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Soil Science

Uptake of NPK, Availability of NPK and Quality Parameters of Bt Cotton (*Gossypium hirsutum* L.) as Influenced by Different Bio-fertilizers and *In-situ* Green Manuring under Irrigation

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Abstract

A field experiment was carried out during *kharif* season of 2009-2010 at the Agriculture College Farm, Raichur, Karnataka (India) to study the response of Bt cotton to different fertilizer levels, bio-fertilizers and *in-situ* green manuring under irrigation. With respect to uptake and availability of NPK, application of sunnhemp *in-situ* green manuring found significantly higher N (128.27 kg ha^{-1} and 206.43 kg ha^{-1}, respectively), P (30.63 kg ha^{-1} and 38.43 kg ha^{-1}, respectively) and K (142.33 kg ha^{-1} and 342.14 kg ha^{-1}, respectively) over no green manuring. Among different fertilizer levels and bio-fertilizers, 150 % recommended dose of fertilizers (RDF) recorded significantly higher uptake and availability of N (132.46 kg ha^{-1} and 212.48 kg ha^{-1}, respectively), P (32.44 kg ha^{-1} and 39.21 kg ha^{-1}, respectively) and K (147.21 kg ha^{-1} and 353.29 kg ha^{-1}, respectively). Significantly higher ginning percentage and lint index were observed with sunnhemp *in-situ* green manuring (35.81 and 4.99, respectively) over no green manuring. Mean fibre length of Bt cotton was not significantly influenced by both use of *in-situ* green manuring and combined use of inorganic nutrients and bio-fertilizers.

Highlights

- Green manure, biofertilizers combinations with inorganics effects on Bt transgenic cotton hybrid were studied.
- Sunnhemp *in-situ* green manuring found significantly higher NPK uptake than no green manuring.
- Interaction effects was non significant for combined use of *in-situ* green manuring and inorganic nutrients and bio-fertilizers

Keywords: Bt cotton, *in-situ* green manuring, Bio-fertilizers, fertilizer levels and irrigation.

Bt cotton was first planted in India in 2002, following its success, the area under this crop and the number of farmers who adopted this technology increased significantly from year to year. The projection made in India for 2020 AD is around 47.5 million bales of lint to meet the anticipated domestic and export requirement. To fulfil this projected requirement, the cotton production has to be increased by 15 % and it has to come mainly from increased productivity. Current stock of cotton in the country is estimated at 54 lakh bales as against 43 lakh bales during the year 2007-08. There is an encouraging response of farmers towards Bt cotton cultivation while replacing traditional varieties and

hybrids at stroke, just to escape bollworm menace and to achieve potential yield. But unfortunately there is no specific blue print regarding agronomic package for Bt cotton which has a tremendous yield potentiality by virtue of its resistance to bollworm on one hand and having an excellent canopy architecture, which supports huge number of bolls on the other. Fertilizer requirement is the most critical inputs as far as cotton cultivation is concerned as it is a long duration crop in black cotton soils under rainfed and irrigated conditions. Production and productivity increases of Bt cotton can be achieved through enhanced soil fertility. Soil fertility can only be sustained if the nutrients removed from soil are replenished by way of additions. By 2020, the projected requirement of cotton would be around 23 million bales. To produce this quantity, anticipated requirement of N, P and K are 1.2, 1.1 and 1.8 million tonnes, respectively (Kairon and Venugopalan, 2000). Supplying the entire quantity of nutrients required through fertilizers may not be possible, because other crops would compete for application, and shortfall in supplies. At present, there is a wide gap between the supply and removal by crops (Tandon and Narayan, 1990). Therefore, an integration of sources has to be done. Nutrient requirement of cotton, for that matter any crop would have to be met through organic sources in combination with mineral fertilizers. This led to the development of Integrated Nutrient Management System (INMS). Hence, a field study was conducted to find out a suitable fertilizer levels for Bt cotton hybrids which are being well accepted by farmers across the country and more so in black cotton soils of TBP and UKP areas in Karnataka.

