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Effect of Agronomic Management Practices and use of Growth Regulators on Yield and Economics of *Bt* Cotton (*Gossypium hirsutum* L.) under Irrigated Condition

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ABSTRACT

A field experiment was conducted during *kharif* 2018-19 at Main Agricultural Research Station farm, Raichur, Karnataka. The experiment laid out in split plot design with three replications. The experiment consisted of two main plot treatments viz., 90 × 60 cm (S_1) and 120 × 60 cm (S_2). The sub plot treatments are M_1 (Nipping at 75DAS), M_2 (Nipping at 90 DAS), M_3 (Spraying of Paclabutrazole 23%SC at 55 DAS and 85DAS), M_4 (Spraying of Paclabutrazole 23%SC at 55 DAS and 85DAS + Nipping at 75D), M_5 (Spraying of Paclabutrazole 23%SC at 55 DAS and 85DAS+ Nipping at 90 DAS), M_6 (Control) and M_7 (Farmer's practice). Data on yield and economics was recorded and statistically analyzed. The experimental results revealed that, spacing of 90 × 60 cm is best spacing for different parameters and is recorded significantly higher seed cotton yield (2693 kg ha^{-1}), number of good opened bolls per plant (24.58), total number of bolls (29.37), boll weight (4.71 g), seed cotton yield per plant (126.9 g),seed index (9.45 g), harvest index (0.43), lint index (4.77), ginning percentage (33.61),), gross returns (Rs. 1,45,416 ha^{-1}), net returns (Rs. 86.379 ha^{-1}) and benefit cost ratio (2.46). Foliar spray of Paclabutrazole 23%SC at 55 DAS and 85DAS + Nipping at 90 DAS (M_5) recorded significantly higher seed cotton yield (2788 kg ha^{-1}), number of good opened bolls per plant (31.37), total number of bolls (35.50), boll weight (5.12 g), seed cotton yield per plant (151.2 g), seed index (9.68 g), lint index (4.63), harvest index (0.44) ginning percentage (33.48), gross returns (Rs. 1.50.552 ha^{-1}), net returns (Rs. 90.398 ha^{-1}) and benefit cost ratio (2.50).

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important fibre crop of Indian farming community grown under diverse agro-climatic condition and playing a pivotal role in agriculture, industrial development, employment generation, agrarian and rural economy of India. Cotton is often called as "white gold" and also as "king of fibre". As per the estimates, 47.5 m bales of lint is required to meet the domestic and export requirements by 2020. To fulfill this projected requirement, the cotton production and productivity has to be increased considerably. The factors responsible for low productivity in

Tunga Bhadra Project (TBP) area of Karnataka are mainly due to decline in soil fertility status, monocropping, pests (cotton bollworm and sucking pests), imbalanced use of fertilizers, deficiency of micronutrients and non adaptability of proper agronomic practices and supply of nutrients is the major limiting factor in cotton production and most of the soil in rainfed areas is not only thirsty but also hungry. It is well established fact that sufficient quantity of nutrients at proper time is needed for achieving higher yield. The nutrient management in cotton is a complex phenomenon due to simultaneous production of vegetative and reproductive structures during the active growth phase. Cotton plant being a heavy feeder require adequate supply of nutrients to optimize the seed cotton yield, quality and net profit in cotton production (Aladakatti *et al.*, 2011).

Cotton suffers from various biotic and abiotic stresses right from the germination to maturity. The growth during the seedling establishment phase has a role to play in yield realization. A good plant frame would provide sufficient space for holding and catering the needs of the reproductive parts during the later part of growth. As the cotton plant is photo insensitive they start producing the reproductive parts irrespective of the environmental and physical conditions by 40-45 DAS. Hence, sufficient morpho-frame will not be available for the plant to hold the reproductive parts. This subjects the plants to either premature death or reduced boll load. Cotton crop failures can be often related to excessive vegetative growth. Lush 2-2.5 m cotton canopies with fully overlapping middle canopy are heavens for insects and boll rot fungi. A luxuriant and dense canopy makes effective insect control essentially impossible and causes lodging, which makes harvesting difficult. Moreover, squares or small bolls may be sheddue to shading effect. The reduced plant growth and modified shape will result in better light penetration, earlier boll opening and higher harvest index. Nipping, various growth regulators are being applied in cotton in an attempt to set more bolls, limit vegetative growth or terminate fruiting.

One of the main factors affecting cotton yield adversely is inadequate supply of nutrients and of excessive vegetative growth. Earlier cotton species (desi) were determinate in growth but growth habit of present day cotton varieties are indeterminate which respond well to the increased fertilizer and require nutrients upto boll bursting stage. Therefore, the need for research is to develop technologies to maximize yield levels of cotton by reducing excessive vegetative growth and enhancing the lateral branches.

