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Effect of Macronutrient and Morphoframe Manipulation on Growth, Yield and Economics of *Bt* Cotton (*Gossypium hirsutum* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Improving the cotton yield with best nutrient levels and effective modification of morphology by optimize the growth.
Study Design: Factorial randomized complete block design.
Place and Duration of Study: Agricultural College Farm, Raichur, (Karnataka, India) and *Kharif* 2016.
Methodology: The experiment was laid out in factorial RCBD with 18 treatments replicated thrice. The studies included three recommended dose of fertilizer (RDF) (F_1: 75% RDF, F_2: 100% RDF (180:90:90 kg NPK ha^{-1}), F_3: 125% RDF) and six morphoframe manipulation practices (B_1: Control, B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS, B_3: Nipping during 85-95 DAS, B_4: Boron @ 0.1% at 70 and 90 DAS, B_5: Nipping with Boron @ 0.1% at 70 and 90 DAS, B_6: Boron @ 0.1% along with Mepiquat chloride @ 100 ppm at 70 and 90 DAS).

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Results: The result of this experiment revealed that there was significant difference in growth, yield contributing characters with respect to macronutrient levels and morphoframe manipulations. Application of 125 per cent RDF recorded significantly higher seed cotton yield (3420 kg ha^{-1}) when compared to 100 per cent RDF (3088 kg ha^{-1}) and 75 per cent RDF (2517 kg ha^{-1}). Foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS recorded significantly higher seed cotton yield (3318 kg ha^{-1}) and it was at par with foliar spray of boron @ 0.1% with nipping during 85-95 DAS (3274 kg ha^{-1}) over the control (2705 kg ha^{-1}).

Keywords: Recommended dose of fertilizer; mepiquat chloride; boron; nipping.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is considered as an important fibre crop of India and Karnataka. It is the backbone of textile industries mainly because of its lint. India contributes 85 per cent of raw material to textile industry and it earns about 33 per cent of total foreign exchange. In India, cotton has an area of 11.88 m ha with a production of 35.2 m bales and productivity of 503 kg lint ha^{-1} during 2015-16 as against an area of 5.88 m ha with a production of 3.04 m bales and productivity of 88 kg ha^{-1} in 1950-51. In Karnataka, cotton occupies an area of 6.12 lakh ha with a production of 18.9 lakh bales and with productivity of 556 kg lint ha^{-1} [1]. The Northern dry zone of the state (Zone 2 and 3) covers partly the Tungabhadra and Upper Krishna Command areas (TBP & UKP). In these regions, *Bt* cotton is intensively cultivated on black soil under irrigation. The area under this crop in these command areas has been increasing steadily over the past half decade and occupying more than 1.5 lakh ha during 2009-10. The average seed cotton yield is around 20 q ha^{-1} which is far less than actual potential yield.

The maximum yield potential of cotton is yet to be trapped under irrigated condition, but low production of cotton yield is due to monocropping practice, decline in soil fertility status and improper morphoframe. Balanced fertilization is one of the major key factors affecting cotton yield. Earlier cotton species (desi) were determinate in growth but present days growth habits of cotton varieties are indeterminate crop which respond well to the increased fertilizer and require nutrients up to boll opening stage. Therefore, need for research to develop technologies to maximize yield levels of cotton by reducing excessive vegetative growth with morphoframe manipulation and balanced fertilization. So, experiment was conducted to know the effect of macronutrients and manipulation of morphoframe on growth and yield of *Bt* cotton (*Gossypium hirsutum* L.).

2. MATERIALS AND METHODS

A field experiment was conducted during the *Kharif* 2016 at Agricultural College farm, Raichur, situated on the latitude of 16°12^{1} N latitude, 77°20^{1} E longitude with an elevation of 389 meters above mean sea level and is located in North Eastern Dry Zone of Karnataka. The experiment was laid out in factorial RCBD with 18 treatments replicated thrice. The studies included three recommended dose of fertilizer (RDF) (F_1: 75% RDF, F_2: 100% RDF (180:90:90 kg NPK ha^{-1}), F_3: 125% RDF) and six morphoframe manipulation practices (B_1: Control, B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS, B_3: Nipping during 85-95 DAS, B_4: Boron @ 0.1% at 70 and 90 DAS, B_5: Nipping with Boron @ 0.1% at 70 and 90 DAS, B_6: Boron @ 0.1% along with Mepiquat chloride @ 100 ppm at 70 and 90 DAS). BG-II (7213-2) variety was selected for study. Half the dose of nitrogen and potassium, entire dose of phosphorous in the form of urea, muriate of potash (MOP) and diammonium phosphate (DAP), respectively were band placed as per the treatments. Fertilizers were applied 4-5 cm deep and 5 cm away from the plant at 30 days after sowing. Remaining half dose of nitrogen and potassium in the form of urea and MOP was top dressed in two equal splits at 60 and 90 days after sowing in the ring form 5 cm away from the plant. The soil of the experimental site was deep black and clay in texture with the available nitrogen (204 kg ha^{-1}), phosphorus (34 kg ha^{-1}), potassium (226 kg ha^{-1}) and organic carbon content (0.64%). Sowing was done by dibbling with spacing of 90×60 cm on 11th July, 2016. Seed index is weight of 100 seeds, which were randomly collected and counted after ginning and their weight was recorded in grams. Fisher's method of analysis of variance was applied for analysis and interpretation of the data. The level of significance used in 'F' test was at 5% (P = 0.05). Critical difference values were calculated whenever 'F' was significant.