Materials and Methods

Field experiment was carried out during *kharif* season of 2009-2010 at the Agriculture College Farm, Raichur, Karnataka (India) on deep black soil having 218.00, 35.0 and 345.00 kg ha^{-1} available N, P_2O_5 and K_2O respectively with pH of 8.20 and organic matter content of 0.70 %. There were 18 treatment combinations consisting of three *in-situ* green manures in main plot were as follows: M_1: Control (No green manuring), M_2: Sunnhemp *in-situ* green manuring (Cotton + Sunnhemp in 1:2 row proportion) and M_3: Dhaincha *in-situ* green manuring (Cotton + Dhaincha in 1:2 row proportion). Whereas in subplot six different fertilizer levels and bio-fertilizers are taken for study as follows: S_1: RDF (150:75:75), S_2: 125 % RDF, S_3: 150 % RDF, S_4: RDF + Seed treatment with *Azotobacter* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}, S_5: RDF + Seed treatment with *Azospirillum* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1} and S_6: RDF + Seed treatment with Phosphobacteria @ 600g ha^{-1} followed by soil application @ 2 kg ha^{-1}. The experiment was laid out in Split plot design and the treatments were replicated thrice. The crop was sown on 19th August 2009 with a plot size of 7.2 m × 6.0 m. All the growth, yield parameters, seed cotton yield, soil nutrient parameters and quality parameters were recorded and statistically analyzed.

Results and Discussion

Uptake and Availability of NPK: NPK uptake and availability were significantly higher with sunnhemp and dhaincha *in-situ* green manuring over no manuring practice (Table. 1 and 2 and Fig. 1 and 2). This increased uptake may be attributed to the increased availability of nutrients in soil. Increased nutrient uptake with green manure treatments inturn resulted in higher dry matter production. Similar results were reported by Badole and More (2000), Katkar *et. al.* (2002) and also by Amit Kumar *et. al.* (2013) who reported higher NPK uptake by cotton with sunnhemp and dhaincha with green leaf and green manuring practices. Among main plot treatments sunnhemp *in-situ* green manuring recorded significantly higher uptake and availability of N (128.27 kg ha^{-1} and 206.43 kg ha^{-1}, respectively), P (30.63 kg ha^{-1} and 38.43 kg ha^{-1}, respectively) and K (142.33 kg ha^{-1} and 342.14 kg ha^{-1}, respectively) as compared to no green manuring N (115.26 kg ha^{-1} and 193.50 kg ha^{-1}, respectively), P (24.45 kg ha^{-1} and 32.05 kg ha^{-1}, respectively) and K (134.62 kg ha^{-1} and 326.82 kg ha^{-1}, respectively). Sunnhemp *in-situ* green manuring was on par with dhaincha *in-situ* green manuring with respect to uptake and availability of N (125.98 kg ha^{-1} and 205.82 kg ha^{-1}, respectively), P (30.60 kg ha^{-1} and 38.03 kg ha^{-1}, respectively) and K (141.97 kg ha^{-1} and 342.12 kg ha^{-1}, respectively). In the present investigation, green manuring with sunnhemp and dhaincha increased the N, P and K availability. This might be due to direct addition of nutrients through organics to the available pool of soil and greater multiplication of soil microbes for the conversion of organically bound form to inorganic form particularly for nitrogen. Further, in calcareous soils added organic material through green manures might have formed a protective cover on sesqueoxide, thus resulting in reduction of phosphate fixation and increase in phosphorus availability (Bellakki and Badanur, 1994). These results are in agreement with the findings of Tarahalkar *et. al.* (1997), Basavanagouda (1998) and Katkar *et. al.* (2002). Among sub-plot treatments, 150 % RDF found significantly higher with uptake and availability of N (132.46 kg ha^{-1} and 212.48 kg ha^{-1}, respectively), P (32.44 kg ha^{-1} and 39.21 kg ha^{-1},

respectively) and K (147.21 kg ha^{-1} and 353.29 kg ha^{-1}, respectively) compared to rest of the treatments. This increase in uptake of nutrients may be attributed to higher total dry matter production. These results are in accordance with the findings of Hulihalli (2003), Amutha *et. al.*, (2009a and 2009b) **;**Kasturikasen Beura and Rakshit (2011), Hosmath, 2011; Blaise (2013) and Lu *et. al.*, (2013).

