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Influence of different nutrient management approaches on growth and yield of *Bt c*otton in a vertisol

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Abstract
The field experiment of *Bt* cotton to evaluate different nutrient management practices was conducted on Vertisol during *kharif* 2016. The experiment was laid out in RBD design and replicated three times. The experiment consisted of eight treatments involving STCR, modified STCR and STL approaches, blanket recommendation and control.
The soil of the experimental site was alkaline in reaction, non saline and low in available nitrogen and high in available phosphorus and potassium.
Growth attributes (plant height, number of monopodial and sympodial branches and dry matter production) and yield attributes, namely, number of bolls per plant (48.0), boll weight (4.83 g boll^{-1}), seed cotton yield per plant (189.4 g) and seed cotton yield per hectare (36.2 q ha^{-1}) were higher with 100 per cent application of nutrients through STCR equation to attain target yield of 40 q ha^{-1} compared to STL approach and blanket recommendation and the former was on par with those recorded under modified STCR approach (application of 50% P, full dose of N and K of STCR equation).
Among different nutrient management approaches to achieve maximum productivity 100 per cent application of nutrients based on STCR approach was the best. Next best approach was application of 50% of P that prescribed for STCR approach and full dose of N and K. Thirdly, soil test based NPK±25% is better compared to blanket recommendation and STL-NPK based on (L, M and H).

Keywords: Nutrient management practices, *Bt c*otton, vertisol

Introduction
Cotton (*Gossypium* spp.) is an important commercial fiber crop grown under diverse agro-climatic conditions and is called as 'white gold' and also as 'king of fiber' crops contributing 85 per cent of raw materials to textile industry. Among the cotton growing states, Karnataka ranks fifth in area with 5.94 lakh ha^{-1} and fourth in production with 20.90 lakh bales of lint and fifth in productivity with an average lint productivity of 630 kg ha^{-1} (Anon., 2014) [1]. *Bt* cotton is intensively cultivated in the North Eastern Dry Zone and Northern Dry Zone of the state (Zone 2 and 3) covering partly the Tungabhadra and Upper Krishna irrigation Commands (TBP and UKP) on black soil. The area under this crop in these commands has been increasing over the past half decade.
Supply of nutrients is the major limiting factor in cotton production and most of soil in rainfed areas is not only thirsty but also hungry. It is well established fact that sufficient quantities of nutrients at proper time are needed for achieving high 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) [2].
The effective fertilizer recommendation should consider crop needs and nutrients already available in the soil. Among different methods and approaches for predicting the fertilizer requirements of crop, the fertilizer recommendation based on targeted yield (Ramamoorthy *et al.*, 1967) [10] is unique one, which provides the balanced nutrition to crop and helps to maintain soil fertility condition.
Moreover, soils of these regions contained medium to high level of available phosphorus in soil.

The phosphorus nutrition of crop is generally done through DAP fertilizer which is indeed a costly input. Further, study conducted in different parts of country recommended the omission of phosphatic fertilizer for one season so as to attain better P use efficiency from the applied phosphatic fertilizers. Keeping all these points in view, different nutrient management practices involving soil test based (STL) and soil test crop response (STCR) based nutrient recommendation approaches have been tested on Bt cotton to develop a balanced fertilizer schedule to increase the productivity and fertilizer use efficiency in *Bt* cotton.

Materials and Methods

A field experiment was carried out during *kharif* 2016, at KVK Farm, University of Agriculture Sciences, Raichur to study the "Influence of different nutrient management practices on growth and yield of *Bt* cotton" on medium deep black soil. The soil of the experimental site belongs to Vertisol and clay in texture. The soils were alkaline in reaction, non saline, low in available N (240.0 kg/ha), high in available phosphorus and potassium (61.6 & 429.5 kg/ha). The experiment was laid out in a Randomized Block Design (RBD) and treatments were replicated thrice. Treatment details of experiment are: T_1: Absolute control;T_2: RDF (150:75:75, N: P_2O_5: K_2O kg ha^{-1});T_3: Soil Test Based (STL) NPK (L, M and H);T_4: Soil test based (STL) NPK ± 25%;T_5: Soil test based NK± 50% & ±25% P;T_6: STL-NK±25% & ±50% STL-P;T_7: STCR-NPK for targeted yield of 40 q ha^{-1};T_8: STCR-NK & 50% STCR-P.