Materials and Methods

A field experiment was conducted during *kharif* 2018-19 at Main Agricultural Research station farm, Raichur, which is situated between 16^o 12' North latitude and 77^o 20' East longitude with an altitude of 389 meters above the mean sea level and it falls within the North Eastern Dry Zone (Zone 2) of Karnataka. There were 14 treatment combinations and the experiment laid out in split plot design with three replications. The experiment consisted of two main plot treatments viz., 90 × 60 cm (S_1) and 120 × 60 cm (S_2). The sub plot treatments are M_1 : Nipping at 75DAS, M_2 : Nipping at 90 DAS, M_3 : Spraying of 0.035% Paclabutrazole 23%SC at 55 DAS and 85DAS, M_4: Spraying of 0.035% Paclabutrazole 23%SC at 55 DAS and 85DAS + Nipping at 75D, M_5 : Spraying of 0.035% Paclabutrazole 23%SC at 55 DAS and 85DAS+ Nipping at 90 DAS, M_6; Control and M_7: Farmer's practice.

The soil of the experimental site was black with alkaline pH of 8.2, EC of 0.35 dSm^{-1} and medium in organic carbon (0.7 %) and had available nitrogen of 225 kg ha^{-1}, available phosphorus and potassium of 33.5 and 221.51 kg ha^{-1}respectively, in soil. The crop was sown on 10-8-2018. Two seeds per hill were dibbled by maintaining 60 cm space between two hills in a row and 90 cm between rows in case of 90×60 cm and 120 cm between rows in case of 120×60 cm. Thinning was done on 7^{th}day after sowing by retaining one good seedling per hill.

Results and Discussion

Yield parameters

Among spacings, 120 cm × 60 cm produced significantly higher number of bolls per plant (33.1), good opened bolls per plant (28.9), as compared to 90 cm × 60 cm (29.4) and (24.6), respectively and M_5 (Spraying of Paclabutrazole 23% SC at 55 DAS and 85 DAS + Nipping at 90 DAS) recorded significantly higher number of bolls per plant (35.5). Higher number of total bolls in wider spacing 120 cm × 60 cm primarily due to better development of individual plant in wider spacing. Widely spaced plant received favourable microclimate. Similar results were also observed by Pradeep Kumar *et al.,* (2017), Paslawar *et al.,* (2017), Hargrias and Saini (2018) and Nehra and Chandra (2001).

Higher number of bolls in M_5 (spraying of 0.035% Paclabutrazole 23% SC at 55 DAS and 85 DAS + Nipping at 90 DAS) was due to increased in number and length of sympodia because of application of 0.035% paclabutrazole 23% SC due to improved source to sink relationship and better translocation of metabolites towards reproductive sinks (fruiting bodies) and also retardation of excessive vegetative growth. Nipping also helps to reduce the vertical growth inhibit (Kataria *et al.,* (2017). These results are in conformity with the findings of York (1983), Brar *et al.,* (2000), Norton *et al.,* (2005), Kumar *et al.,* (2006), Zakaria (2006), Dinesh Nawalkar *et al.,* (2014) and Siddu Malakannavar *et al.,* (2018).

Higher boll weight (5.01 g $boll^{-1}$),seed cotton yield per plant (146.36 g $plant^{-1}$) in 120 cm × 60 cm and M_5 (spraying of 0.035% Paclabutrazole 23 %SC at 55 DAS and 85 DAS+ Nipping at 90 DAS) also recorded higher boll weight (5.12 g $boll^{-1}$), seed cotton yield per plant (151.22 g $plant^{-1}$). Seed cotton yield per plant was governed by yield component like number of bolls per plant and boll weight which may be attributed to the production of higher number of sympodial branches, number of bolls per plant, boll weight and higher number of good opened bolls. Growth regulator improves the source-sink relationship and better translocation of metabolites towards reproductive parts (fruiting bodies) due to retardation of excessive vegetative growth (Siddique *et al.,* 2002) and nipping inhibits the vertical growth Kataria *et al.,* (2017). Similar results are also reported by Kataria *et al.,* (2018). The spacing 90 cm × 60 cm produced significantly higher seed cotton yield (2693 kg ha^{-1}) compared to 120 cm × 60 cm (2339 kg ha^{-1})due to the higher plant density with total number of bolls (29.37), boll weight (4.71 g) and similar results were reported by Manjunatha *et al.,*(2010), Pradeep Kumar *et al.,* (2017), Paslawar *et al.,* (2017), Hargrias and Saini (2018) and Nehra and Chandra (2001) and also M_5 (Spraying of 0.035% Paclabutrazole 23% SC at 55 DAS and 85 DAS + Nipping at 90 DAS) recorded higher seed cotton yield (2788 kg ha^{-1}) due to application of paclabutrazole 23% SC which reported higher seed cotton yield due to similar biochemical action took place as that of the mepiquat chloride with higher total number of bolls (35.5),boll weight (5.1), lower plant height (86.10 cm at final picking) and dry matter production (375.17 g per plant) (Table 1).