Table 1: Uptake of nutrients (kg ha^{-1}) by Bt cotton as influenced by nutrient management practices

Treatments	Nitrogen uptake	Phosphorus uptake	Potassium uptake
Main plot			
M_1	115.26	24.45	134.62
M_2	128.27	30.63	142.33
M_3	125.98	30.60	141.97
S. Em.±	1.48	0.45	1.64
C.D. at 5%	5.8	1.79	6.4
Sub plot			
S_1	113.50	23.73	131.31
S_2	121.80	28.21	139.73
S_3	132.46	32.44	147.21
S_4	124.04	28.36	139.80
S_5	123.39	29.18	140.20
S_6	123.82	29.46	139.59
S. Em.±	2.5	0.73	2.20
C.D. at 5%	7.4	2.11	6.3
Interactions			
MXS			
S. Em.±	4.4	1.26	3.8
C.D. at 5%	NS	NS	NS
SXM			
S. Em.±	4.3	1.24	3.8
C.D. at 5%	NS	NS	NS

DAS - Days after sowing NS - Non significant

Main plot treatments	Sub plot treatments
M_1: Control (No green manuring)	S_1: RDF (150:75:75)
M_2: Sunnhemp *in-situ* green manuring (Cotton + Sunnhemp in 1:2 row proportion)	S_2: 125% RDF
M_3: Dhaincha *in-situ* green manuring (Cotton + Dhaincha in 1:2 row proportion)	S_3: 150% RDF
	S_4: RDF + Seed treatment with *Azotobacter* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	S_5: RDF + Seed treatment with *Azospirillum* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	S_6: RDF + Seed treatment with Phosphobacteria @ 600 g ha^{-} followed by soil application @ 2 kg ha^{-1}

Table 2: Available nutrients (kg ha^{-1}) in the soil at harvest as influenced by nutrient management practices

Treatments	Available Nitrogen	Available Phosphorus	Available Potassium
Main plot			
M_1	193.50	32.05	326.82
M_2	206.43	38.43	342.14
M_3	205.82	38.03	342.12
S. Em.±	2.72	0.73	3.13
C.D. at 5%	10.6	2.87	12.2
Sub plot			
S_1	192.87	32.21	316.44
S_2	201.46	36.28	337.90
S_3	212.48	39.21	353.29
S_4	201.63	35.93	337.98
S_5	201.79	36.52	337.81
S_6	201.28	36.86	338.72
S. Em.±	2.80	0.76	4.2
C.D. at 5%	8.1	2.19	12.3
Interactions			
MXS			
S. Em.±	4.8	1.31	7.3
C.D. at 5%	NS	NS	NS
SXM			
S. Em.±	5.2	1.40	7.4
C.D. at 5%	NS	NS	NS

DAS - Days after sowing NS - Non significant

Main plot treatments	Sub plot treatments
M_1: Control (No green manuring)	S_1: RDF (150:75:75)
M_2: Sunnhemp *in-situ* green manuring (Cotton Sunnhemp in 1:2 row proportion)	S_2: 125% RDF
M_3: Dhaincha *in-situ* green manuring (Cotton + Dhaincha in 1:2 row proportion)	S_3: 150% RDF
	S_4: RDF + Seed treatment with *Azotobacter* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	S_5: RDF + Seed treatment with *Azospirillum* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	S_6: RDF + Seed treatment with Phosphobacteria @ 600 g ha^{1} followed by soil application @ 2 kg ha^{-1}

