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Research Article

Yield and nutrient status of Bt cotton hybrids under site specific nutrient management (SSNM) approach

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ABSTRACT : A field experiment was carried out at MARS, UAS, Dharwad to study the yield and nutrient status of transgenic cotton hybrids under SSNM approach. The field trial was laid out in RCBD with four Bt cotton hybrids and three target yield levels. Among the transgenic cotton hybrids, MRC-6322 recorded significantly higher seed cotton yield (3286 kg ha^{-1}) and nutrient uptake (N-141.13, P-20.18 and K-174.30 kg ha^{-1}) over MRC-6918 Bt cotton hybrid. Plant height (103.52cm) and number of square (29.72) recorded significantly higher in MRC 6918 Bt cotton. Significantly higher LAI (2.61), number of sympodial branches (20.69) and number of bolls (67.69) per plant recorded in MRC 6322 over MRC-6918 Bt cotton hybrid. Significantly higher available nutrients were recorded with MRC 6918 and in F_3 (N-231.25, P-52.16 and K-352.44 kg ha^{-1}) level targeted for3 t ha^{-1}. Seed cotton yield increased with increase in fertilizer level targeted from 2 to 3 t ha^{-1}. Improvement in seed cotton yield was in the order of 63.90, 15.60 and 7.30 per cent over their respective target yield levels. Significantly higher seed cotton yield was recorded with F_3 level (3219 kg ha^{-1}) over F_1 (2738 kg ha^{-1}) level and at par with F_2 (2891 kg ha^{-1}) level. Growth and yield components increased with increase in fertilizer levels. Significantly higher yield and growth components and nutrient uptake (N-141.75, P-19.23 and K-166.28 kg ha^{-1}) was recorded in 3 t ha^{-1} (F_3) targeted yield level.

KEY WORDS : SSNM, Targeted yield, Bt-cotton, LAI

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INTRODUCTION

Cotton (*Gossypium* spp.) is a natural fibre of vegetable origin, composed of cellulose and often referred as 'white gold' or 'queen of fibres'. It enjoys a predominant position amongst cash crops in India and world as well and makes up 75 per cent of the raw material needs of the Indian textile industry and provides employment to 60 million people. Today, China is the largest producer of cotton (33 million bales), whereas India ranks second in global cotton production (27 million bales). India's cotton production to surpass China by 2015 based on the growth trend in last one decade. To fulfill the projected requirement, the cotton production increment has to come mainly from increased productivity. India has the largest area under cotton cultivation with relatively low productivity. The primary reasons for the low productivity of cotton in India are; cultivation of crops predominantly under rainfed condition, use of less efficient cultivars, predominance of pests on the crop and inadequate supply of nutrients, besides other reasons.

Bt Cotton is a genetically engineered form of natural cotton. The Bollgard-I with a single (Cry 1 Ac) Bt gene, Bollgard-II with two (Cry 1 Ac and Cry 2 Ab) Bt genes. From a low initial uptake in 2002 has spread to over 85 per cent of the area and

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covering an area of 9.4 million hectares in 2010-11 (Jishnu, 2011). Bt cotton hybrids exhibited excellent control of American boll worm and reduced the use of insecticides leading to create eco-friendly environment without compromising on profitable yield. Next to bollworm, the important issue that needs to be addressed in crop production is nutrient usage. Cotton, particularly hybrids being exhaustive, draw plenty of soil nutrients and thus under continuous cropping pattern nutrient management assumes importance.

Soil test give fairly good information about available soil nutrient status and therefore, soil test is the best basis for fertilizer recommendation for a crop for a particular location. Site specific nutrient management (SSNM) is applying those concepts to area within a field that are known to require different management options from the field average and applying nutrient to crop as and when needed. It advocates need based supply of nutrients ensure application of nutrients at right time in deserved quantities by the crop for obtaining targeted yields. Site specific crop and soil management is really a 'repacking' of management concepts. The SSNM avoids indiscriminate use of fertilizer by preventing excess or inadequate nutrient inputs. It also ensures that N, P and K are applied at proper rate and ratio commensurate with crops nutrient needs. Fertilizers are then applied in a timely fashion to overcome the deficit in nutrients between the total demand by crop to achieve a yield target and the supply from indigenous sources. Further, crop has the potential to produce still higher yield levels under improved management situation. Therefore, in the present investigation an effort was made to achieve pre sowing yield targets through site specific nutrient management based on soil nutrient status and crop uptake rates/values.