Table.1 Total number of bolls, Good opened bolls, Boll weight, Seed cotton yield per plant, seed cotton yield, of *Bt*-cotton as influenced by spacing and agronomic management practices

Treatment	Total number of bolls per plant	Good opened bolls per plant	Boll weight (g)	Seed cotton yield (g plant^{-1})	Seed cotton yield (kg ha^{-1})
Spacing (S)					
S_1	29.4	24.6	4.71	126.9	2693
S_2	33.1	28.9	5.01	146.4	2339
S. Em.±	**0.4**	**0.4**	**0.09**	**2.5**	**45.50**
C. D. at 0.05	**2.4**	**2.5**	NS	**15.2**	**276.88**
Agronomic management practices (M)					
M_1	29.6	24.9	4.67	127.2	2355
M_2	29.8	25.1	4.75	131.6	2415
M_3	31.9	27.3	4.96	141.3	2614
M_4	34.0	29.6	5.01	145.4	2661
M_5	35.5	31.4	5.12	151.2	2788
M_6	27.9	23.1	4.64	124.7	2312
M_7	30.2	25.5	4.86	135.1	2465
S. Em.±	**1.6**	**1.6**	**0.13**	**4.8**	**84.72**
C. D. at 0.05	**4.8**	**4.8**	NS	**13.9**	**247.28**
Interaction (S X M)					
S. Em.±	**2.3**	**0.2**	**0.18**	**6.7**	**119.81**
C. D. at 0.05	NS	NS	NS	NS	NS

NS – Non significant
MAIN PLOT: Spacing (S)
S_1- 90 cm × 60 cmS_2- 120 cm × 60 cm
SUB PLOTS: Agronomic Management Practices (M)
M_1 : Nipping at 75 DAS
M_2 : Nipping at 90 DAS
M_3 : Spraying of Paclabutrazole 23 %SC at 55 DAS and 85 DAS
M_4 :.M3 + Nipping at 75 DAS
M_5 : M3 + Nipping at 90 DAS
M_6 : Control
$M_{7:}$ Farmer practice

Table.2 Seed index, Ginning percentage, lint index and harvest index of *Bt*-cotton as influenced by spacing and agronomic management practices

Treatment	Seed index (g)	Ginning percentage	Lint index	Harvest index
Spacing (S)				
S_1	9.45	33.61	4.77	0.43
S_2	9.54	30.28	4.14	0.39
S. Em.±	**0.20**	**0.65**	**0.13**	**0.02**
C. D. at 0.05	NS	NS	NS	NS
Agronomic management practices (M)				
M_1	9.40	31.47	4.42	0.39
M_2	9.46	31.59	4.43	0.40
M_3	9.56	31.98	4.44	0.42
M_4	9.64	32.43	4.49	0.43
M_5	9.68	33.48	4.63	0.44
M_6	9.17	30.84	4.33	0.39
M_7	9.54	31.80	4.44	0.41
S. Em.±	**0.07**	**0.74**	**0.11**	**0.01**
C. D. at 0.05	**0.21**	NS	NS	NS
Interaction (S X M)				
S. Em.±	**0.10**	**1.05**	**0.15**	**0.02**
C. D. at 0.05	NS	NS	NS	NS

NS – Non significant
MAIN PLOT: Spacing (S)
S_1- 90 cm × 60 cmS_2- 120 cm × 60 cm
SUB PLOTS: Agronomic Management Practices (M)
M_1 : Nipping at 75 DAS
M_2 : Nipping at 90 DAS
M_3 : Spraying of Paclabutrazole 23 %SC at 55 DAS and 85 DAS
M_4 :.M3 + Nipping at 75 DAS
M_5 : M3 + Nipping at 90 DAS
M_6 : Control
M_7 : Farmer practice

Table.3 Cost of cultivation, gross returns, net returns and benefit cost ratio *Bt*-cotton as influenced by spacing and agronomic management practices