STCR equation for calculating the fertilizer nutrient requirement

FN: 11.33 T- 0.59 SN; FP_2O_5: 6.45 T- 4.4 SP; FK_2O: 4.71 – 0.41 SK

FN = Fertilizer nitrogen; FP_2O_5 = Fertilizer phosphorus; FK_2O = Fertilizer K

T = Target yield; SN = Soil available N; SP = Soil available P; SK = Soil available K

Fertilizers (NPK) were applied as per the treatment details. Half of the nitrogen and potassium and entire dose of phosphorus was applied in the form of diammonium phosphate (DAP), urea and muriate of potash (MOP) as per the treatments. Soil application of $MgSO_4$ @ 25 kg ha^{-1} and foliar spray of $MgSO_4$ and 19:19:19 @ 1 per cent at 60 and 90 DAS is common for Treatment T_2 to T_8. Recommended cultural practises for cotton were carried out as per Package of Practises developed by UAS, Raichur. Growth and yield attributes were recorded, analysed statistically and interpreted.

Results and Discussion

Seed cotton Yield

The seed cotton yield (q ha^{-1}) differed significantly due to application of nutrients through different approaches (Table 1 and Fig. 1). The higher seed cotton yield per plant (189.4 g $plant^{-1}$) and seed cotton yield per hectare (36.2 q ha^{-1}) was recorded with application of major nutrients based on STCR equation for the targeted yield 40 q ha^{-1} (T7) and was superior to all other treatments except treatment T_8: STCR-NK and 50% STCR-P (185.0 g $plant^{-1}$ & 34.1 q ha^{-1}). Among the STL treatment combinations, higher seed cotton yield was registered in treatment T_4: STL-NPK ± 25% (28.7 q ha^{-1}) and lower in STL-NPK (low, medium and high category) (27.7 q ha^{-1}). The seed cotton yield (25.5 q ha^{-1}) registered with application of RDF @ 150:75:75 kg ha^{-1} was low compared to STL and STCR treatments. Higher seed cotton yield recorded with STCR equation and soil test level (STL) fertilizer recommendation is because, application of fertilizers based on general recommendation may be in- sufficient to meet nutrient demand by the crop to obtain sustained yield levels. The higher yield realized in treatment consisting of STCR and STL was due to balanced supply of nutrients, efficient utilization of applied NPK fertilizer nutrients and the synergistic effect of addition of various sources of nutrients. Application of fertilizer doses based on soil test values probably helped in providing balanced nutrition to the crop which further helped in building up of higher dry matter accumulation, through higher bio-chemical process and higher photosynthetic rate and higher leaf area with subsequent better translocation of photosynthates from source to sink for improving all the growth and yield components and inturn to put forth higher yield. A similar variation in yield components of *Bt* cotton was also reported by the Gudadhe *et al.* (2011) [6] who obtained maximum seed cotton yield, stalk yield and biological yield with the application of fertilizer dose according to soil test crop response approach. Praveena Katharine *et al*. (2014) [9] reported STCR treatments greatly influenced the growth and yield attributes of the crop and recorded significantly higher yield under STCR-IPNS for targeted yield of 4 t ha^{-1} of cotton and proved superior over blanket, farmer's practice and control.

Number of bolls per plant and boll weight

Number of bolls per plant (Table 2), among the fertilizer applied treatments, the number of bolls per plant recorded at 75, 115 DAS and at harvest, respectively, was the highest (7.1, 30.7 and 48.0) with treatment T_7: STCR-NPK for target yield of 40 q ha^{-1} and the lowest being 4.2, 16.8 and 35.1 with application of RDF (treatment T_2). The per cent increase in the number of bolls per plant at corresponding intervals with T_7 treatment over T_2 treatment was 2.9, 13.8 and 13.0 per cent, respectively. The increase in number of bolls per plant was due to adequate supply of nutrients (particularly of major nutrients) at critical growth stages of crop and improved supply of nutrients. The results are in consonance with the findings of Praveena Katharine *et al*. (2014) [9] who opined that, STCR equations for targeted yield was superior over blanket, farmer's practice and control which might be due to application of right quantity of nutrients to meet the crop requirement. The reasons for higher bolls per plant of these hybrids were due to higher dry matter accumulation, higher bio-chemical process and higher photosynthetic rate with higher translocation of photosynthates from source to sink.