EXPERIMENTAL METHODS

The field experiment was conducted at Main Agricultural Research Station, UAS, Dharwad on medium deep black soil. Experiment consists of four Bt cotton (MRC-6322, MRC-6918, MRC-7351 and MRC-7201) hybrids and three fertilizer levels for 2, 2.5 and 3 t ha^{-1} targeted yield and it was laid out in a Randomized Complete Block Design (RCBD) with three replications. The different cotton genotypes were dibbled at 90 cm apart with intra row spacing of 60 cm, two seeds per hill dibbled to a depth of 4 cm on flat bed. Gap filling was done 10 days after sowing. Only one plant per spot was retained after thinning. The soil test results of the experiment site reveal that low in nitrogen, medium in phosphorous and high in potassium. The uptake of 4.45, 0.83 and 7.47 kg of N, P_2O_5, K_2O ha^{-1} (Das *et al.,* 1991) of nutrients for 100 kg of seed cotton yield was considered for working out required quantity of nutrients for targeted yields. If the available nutrient status (N, P and K) of the soil is medium, then apply the exactly as removed quantity, if it is low, then apply the 25 per cent more than required quantity and if it is high, then apply the 25 per cent less then required quantity. Fertilizer levels were calculated based on soil nutrient availability, nutrient uptake by cotton plants for one quintal/ kg and target yield levels. By using above procedure/criteria calculated the required quantity of fertilizer for different targeted yield level where as F_1 - 145:39:99 NPK kg ha^{-1} for 2 t ha^{-1}, F_2 - 181:49:124 NPK kg ha^{-1} for 2.5 t ha^{-1} and F_3 - 217:59:148 NPK kg ha^{-1} for 3 t ha^{-1}. Fifty per cent of nitrogen fertilizer and full dose of phosphorus and potassium were applied at the time of sowing and the remaining 50 per cent of N was top dressed 50 days after sowing (DAS). Crop cultivated under rainfed condition with a mean annual total rain fall of 870 mm and 476.5 mm rainfall received during the cropping period in 55 rainy days. Inter-cultivation was done at 30, 45 and 60 DAS.

EXPERIMENTAL RESULTS AND ANALYSIS

Among the transgenic cotton hybrids, MRC-6322 (Bollgard-I) recorded significantly higher seed cotton yield of 3286 kg ha^{-1} with higher LAI, number of sympodial branches

Table 1 : Bolls per plant and seed cotton yield (kg ha^{-1}) of Bt cotton hybrids as influenced by fertilizer levels for targeted yield

Treatments	Bolls per plant				Seed cotton yield (kg ha^{-1})			
Bt Hybrids	Fertilizer for target yield				Fertilizer for target yield			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
MRC-6322	63.27^{ab}	68.53^{a}	71.27^{a}	67.69^{a}	3062^{ab}	3067^{ab}	3730^{a}	3286^{a}
MRC-6918	51.00^{bcd}	49.27^{cd}	60.20^{abc}	53.49^{b}	2472^{b}	2494^{b}	2769^{b}	2578^{b}
MRC-7351	52.13^{bcd}	55.73^{bcd}	54.13^{bcd}	54.00^{b}	2857^{b}	3006^{ab}	3290^{ab}	3051^{a}
MRC-7201	43.67^{d}	55.40^{bcd}	59.67^{abc}	52.91^{b}	2561^{b}	2997^{ab}	3086^{ab}	2881^{ab}
Mean	52.52^{b}	57.23^{ab}	61.32^{a}	-	2738^{b}	2891^{ab}	3219^{a}	-
	S.E.±		LSD(P=0.05)		S.E.±		LSD(P=0.05)	
Hybrid (G)	1.26		2.01		80.23		407.60	
Fertilizer (F)	1.09		5.55		69.48		353.00	
G X F	2.18		11.10		138.96		705.90	