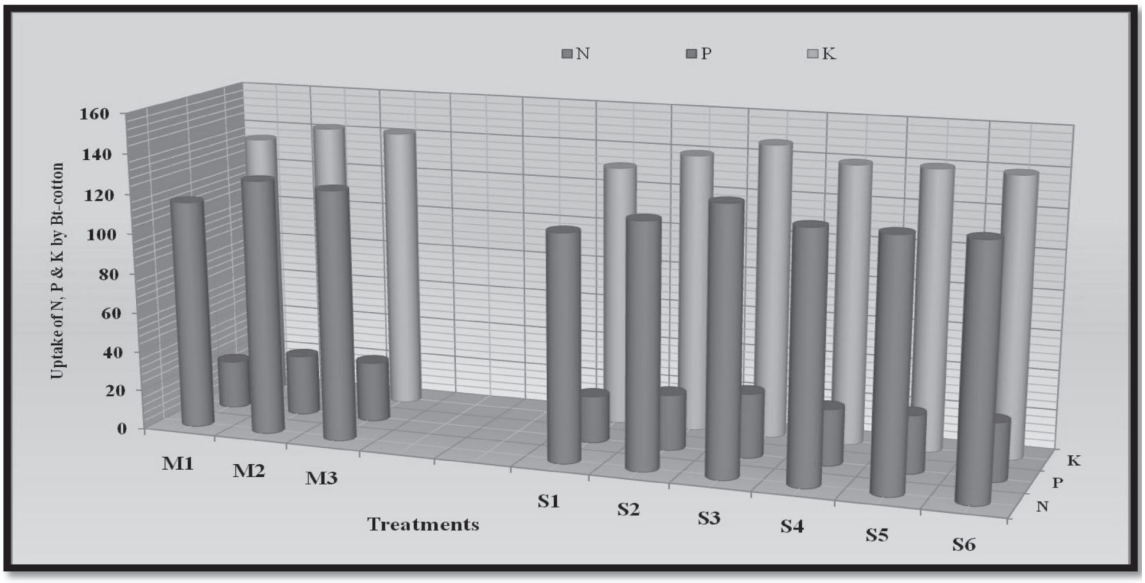

Fig. 1: Uptake of NPK (kg ha^{-1}) by Bt cotton as influenced by nutrient management practices

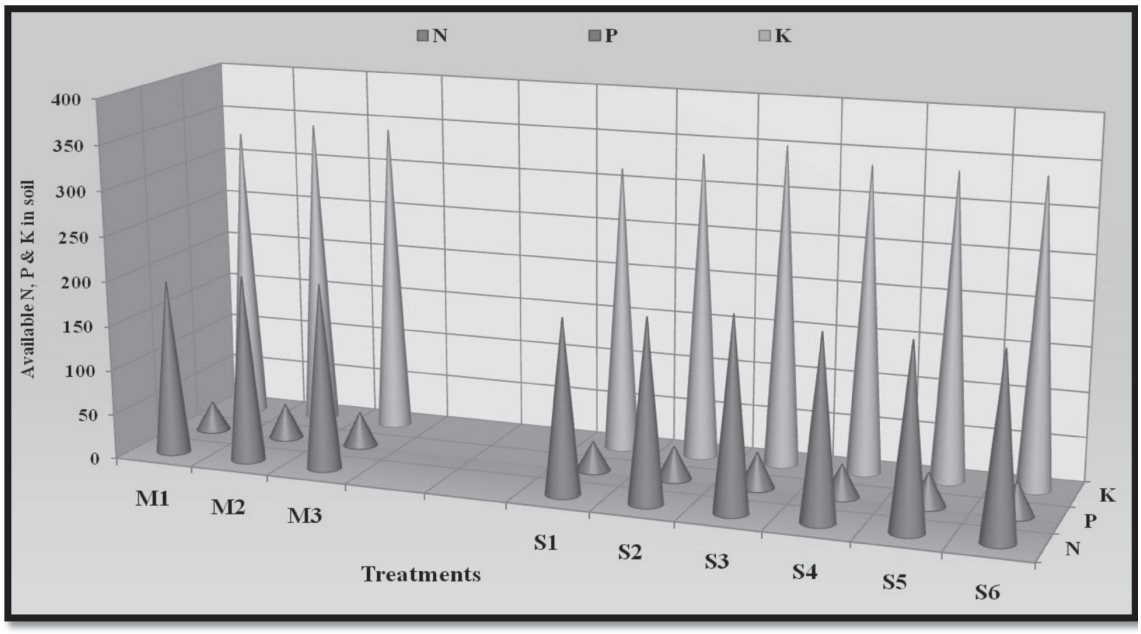

Fig. 2: Availability of NPK (kg ha^{-1}) to Bt cotton as influenced by nutrient management practices

Quality parameters: Ginning percentage and lint index were significantly affected by both main plot treatments as well as sub-plot treatments. However, interaction effect was found to be non-significant (Table. 3). Among main plot treatments, sunnhemp *in-situ* green manuring (35.81) recorded significantly higher ginning percentage compared to no green manuring (33.19) and was on par with dhaincha *in-situ* green manuring (35.66). Among sub-plot treatments, significantly higher ginning percentage was recorded in 150 % RDF (37.16) which was on par with RDF + seed treatment with *Azospirillum* @ 600 g per ha followed by soil application @ 2 kg per ha (35.28), and RDF + seed treatment with *Azotobacter* @ 600 g per ha followed by soil application @ 2 kg per ha (34.78). There was no significant difference among RDF + seed treatment with *Azospirillum* @ 600 g per ha followed by soil application