The highest mean boll weight in treatment (T_7) receiving nutrients according to STCR equation was 5.02, 4.93 and 4.83 g $boll^{-1}$ and in treatment receiving nutrients based on STL-NPK± 25% (T_4: 4.33, 4.28 and 4.19 g $boll^{-1}$) at 75, 115 DAS and at harvest, respectively. The mean boll weight recorded in treatment T_2 (application of RDF) and T_1 (un-fertilized control) at 75, 115 DAS and at harvest, was 4.37, 4.32 and 4.23 g $boll^{-1}$ as well as 3.87, 3.82 and 3.71 g $boll^{-1}$, respectively. These results are in line with report of Praveena Katharine *et al*. (2014) [9] who stated that, fertilizer recommendation based on STCR equation for achieving targeted yield was superior over blanket, farmer's practice and control, which might be due to application of right amount of nutrients to meet the crop requirement.

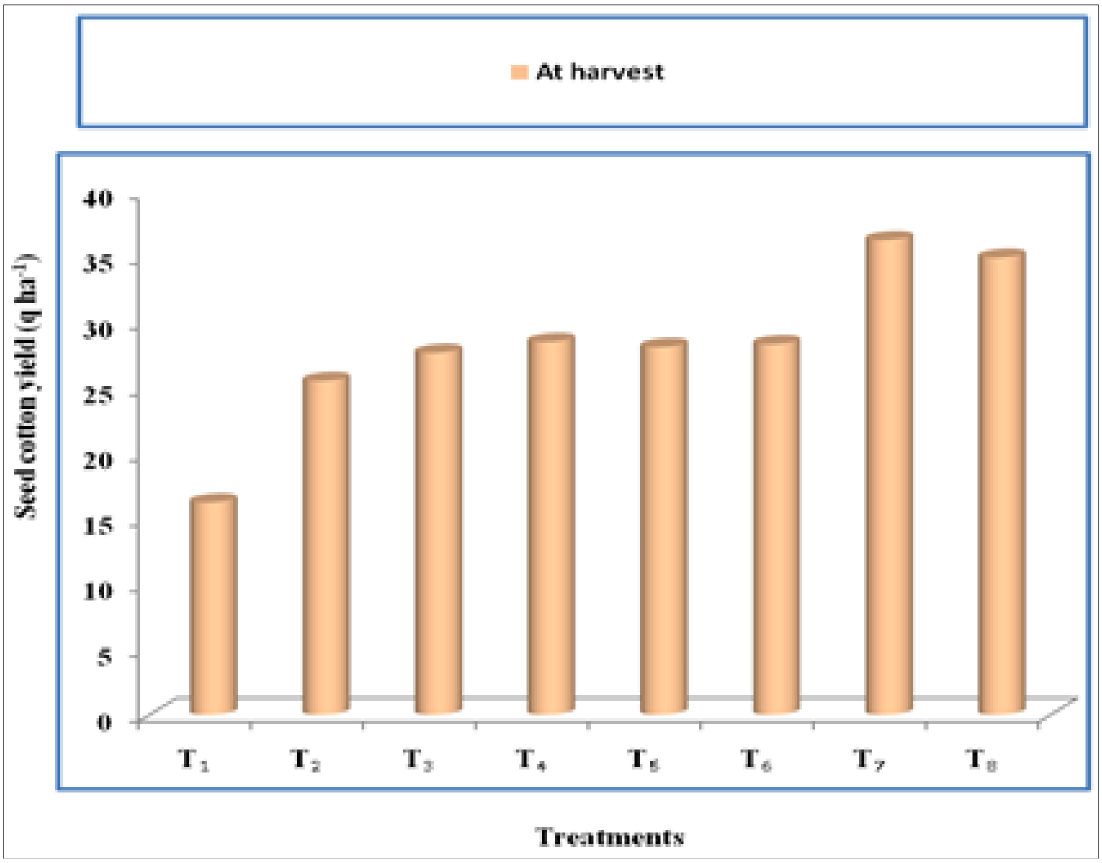
Dry matter production

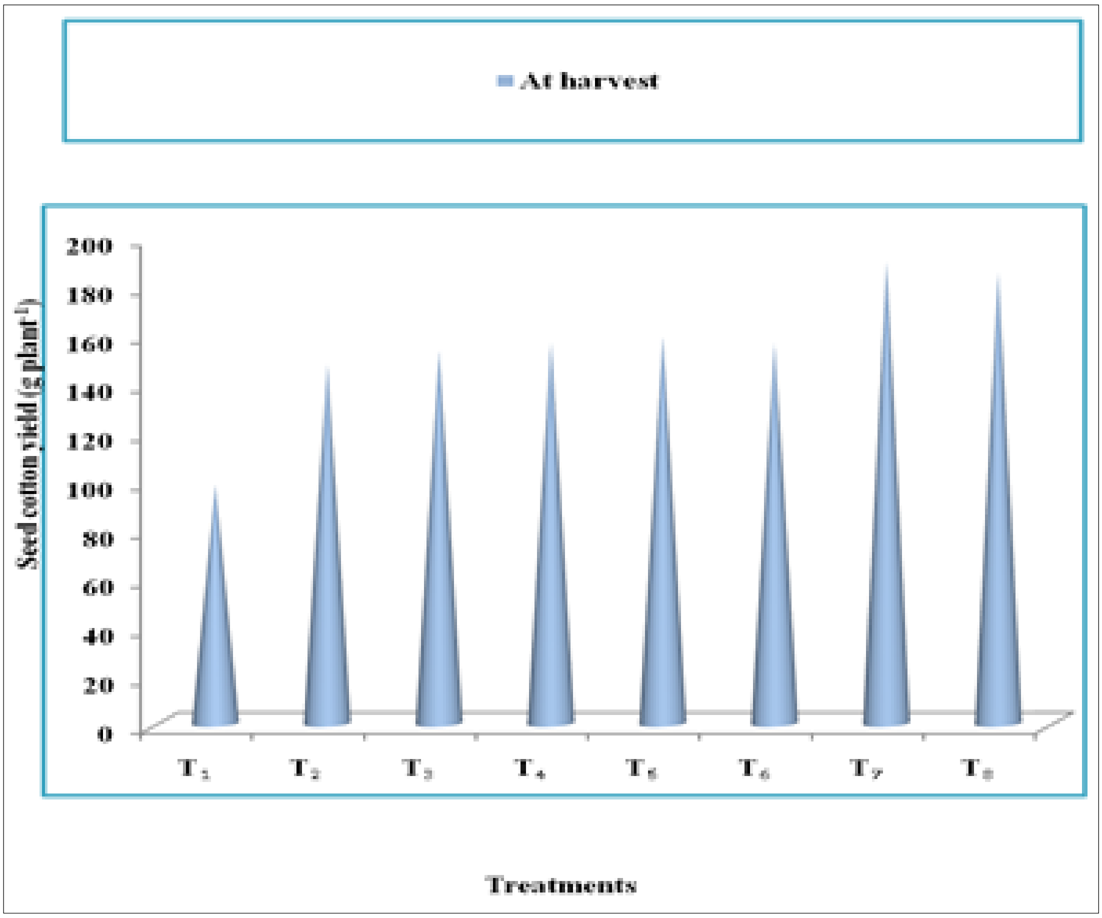
The performance of any cultivar basically depends on its dry matter production ability; the total dry matter production inturn is dependent on total photosynthetic area and rate of photosynthesis. The higher dry matter per plant (Table 2) was recorded in treatment T_7: STCR- NPK for targeted yield of 40 q ha^{-1} (250.2, 320.0 and 418.1 g $plant^{-1}$) which was superior to all other treatments except Treatment T_8: STCR-NK & 50% STCR-P (249.7, 312.4 and 414.1 g $plant^{-1}$) at 75, 115 DAS and at harvest of the crop, respectively. This might be due to higher levels of fertilizers application, consequently improved nutrient availability in soil and further absorption of adequate nutrients by plant. Similar findings were reported by Manjunatha *et al.* (2014) [8] and Biradar *et al.* (2011) [4]. They observed that in-adequate supply of nitrogen drastically reduced plant height, leaf area and dry matter production per plant as compared to the effect of supply of other primary and micronutrients. This signifies the importance of nitrogen in promoting the growth and yield attributing parameters of the transgenic cotton.