Note : Means with same alphabet do not differ significantly

F_1: 145:39:99 NPK kg ha^{-1} (2 t ha^{-1}) F_2: 181:49:124 NPK kg ha^{-1} (2.5 t ha^{-1}) F_3: 217:59:148 NPK kg ha^{-1} (3 t ha^{-1})

and number of bolls per plant than the other Bollgard cotton hybrids. The improvement of yield in MRC-6322 over MRC-6918 was to the tune of 28 per cent (Table 1). However, the yield difference between MRC-6322 and MRC-7351, and MRC-6322 and MRC-7201 were as much as 440 kg and 644 kg, respectively. These results are in conformity with the findings of Khadi *et al.* (2002) and Mayee *et al.* (2004).

Ability of a cultivar also depends on its ability in making use of the available or provided resources. MRC-6322 also faired better over other Bt hybrids in its ability in making use of soil available nutrients as evidenced from data on uptake of nitrogen, phosphorus and potassium. MRC-6322 recorded higher uptake of N (141kg ha^{-1}), P (20.18 kg ha^{-1}) and K (174 kg ha^{-1}) than other Bt cotton hybrids which helped in obtaining higher plant vigour in turns of total number of branches, productive branches, number of squares etc, coupled with large photosyntheticaly active leaf area reflecting in higher leaf area index. Soil nutrient analysis at final picking also followed plant uptake pattern where in soil under MRC-6322 had the lowest available N, P and K status (Table 4). While significantly higher quantities of these nutrients were observed in MRC-6918 which was less productive in terms of biomass production as well as economic yield. MRC-7351 and MRC-7201 closely followed MRC-6322.

Yield obtained with highest fertilizer level differed significantly from the fertilizer level targeted for average yield (2 t ha^{-1}) and improvement in yield was in the order of 36.9, 15.6 and 7.3 per cent. Dustur and Dabir (1961) reasoned that such an improvement in yield due to higher fertilizer application is due to improvement in yield attributes as a consequence of overall improved growth. Accordingly in the present study more number of bolls per plant was recoded with F_3 level. These results are also in line with reports made by Ganajaxi *et al.* (1996) and Singh *et al*. (2003). Leaf area and leaf area index (Table 2) from grand growth stage to first picking were found to have the highest value with F_3 level while F_1 level recorded significantly lower values for these parameters.

Application of fertilizer for 3 tonne targeted yield recorded significantly higher plant height during advanced stages. The increased plant height (Table 2) could be accounted to the role of nitrogen in cell division and cell elongation which might have occurred intensively with higher fertilizer (F_3) level. Brar *et al.* (2000), Rafa *et al.* (2003), and Ansari and Mahee (2003) also reported increased plant height with increased fertilizer dose in cotton. Besides plant height, numbers of monopodial and sympodial branches with F3 level were also significantly higher. These results are in line with Nayak *et al.* (1997) who reported higher number of sympodial branches with highest level of fertilizer.

Infact, greater vigour and plant productivity in F_3 were the result of higher availability of major nutrients with F_3 level which were made best use by plant with this treatment as

Table 2 : Plant height (cm), leaf area index (LAI), sympodial branches and No. of squares per plant of different Bt cotton hybrids as influenced by fertilizer levels for targeted yields