@ 2 kg per ha (35.28), RDF + seed treatment with *Azotobacter* @ 600 g per ha followed by soil application @ 2 kg per ha (34.78), RDF + seed treatment with Phosphobacteria @ 600 g per ha followed by soil application @ 2 kg per ha (34.73) and 125 % RDF (34.58). Further RDF + seed treatment with *Azotobacter* @ 600 g per ha followed by soil application @ 2 kg per ha (34.78), RDF + seed treatment with Phosphobacteria @ 600 g per ha followed by soil application @ 2 kg per ha (34.73), 125 % RDF (34.58) and 100 % RDF (32.77) were found to be on par with each other. With respect to lint index, sunnhemp *in-situ* green manuring (4.99) recorded significantly higher lint index compared to no green manuring (4.27) and was on par with dhaincha *in-situ* green manuring (4.68). Further dhaincha *in-situ* green manuring (4.68) was on par with no green manuring (4.27). Among sub-plot treatments, significantly higher lint index was recorded in 150 % RDF (5.66) which was followed by 125 % RDF (4.66). 125 % RDF (4.66) was on par with RDF + seed treatment with *Azospirillum* @ 600 g per ha followed by soil application @ 2 kg per ha (4.57), RDF + seed treatment with Phosphobacteria @ 600 g per ha followed by soil application @ 2 kg per ha (4.52) and RDF + seed treatment with *Azotobacter* @ 600 g per ha followed by soil application @ 2 kg per ha (4.41). Further, there was no significant difference among RDF + seed treatment with *Azospirillum* @ 600 g per ha followed by soil application @ 2 kg per ha (4.57), RDF + seed treatment with Phosphobacteria @ 600 g per ha followed by soil application @ 2 kg per ha (4.52), RDF + seed treatment with *Azotobacter* @ 600 g per ha followed by soil application @ 2 kg per ha (4.41) and 100 % RDF (4.05). whereas, Mean fibre length of Bt cotton was not significantly influenced by both use of *in-situ* green manuring and combined use of inorganic nutrients and bio-fertilizers as well as their interaction effect. These results are in accordance with the findings of Bauer *et. al.* (1993), Biradar (2000), Hongal (2001) Ram prakash *et. al.* (2001), Ratnakumari and Subbaravamma, (2006), Srinivasulu *et. al,.* (2006) Srinivasulu and Hema (2007).

Table 3: Ginning percentage, Lint index and mean fibre length (mm) of Bt cotton as influenced by nutrient management practices

Treatments	Ginning percentage	Lint index	Mean fibre length (mm)
Main plot			
M_1	33.19	4.27	32.86
M_2	35.81	4.99	32.82
M_3	35.66	4.68	32.51
S. Em.±	0.80	0.17	0.40
C.D. at 5%	2.4	0.51	NS
Sub plot			
S_1	32.77	4.05	32.38
S_2	34.58	4.66	32.99
S_3	37.16	5.66	32.81
S_4	34.78	4.41	32.82
S_5	35.28	4.57	32.52
S_6	34.73	4.52	32.87
S. Em.±	0.83	0.20	0.31
C.D. at 5%	2.40	0.58	NS
Interactions			
MXS			
S. Em.±	1.44	0.35	0.55
C.D. at 5%	NS	NS	NS
SXM			
S. Em.±	1.54	0.36	0.64
C.D. at 5%	NS	NS	NS

DAS - Days after sowing NS - Non significant

Main plot treatments	Sub plot treatments
M_1: Control (No green manuring)	S_1: RDF (150:75:75)
M_2: Sunnhemp *in-situ* green manuring (Cotton + Sunnhemp in 1:2 row proportion)	S_2: 125% RDF
M_3: Dhaincha *in-situ* green manuring (Cotton + Dhaincha in 1:2 row proportion)	S_3: 150% RDF
	RDF + Seed treatment with *Azotobacter* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	RDF + Seed treatment with *Azospirillum* @ 600 g ha^{-1} followed by soil application @ 2 kg ha^{-1}
	RDF + Seed treatment with Phosphobacteria @ 600 g ha^{1} followed by soil application @ 2 kg ha^{-1}

Interaction effects between *in-situ* green manuring, combined use of inorganic nutrients and bio-fertilizers was not found to differ significantly for Uptake and availability of NPK and quality of Bt cotton.

Conclusion

Ginning percentage, lint index and mean fibre length were affected by use of green manuring and combined use of inorganic nutrients with bio-fertilizers. Significantly higher values were recorded in *in-situ* green manuring than no green manuring. Among sub plot treatments, application of 150 % RDF recorded significantly higher values than rest of the treatments. Similar results were obtained in Nitrogen, Phosphorus and potassium uptake at harvest (kg ha^{-1}) and its availability in soil; and also it holds good for the economics of cotton.

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