3. RESULTS AND DISCUSSION

3.1 Effect of Fertilizer Levels

In the present investigation, the yield attributing characters were significantly (Tables 2 and 3) influenced by different levels of fertilizer. Significantly higher values were noticed with 125 per cent RDF (34.06, 38.22 and 4.94 g; number of good opened bolls per plant, total number of bolls per plant, boll weight (g), respectively) compare to 100 per cent RDF (31.11, 35.61 and 4.79 g; number of good opened bolls per plant, total number of bolls per plant, boll weight, respectively) and 75 per cent RDF (24.49, 29.21 and 4.59 g; number of good opened bolls per plant, total number of bolls per plant, boll weight, respectively). Significant increase in boll weight due to higher phosphate content in cotton throughout the boll development stage with higher level of fertilizer [2]. The increase in the yield attributing characters with 125 per cent RDF might be due to significantly higher amount of dry matter production and its accumulation in reproductive parts and leaf area up to the harvest [3] and [4]. Harvest index of cotton differed significantly due to application of RDF. Significantly higher harvest index was recorded with 125 per cent RDF (0.44) when compared to 100 per cent RDF (0.43) and 75 per cent RDF (0.36). This is due to significantly higher economical yield obtained with higher fertilizer application.

3.2 Effect of Morphoframe Manipulation

Morphoframe manipulations showed significant effect on growth and yield attributes and is presented in Tables 1, 2 and 3. Seed cotton yield was significantly higher (3318 kg ha^{-1}) with foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS and it was at par with foliar spray of boron @ 0.1% at 70 and 90 DAS with nipping during 85-95 DAS (3274 kg ha^{-1}). Significantly lower seed cotton yield recorded with control (2705 kg ha^{-1}). Higher seed cotton yield due to mepiquat chloride and boron is due to the fact that mepiquat chloride restricts the vegetative growth of plants and increases the partitioning of assimilates towards fruiting bodies [5]. Boron being a part of enzyme or a catalyst in enzymatic reaction, this helps in development of strong cell wall, increase the pollen growth and pollen germination and has effect on square, boll number, flower and boll shedding [6]. Foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS recorded significantly higher number bolls $plant^{-1}$ (36.33), boll weight (4.95 g), seed cotton yield $plant^{-1}$ (180.70 g) and seed index (9.37 g) and was on par with foliar spray of boron @ 0.1% with nipping during 85-95 DAS (35.76, 4.93 g, 177.77 g and 9.36 g, respectively). Foliar spray of mepiquat chloride recorded significantly lower plant height (95.36 cm) and dry matter production (385.15 g $plant^{-1}$). Mepiquat chloride cause more compact growth in plant by checking the apical dominance by acting as anti-gibberellin. Foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS recorded significantly higher number sympodial branches $plant^{-1}$ (24.97) and dry matter accumulation in reproductive parts (161.33 g $plant^{-1}$) [7].

3.3 Effect of Fertilizer Levels and Morphoframe Manipulation

Interaction effects between fertilizer levels and morphoframe manipulations revealed that, application of 125 per RDF with foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS recorded significantly higher seed cotton yield (3754 kg ha^{-1}) when compared to other treatment combinations and it was at par with 125 per cent RDF with foliar spray of boron @ 0.1% with nipping during 85-95 DAS (3749 kg ha^{-1}). Application of 125 per RDF with foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% at 70 and 90 DAS recorded significantly higher dry matter accumulation in reproductive parts (165.71 g $plant^{-1}$), boll weight (5.19 g), seed cotton yield $plant^{-1}$ (209.83 g) and harvest index (0.47) than all other treatment combinations except 125 per cent RDF with foliar spray of boron @ 0.1% with nipping during 85-95 DAS (Tables 1, 2 and 3).