Treatments	Plant height (cm)				Leaf area index				Sympodial branches				No. of squares plant^{-1} (135 DAS)			
	Fertilizer levels				Fertilizer levels				Fertilizer levels				Fertilizer levels			
Bt Hybrids	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
MRC-6322	87.09^{c}	91.20^{bc}	96.11^{bc}	91.47^{b}	2.36^{gh}	2.56^{cd}	2.90^{a}	2.61^{a}	20.40^{ab}	21.07^{a}	20.60^{ab}	20.69^{a}	24.19^{abcd}	22.60^{cd}	26.20^{abcd}	24.33^{b}
MRC-6918	97.14^{bc}	100.8^{b}	112.61^{a}	103.52^{a}	2.33^{g}	2.44^{efg}	2.62^{bc}	2.46^{c}	19.53^{ab}	19.53^{ab}	21.20^{a}	20.09^{ab}	29.94^{ab}	28.80^{abc}	30.42^{a}	29.72^{a}
MRC-7351	93.73^{bc}	97.55^{bc}	116.57^{a}	102.62^{a}	2.38^{fgh}	2.50^{de}	2.69^{b}	2.52^{b}	19.27^{b}	18.93^{b}	19.70^{b}	19.09^{c}	23.22^{bcd}	27.27^{abcd}	25.43^{abcd}	25.31^{b}
MRC-7201	92.85^{bc}	97.38^{bc}	101.89^{b}	93.37^{b}	2.15^{i}	2.46^{ef}	2.64^{bc}	2.42c	18.93^{b}	19.60^{ab}	20.00^{ab}	19.51^{bc}	20.47^{d}	24.53^{abcd}	25.70^{abcd}	23.57^{b}
Mean	92.70^{b}	96.74^{b}	106.80^{a}	-	2.30^{c}	2.49^{b}	2.70^{a}	-	19.53^{a}	19.78^{a}	20.22^{a}	-	24.45^{a}	26.94^{a}	25.73^{a}	-
		S.E.±	LSD (P=0.05)			S.E.±	LSD (P=0.05)			S.E.±	LSD (P=0.05)			S.Em.±	LSD (P=0.05)	
Hybrid (G)		1.11	5.64			0.01	0.02			0.18	0.89			0.70	3.58	
Fertilizer (F)		0.96	4.89			0.02	0.02			0.16	NS			0.60	NS	
G X F		1.92	9.77			0.02	0.04			0.32	1.53			1.21	6.19	

Note : Means with same alphabet do not differ significantly

F_1: 145:39:99 kg ha^{-1} NPK (2 t ha^{-1}) F_2: 181:49:124 kg ha^{-1} NPK (2.5 t ha^{-1}) F_3: 217:59:148 kg ha^{-1} NPK (3 t ha^{-1})

Table 3 : Nitrogen, phosphorous and potassium uptake (kg ha^{-1}) in Bt cotton hybrids as influenced by fertilizer levels for targeted yields

Treatments	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})			
Bt Hybrids	Fertilizer for target yield				Fertilizer for target yield				Fertilizer for target yield			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
MRC-6322	132.53^{abc}	136.17^{abc}	154.67^{a}	141.13^{a}	18.72^{ab}	18.33^{ab}	23.48^{a}	20.18^{a}	171.13^{ab}	167.34^{ab}	184.42^{a}	174.30^{a}
MRC-6918	118.63^{c}	117.01^{c}	126.50^{bc}	120.71^{b}	14.02^{b}	14.83^{b}	16.35^{b}	15.07^{b}	138.18^{d}	134.69^{d}	149.99^{bcd}	140.96^{c}
MRC-7351	132.78^{abc}	146.04^{ab}	140.16^{abc}	139.66^{a}	17.80^{ab}	20.11^{ab}	18.75^{ab}	18.89^{a}	163.02^{abc}	178.61^{a}	168.73^{ab}	170.12^{a}
MRC-7201	121.42^{bc}	135.36^{abc}	145.67^{ab}	134.32^{a}	15.26^{b}	19.08^{ab}	18.32^{ab}	17.55^{ab}	141.20^{cd}	166.81^{ab}	161.96^{abc}	156.66^{b}
Mean	126.42^{b}	133.64^{ab}	141.75^{a}	-	16.45^{b}	18.09^{ab}	19.23^{a}	-	153.38^{b}	161.86^{ab}	166.28^{a}	-
	S.E.±		LSD(P=0.05)		S.E.±		LSD(P=0.05)		S.E.±		LSD(P=0.05)	
Hybrid (G)	1.45		12.35		0.53		3.05		2.12		11.87	
Fertilizer (F)	1.25		10.70		0.46		2.64		1.83		10.28	
G X F	2.51		21.39		0.93		5.23		3.67		20.86	

