton as influenced by management practices under late sown conditions

There was significant increase in the yield per plant with the application of 150 per cent RDF (111.48 g) over application of 100 per cent RDF (104.37 g) (Table 1). These results confirm the findings of Manjappa *et al.* (1997).

Yield per plant is determined by number of harvested bolls per plant and mean boll weight. These parameters were significantly higher with the application of higher fertilizer level upto 150 per cent RDF (33.72 and 4.22 g, respectively) over 100 per cent RDF (30.74 and 3.92 g, respectively) (Table 1).

Delayed sowing reduces cotton yields mainly because of curtailment in vegetative as well as reproductive growth period apart from pre-mature shedding of buds and bolls (Sivasankaran *et al.*, 1995). This physiological disorder could be controlled effectively by foliar spraying of growth regulator. It is known that, the plant growth regulators are known to modify the source sink relationship and increase the translocation and photosynthetic efficiency resulting in increased square and boll retention and boll set per cent.

In the present investigation, the data revealed that maximum seed cotton yield of 2488 kg ha^{-1} was obtained with spraying of NAA @ 10 ppm thrice at squaring, flower commencement and full blooming stages. This treatment recorded significantly higher seed cotton yield over the treatment which received two sprays of NAA at flower commencement and full blooming stages (2297 kg ha^{-1}) which inturn was significantly superior over control (water spray). The lowest seed cotton yield was recorded with control (2138 kg ha^{-1}). Increase in seed cotton yield with three sprays of NAA was 8.3 and 16.3 per cent over two sprays of NAA and control, respectively. These results are in conformity with the findings of Brar and Singh

(1983) who observed significantly higher seed cotton yields with two NAA sprays at flower commencement and mid flowering stage over NAA spray alone at flower commencement stage. Similarly, Satyanarayana Rao and Janawadwe, (2006) have also reported increase in seed cotton yield with sprayings of NAA.

Total chlorophyll content determines the photosynthetic capacity and influence the rate of photosynthesis, dry matter production and the seed cotton yield (Krasichkova *et al*., 1989). Lohot (2000) observed that the application of NAA @ 40 ppm on 55th day after sowing of cotton resulted in higher rate of photosynthesis (23.63 μ mol CO_2 m^{-2} s^{-1}) and chlorophyll content of leaves (0.777 mg g^{-1} of fresh weight of leaf) at 90 DAS when compared to control (21.21 μ mol CO_2 m^{-2} s^{-1} and 0.674 mg g^{-1}, respectively) which inturn led to higher production of assimilates and their translocation to developing bolls. In the present study, higher yields due to application of NAA thrice may be attributed to the development of optimum canopy with increased chlorophyll content leading to higher photosynthetic efficiency. Foliar spraying of NAA thrice resulted in significantly higher chlorophyll content in leaves (1.86 mg g^{-1} fresh leaves) at 90 DAS as compared to NAA spray twice (1.72 mg g^{-1} fresh leaves) and control (1.60 mg g^{-1} fresh leaves) (Table 3).

Higher seed cotton yield in NAA applied crop was closely related to higher yield parameters such as bolls $plant^{-1}$, mean boll weight, and seed cotton yield $plant^{-1}$ as compared to control (water spray) (Table 1). The final boll number is the result of successful transformation of squares to flowers and to then bolls. Auxins and Gibberellins produced in seeds and pericarp might have

Table 3 : Ginning percentage, lint index, mean fibre length (mm) and chlorophyll content (mg g^{-1} fresh leaf weight) in Bt cotton as influenced by management practices under late sown

Treatments	Ginning percentage	Lint index	Mean fibre length (mm)	Chlorophyll content (mg g^{-1} fresh leaf weight) 90 DAS
Plant spacings (S)				
S_1- 90 x 30 cm (37,036 plants ha^{-1})	35.60	5.02	30.14	1.57
S_2- 90 x 45 cm (24,691 plants ha^{-1})	35.82	5.22	31.11	1.73
S_3- 90 x 60 cm (18,518 plants ha^{-1})	37.11	5.34	31.25	1.87
S. E. ±	0.84	0.12	0.58	0.008
C.D. (P=0.05)	NS	NS	NS	0.032
Fertilizer levels (F)				
F_1- 100% RDF	36.33	5.19	30.79	1.66
F_2- 150% RDF	36.03	5.20	30.88	1.80
S. E.±	0.87	0.09	0.46	0.006
C.D. (P=0.05)	NS	NS	NS	0.021
Growth regulator sprays (G)				
G_1- Control (water spray)	36.36	5.20	30.87	1.60
G_2- NAA @ 10 ppm (2 sprays)	36.08	5.17	30.75	1.72
G_3- NAA @ 10 ppm (3 sprays)	36.10	5.21	30.88	1.86
S. E.±	0.60	0.17	0.43	0.008
C.D. (P=0.05)	NS	NS	NS	0.023
Interactions				
S x F				
S. E.±	1.52	0.16	0.80	0.011
C.D. (P=0.05)	NS	NS	NS	NS
S x G				
S. E.±	1.04	0.30	0.74	0.013
C.D. (P=0.05)	NS	NS	NS	NS
F x G				
S. E.±	0.85	0.24	0.61	0.011
C.D. (P=0.05)	NS	NS	NS	NS
S x F x G				
S. E.±	1.47	0.43	1.05	0.019
C.D. (P=0.05)	NS	NS	NS	NS

NS = Non significant

been transported to and interacted at the abscission zone located at the base of pedicel. If auxins and gibberellins were not available in sufficient amount so as to neutralize the effects of abscission, the boll will shed (Verma, 1978). In the present study, spraying of NAA thrice resulted in significant increase in boll setting percentage (45.90 per cent) over control (41.14 per cent) (Table 1 and Fig 1). This inturn has reflected in higher number of harvested bolls plant^{-1} (Table 1). The increase in boll number is due to reduction in the abscission of intact buds and bolls. Auxins supplied through growth promoters (NAA) counteracted the abscission effect of ABA and thus reduced the shedding over control. It was suggested that endogenous auxin content may be playing a key role in the phenomenon of abscission and that a certain concentration might regulate the process (Verma, 1978). Significantly higher seed cotton yield plant^{-1} was recorded with three sprays of NAA (111.86 g plant^{-1}) over two sprays of NAA (108.22 g plant^{-1}) and control (103.69 g plant^{-1}). The increase in seed cotton yield plant^{-1} with three sprays of NAA was 3.4 and 7.9 per cent over two sprays of NAA and control, respectively which is due to higher boll weight with NAA application (Table 1). Kiran Kumar *et al.* (2004) have also reported higher yield, yield parameters and boll setting percentage when cotton crop was sprayed with NAA.

None of the quality parameters *viz.*, mean fibre length, lint index, ginning percentage were not influenced by the population levels. Similar results were observed by Dhillon *et al.* (2006).

Fibre quality parameters *i.e.* mean fibre length, ginning percentage, lint index were not significantly influenced by levels of fertilizers (Table 3). This might be more controlled by genetic make – up of the plant than nutrient status of the plant. These results are in conformity with the findings of Padole *et al.* (1998) who also did not notice much variation in fibre quality due to levels of fertilizers.

None of the quality parameter *viz.*, ginning percentage, mean fibre length, lint index were significantly influenced by spraying of NAA (Table 3). These results are in agreement with those of Satyanarayana Rao and Janawade (2006).

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