3.4 Economics

There was significant difference in economic analysis of *Bt*-cotton due to the application of different levels of fertilizer (Table 4). Application of higher levels of fertilizer (125%) recorded significantly higher gross returns (₹1,84,669 ha^{-1}), net returns (₹1,27,341 ha^{-1}) and benefit cost ratio (3.22) when compared to the application of 100 per cent (₹1,66,776 ha^{-1}, ₹1,12,015 $ha^{-1}$and 3.04, respectively) and 75 per cent RDF (₹ 1,35,920 ha^{-1}, ₹ 83,650 ha^{-1} and 2.60, respectively). The decrease in gross returns, net returns and benefit cost ratios were noticed with decreased levels of fertilizer (Table 4).

Table 1. Effect of macronutrients and morphoframe manipulations on growth attributes of *Bt* cotton at final picking

Treatments	Plant height (cm)				Number of sympodial branches (plant^{-1})				Dry matter accumulation in reproductive parts (g plant^{-1})				Total dry matter production (g plant^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
B_1	119.6	123.3	127.1	123.3	20.86	23.07	24.46	22.79	142.13	153.03	157.71	150.95	380.54	398.70	427.27	402.17
B_2	92.01	95.94	98.12	95.36	22.97	24.69	25.89	24.52	150.48	157.33	161.08	156.30	365.02	386.68	403.77	385.15
B_3	93.20	97.31	99.70	96.74	22.50	24.10	25.43	24.01	147.79	157.17	160.64	155.20	363.97	387.87	405.00	385.61
B_4	121.9	125.4	128.4	125.2	22.28	24.33	25.47	24.02	144.76	156.94	159.77	153.82	383.06	401.38	430.08	404.84
B_5	94.71	98.99	101.6	98.44	23.16	25.26	26.23	24.88	157.39	160.05	164.84	160.76	377.68	393.66	425.60	398.98
B_6	93.22	97.04	100.2	96.82	23.10	25.39	26.41	24.97	158.19	160.08	165.71	161.33	375.85	392.74	425.97	398.19
Mean	102.5	106.3	109.1		22.48	24.47	25.65		150.12	157.43	161.63		374.35	393.51	419.61	
	S. Em.±		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**	
F	0.49		1.41		0.35		1.02		0.65		1.87		1.61		4.64	
B	0.69		1.99		0.50		1.44		0.92		2.64		2.28		6.56	
F×B	1.20		NS		0.87		NS		1.59		4.57		3.95		NS	

DAS – Days after sowing;
F_1: 75% RDF
F_2: 100% RDF
F_3: 125% RDF

NS – Non significant
B_1: Control
B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS
B_3: Nipping during 85-95 DAS
B_4: Boron @ 0.1% at 70 and 90 DAS
B_5: Nipping + Boron @ 0.1% at 70 and 90 DAS
B_6: Boron @ 0.1% + Mepiquat chloride @ 100 ppm at 70 and 90 DAS

Table 2. Effect of macronutrients and morphoframe manipulations on yield attributes of *Bt* cotton

Treatments	Good opened bolls plant^{-1}				Bad opened bolls plant^{-1}				Bolls plant^{-1}				Individual boll weight (g)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
B_1	22.00	28.53	31.20	27.24	5.33	4.87	4.40	4.87	27.33	33.40	35.60	32.11	4.46	4.50	4.70	4.55
B_2	24.27	30.83	33.83	29.64	4.70	4.40	4.13	4.41	28.97	35.23	37.97	34.06	4.61	4.79	4.90	4.76
B_3	24.13	30.60	33.63	29.46	4.80	4.53	4.17	4.50	28.93	35.13	37.80	33.96	4.58	4.75	4.87	4.73
B_4	24.00	30.40	33.53	29.31	4.83	4.60	4.20	4.54	28.83	35.00	37.73	33.86	4.57	4.74	4.82	4.71
B_5	26.27	32.87	35.40	31.51	4.33	4.33	4.07	4.24	30.60	37.20	39.47	35.76	4.65	4.98	5.17	4.93
B_6	26.27	33.40	36.73	32.13	4.33	4.27	4.00	4.20	30.60	37.67	40.73	36.33	4.68	5.00	5.19	4.95
Mean	24.49	31.11	34.06		4.72	4.50	4.16		29.21	35.61	38.22		4.59	4.79	4.94	
	S. Em.±		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**	
F	0.35		1.02		0.07		0.19		0.37		1.06		0.02		0.06	
B	0.50		1.44		0.09		0.27		0.52		1.50		0.03		0.08	
F×B	0.87		NS		0.16		NS		0.90		NS		0.05		0.14	

NS – Non significant

F_1: 75% RDF
F_2: 100% RDF
F_3: 125% RDF

B_1: Control
B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS
B_3: Nipping during 85-95 DAS
B_4: Boron @ 0.1% at 70 and 90 DAS
B_5: Nipping + Boron @ 0.1% at 70 and 90 DAS
B_6: Boron @ 0.1% + Mepiquat chloride @ 100 ppm at 70 and 90 DAS

Table 3. Effect of macronutrients and morphoframe manipulations on seed cotton yield and yield attributes of *Bt* cotton