Note : Means with same alphabet do not differ significantly

F_1: 145.39.99 kg ha^{-1} NPK (2 t ha^{-1}) F_2: 181.49.124 kg ha^{-1} NPK (2.5 t ha^{-1}) F_3: 217.59.148 kg ha^{-1} NPK (3 t ha^{-1})

Table 4 : Available nitrogen, P_2O_5 and K_2O (kg ha^{-1}) in soil after harvest of the crop as influenced by fertilizer levels for targeted yields

Treatments	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})			
Bt Hybrids	Fertilizer for target yield				Fertilizer for target yield				Fertilizer for target yield			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
MRC-6322	187.81^{f}	209.89^{cd}	212.80^{cd}	203.50^{c}	35.25^{g}	41.82^{ef}	49.18^{cd}	42.08^{c}	306.03^{d}	325.11^{bcd}	330.36^{bc}	320.50^{c}
MRC-6918	245.61^{ab}	254.66^{a}	256.17^{a}	252.21^{a}	47.75^{d}	57.77^{ab}	59.27^{a}	54.93^{a}	369.39^{a}	373.61^{a}	377.32^{a}	373.44^{a}
MRC-7351	195.14^{ef}	209.86^{cd}	216.45^{c}	207.15^{c}	39.33^{fg}	44.68^{de}	47.10^{d}	43.70^{c}	316.22^{cd}	327.43^{bc}	341.47^{b}	328.37^{bc}
MRC-7201	201.97^{de}	207.22^{cde}	239.58^{b}	216.25^{b}	40.40^{df}	47.24^{d}	53.09^{bc}	46.91^{b}	321.76^{bcd}	333.94^{bc}	360.61^{a}	338.77^{b}
Mean	207.63^{c}	220.46^{b}	231.25^{a}	-	40.68^{c}	47.88^{b}	52.16^{a}	-	328.35^{c}	340.02^{b}	352.44^{a}	-
	S.E.±		LSD(P=0.05)		S.E.±		LSD(P=0.05)		S.E.±		LSD(P=0.05)	
Hybrid (G)	2.43		7.37		0.60		2.72		2.23		10.78	
Fertilizer (F)	2.10		6.34		0.52		2.36		2.02		9.34	
G X F	4.21		12.77		1.04		4.72		4.04		18.67	

Note : Means with same alphabet do not differ significantly

F_1: 145:39:99 kg ha^{-1} NPK (2 t ha^{-1}) F_2: 181:49:124 kg ha^{-1} NPK (2.5 t ha^{-1}) F_3: 217:59:148 kg ha^{-1} NPK (3 t ha^{-1})

evidenced from uptake values (Table 3). Greater reduction in soil available nutrient status at last picking over the initial value in F_1 level clearly indicated the inadequacy of nutrients in the soil pool for complete expression of genetic potential of cotton cultivars.

MRC-6322 cotton hybrid recorded 53.1, 22.66, 24.34 per cent, MRC-7351 produced 42.83, 20.25, 9.67 per cent and MRC-7201 recorded 28.06, 19.86, 7.3 per cent higher yield over targeted yield levels of 2, 2.5 and 3 t ha^{-1} for F_1, F_2 and F_3 levels, respectively. Higher seed cotton yield recorded in MRC-6322 at all the levels of NPK application was due to higher number of yield attributing components like sympodial branches and bolls per plant. Patil and Malewar, (1994) reported the application of higher level of fertilizer supported the production of higher number of yield components. Lower seed cotton yield with MRC-6918 could be attributed to less efficient translocation of photosynthates towards fruiting body besides, its poor efficiency in making use of higher (F_3) level of fertilizer.

All the fertilizer levels achieved the pre-sowing yield target in Bt cotton hybrids under rainfed condition. Soil test give fairly good information about available soil nutrient status and therefore, soil test is the best basis for fertilizer recommendation for a crop for a particular location. Overall the SSNM concept performed well in Bt cotton hybrids.

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