Treatments	Economics			
	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C ratio
Spacing (S)				
S_1	59038	145416	86379	2.46
S_2	58638	126280	67642	2.15
S. Em.±	-	**2705**	**1353**	**0.05**
C. D. at 0.05	-	**16458**	**8230**	**0.30**
Agronomic management practices (M)				
M_1	57749	127188	69439	2.20
M_2	57749	130392	72643	2.26
M_3	59804	141174	81370	2.36
M_4	60154	143676	83522	2.39
M_5	60154	150552	90398	2.50
M_6	57399	124839	67440	2.17
M_7	58856	133119	74263	2.26
S. Em.±	-	**5850**	**3371**	**0.05**
C. D. at 0.05	-	**17075**	**9839**	**0.15**
Interaction (S X M)				
S. Em.±	-	**8273**	**4767**	**0.07**
C. D. at 0.05	-	NS	NS	NS

NS – Non significant
MAIN PLOT: Spacing (S)
S_1- 90 cm × 60 cm S_2 - 120 cm × 60 cm
SUB PLOTS: Agronomic Management Practices (M)
M_1 : Nipping at 75 DAS
M_2 : Nipping at 90 DAS
M_3 : Spraying of Paclabutrazole 23 %SC at 55 DAS and 85 DAS
M_4 :.M3 + Nipping at 75 DASM_5 : M3 + Nipping at 90 DAS
M_6 : ControlM_7 : Farmer practice

The mepiquat chloride increased CO_2 uptake and fixation in cotton leaves, resulting in increased assimilate production (Gausman *et al.,* 1980). Mepiquat chloride restricts the vegetative growth of plants and increases the partitioning of assimilates towards fruiting bodies (Kaur, 1998) and these results are conformity with findings of Siddu Malakannavar *et al.,* (2018). Increase in number of sympodial branches and its length, chlorophyll content and transport of photosynthates towards reproductive parts, it was produced and retained more number of squares ultimately plant attained more number of bolls and nipping inhibits the vertical growth Kataria *et al.,* (2017), These results are also in conformity with findings of Anon (2010), Ratna kumari and George (2013).

Higher seed index (9.54 g) was recorded in 120 cm × 60 cm and M_5 (Spraying of 0.035% Paclabutrazole 23% SC at 55 DAS and 85

DAS + Nipping at 90 DAS) also recorded higher seed index (9.68).Higher seed index was recorded due to application of 0.035% paclabutrazole 23% SC, which causes more compact growth in plants by checking the apical dominance by acting as the anti – gibberllin and nipping inhibits the vertical growth as confirmed by Kataria *et al.,* (2017). Therefore, higher seed index was recorded in M_5 (Spraying of 0.035% Paclabutrazole 23 % SC at 55 DAS and 85 DAS + Nipping at 90 DAS).

Higher ginning percentage (33.61),harvest index (0.43), lint index(4.77) recorded in 90 × 60 cm and agronomic management practices treatment, M_5 (Spraying of 0.035% Paclabutrazole 23% SC at 55 DAS and 85 DAS + Nipping at 90 DAS) which recorded higher ginning percentage (33.48), harvest index (0.44)lint index (4.63).The quality characters like ginning percentage, lint index are controlled by genes and were not significantly influenced by different spacing, agronomic management practices and their interaction. These results were conformity with work of the Pradeep Kumar *et al.,* (2017). Lint index is a measure of seed index and ginning percentage, so increase in seed index and ginning percentage lead to increase lint index. These results were conformity with Narayana *et al.,* (2008). Harvest index is a measure of economical yield, so increase in harvest index was due to increase in economic yield (Table 2).

The spacing 90 cm × 60 cm produced significantly higher gross returns (Rs. 1,45,416 ha^{-1}), net returns (Rs. 86,379 ha^{-1}), benefit cost ratio (2.46) and also M_5 (Spraying of 0.035% Paclabutrazole 23% SC at 55 DAS and 85 DAS + Nipping at 90 DAS) recorded significantly higher gross returns (Rs. 1,50.552 ha^{-1}), net returns (Rs. 90,398 ha^{-1}), benefit cost ratio (2.50) (Table 3). These results were close conformity with findings of Brar *et al.,* (2000), and Siddu malkannavar *et al.,* (2018).There was significant difference in economic analysis of *Bt*cotton due to the of different spacings. Among spacings, 90 cm × 60 cm produced significantly higher net returns (Rs. 86,379 ha^{-1}) compared to 120 × 60 cm (Rs. 67,642 ha^{-1}). It was revealed that closer spacing obtained higher gross returns (Rs. 1,5,416 4ha^{-1}) and benefit: cost ratio (2.46) and found to better than the wider spacing. 120 x 60 cm (Rs.1.26,280 ha^{-1} and 2.15). These results close conformity with findings of Srinivasulu *et al.,* (2006), Vishwanath (2007), Reddy and Gopinath (2008), Shwetha *et al.,* (2009) and Paslawar *et al.,* (2015).

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