Treatments	Seed cotton yield (g plant^{-1})				Seed cotton yield (kg ha^{-1})				Seed Index (g)				Harvest index			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
B_1	125.57	150.95	169.75	148.76	2337	2689	3088	2705	8.29	8.82	9.32	8.81	0.32	0.38	0.39	0.36
B_2	132.98	164.96	182.54	160.16	2441	3042	3355	2946	8.53	9.05	9.67	9.08	0.36	0.42	0.44	0.41
B_3	130.71	164.67	181.33	158.90	2438	3013	3290	2914	8.82	9.25	9.70	9.26	0.35	0.42	0.44	0.40
B_4	129.78	163.79	179.25	157.61	2420	2978	3283	2894	8.45	8.98	9.49	8.98	0.33	0.40	0.41	0.38
B_5	145.10	185.57	202.64	177.77	2707	3367	3749	3274	8.89	9.34	9.87	9.36	0.39	0.46	0.47	0.44
B_6	145.22	187.05	209.83	180.70	2759	3442	3754	3318	8.94	9.36	9.78	9.37	0.40	0.47	0.47	0.45
Mean	134.89	169.50	187.56		2517	3088	3420		8.65	9.13	9.64		0.36	0.43	0.44	
	S. Em.±		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**	
F	1.11		3.20		18		52		0.09		0.25		0.003		0.01	
B	1.57		4.52		25		73		0.12		0.35		0.005		0.01	
F×B	2.73		7.83		44		127		0.21		NS		0.008		0.02	

NS – Non significant

F_1: 75% RDF
F_2: 100% RDF
F_3: 125% RDF

B_1: Control
B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS
B_3: Nipping during 85-95 DAS
B_4: Boron @ 0.1% at 70 and 90 DAS
B_5: Nipping + Boron @ 0.1% at 70 and 90 DAS
B_6: Boron @ 0.1% + Mepiquat chloride @ 100 ppm at 70 and 90 DAS

Table 4. Effect of macronutrients and morphoframe manipulations on economics of *bt* cotton

Treatments	Cost of cultivation (Rs./ha)				Gross returns (Rs./ha)				Net returns (Rs./ha)				BC ratio			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
B_1	51852	54343	56910	54368	126193	145208	166762	146054	74341	90865	109852	91686	2.43	2.67	2.93	2.68
B_2	52088	54579	57146	54604	131817	164245	181147	159069	79729	109666	124001	104465	2.53	3.01	3.17	2.90
B_3	52152	54643	57210	54668	131648	162717	177645	157337	79496	108074	120435	102669	2.52	2.98	3.11	2.87
B_4	52332	54823	57390	54848	130707	160805	177293	156268	78375	105982	119903	101420	2.50	2.93	3.09	2.84
B_5	52632	55123	57690	55148	146169	181822	202435	176809	93537	126699	144745	121661	2.78	3.30	3.51	3.19
B_6	52568	55059	57626	55084	148989	185863	202735	179195	96421	130804	145109	124111	2.83	3.38	3.52	3.24
Mean	52271	54762	57329		135920	166776	184669		83650	112015	127341		2.60	3.04	3.22	
	S. Em.±		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**		**S. Em.±**		**C.D. at 5%**	
F	-		-		972		2794		972		2794		0.02		0.05	
B	-		-		1375		3951		1375		3951		0.03		0.07	
F×B	-		-		2381		6844		2381		6844		0.04		NS	

NS – Non significant

F_1: 75% RDF
F_2: 100% RDF
F_3: 125% RDF

B_1: Control
B_2: Mepiquat chloride @ 100 ppm at 70 and 90 DAS
B_3: Nipping during 85-95 DAS
B_4: Boron @ 0.1% at 70 and 90 DAS
B_5: Nipping + Boron @ 0.1% at 70 and 90 DAS
B_6: Boron @ 0.1% + Mepiquat chloride @ 100 ppm at 70 and 90 DAS

The higher gross and net returns were mainly due to higher economic yield associated with higher levels of fertilizer applied treatment. These results were in close conformity with reports of [8] and [9] (Table 4). Among different morphoframe modification, foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% recorded higher gross return, net return and benefit cost ratio (₹1,79,195 ha^{-1}, ₹1,24,111 ha^{-1} and 3.24, respectively) over the control (₹ 1,46,054 ha^{-1}, ₹ 91686 ha^{-1} and 2.68 respectively).

4. CONCLUSION

Based on the results it can be concluded that application of 125 per cent RDF recorded significantly higher seed cotton yield and net returns compared to 100 and 75 per cent RDF. Application of 125 per cent RDF with foliar spray of mepiquat chloride @ 100 ppm along with boron @ 0.1% recorded higher seed cotton yield, net returns and benefit cost ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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