Among the STL treatments, the higher dry matter per plant (T_5: 208.7, 295.1 and 380.1 g $plant^{-1}$) was recorded with the treatment receiving STL- NK ± 50% & 25% P compared to treatment involving application of nutrients based on low, medium and high category (T_3: 181.7, 273.4 and 358.1 g $plant^{-1}$). The extent of increase in dry matter production in treatment T_5 over T_3 is 24.1, 16.4 and 0.98 per cent, respectively, at 75, 115 DAS and at harvest. Significant increase in dry matter per plant at 75, 115 and at harvest (168.2, 253.4 and 346.4 g $plant^{-1}$) was observed by the application of RDF @ 150:75:7 kg ha^{-1} compared to control treatment (no application of nutrients).

Table 1: Cotton yield as influenced by different nutrient management practices

Treatment	Cotton yield (g $plant^{-1}$)	Cotton yield (q ha^{-1})
T_1: Absolute control	97.6	16.2
T_2: RDF (150: 75: 75, N: P_2O_5: K_2O kg ha^{-1})	147.4	25.5
T_3: Soil test based (STL) NPK (L, M & H)	153.1	27.7
T_4: Soil test based (STL) NPK ± 25%	158.7	28.7
T_5: Soil test based NK ± 50% & ± 25% P	156.1	28.4
T_6: STL-NK ± 25% & 50% STL- P	156.0	28.3
T_7: STCR - NPK for targeted yield of 40 q ha^{-1}	189.4	36.2
T_8: STCR-NK & 50% STCR-P	185.0	34.1
Mean	155.4	28.3
S.Em±	4.46	0.80
CD at 5%	13.51	2.43





Legend

T_1: Absolute control

T_2: RDF (150:75:75 kg ha^{-1})

T_3: STL-NPK (L, M & H)

T_4: STL-NPK ± 25%

T_5: STL-NK± 50% & ± 25% P

T_6: STL-NK± 25% & 50% STL-P

T_7: STCR-NPK for targeted yield of 40 q ha^{-1}

T_8: STCR-NK & 50% STCR-P

Fig 1: Seed cotton as influenced by different nutrient management approaches

Table 2: Yield parameters of *Bt* cotton as influenced by different nutrient management practices at different growth stages of crop.

Treatment	Number of bolls plant^{-1}			Boll weight (g boll^{-1})			Dry matter production (g plant^{-1})		
	75 DAS	115 DAS	At harvest	75 DAS	115 DAS	At harvest	75 DAS	115 DAS	At harvest
T_1: Absolute control	2.5	13.7	25.1	3.87	3.82	3.71	107.7	196.4	308.7
T_2: RDF (150: 75: 75 kg N: P_2O_5: K_2O ha^{-1})	4.2	16.9	35.1	4.37	4.32	4.23	168.2	253.4	346.4
T_3: Soil test based (STL) NPK (L, M & H)	4.3	17.2	37.5	4.25	4.19	4.10	181.7	273.4	358.1
T_4: Soil test based (STL) NPK ± 25%	4.9	19.7	40.0	4.33	4.28	4.19	202.1	285.7	369.7
T_5: Soil test based NK ± 50% & ± 25% P	4.8	19.2	38.2	4.19	4.16	4.08	208.7	295.1	380.1
T_6: STL-NK ± 25% & 50% STL- P	4.7	19.3	39.2	4.30	4.25	4.16	201.9	281.0	368.1
T_7: STCR - NPK for targeted yield of 40 q ha^{-1}	7.1	30.7	48.0	5.02	4.93	4.83	249.7	320.0	418.1
T_8: STCR-NK & 50% STCR-P	7.00	28.8	43.4	4.93	4.89	4.78	250.2	312.4	414.1
Mean	4.92	20.7	38.3	4.41	4.36	4.26	196.3	277.2	370.4
S.Em±	0.29	1.7	1.38	0.07	0.06	0.06	4.46	7.88	8.82
CD at 5%	0.89	5.27	4.18	0.20	0.19	0.18	13.53	23.90	26.76

Table 3: Growth parameters of *Bt* cotton as influenced by different nutrient management practices at different crop growth stages.

Treatment	Plant height (cm)			Monopodial branches plant^{-1}			Sympodial branches plant^{-1}		
	75 DAS	115 DAS	At harvest	75 DAS	115 DAS	At harvest	75 DAS	115 DAS	At harvest
T_1: Absolute control	68.9	93.6	109.2	1.40	1.53	1.73	10.7	14.3	16.4
T_2: RDF (150: 75: 75, N: P_2O_5: K_2O kg ha^{-1})	87.5	106.5	128.5	1.47	1.73	1.93	11.1	16.2	19.6
T_3: Soil test based (STL) NPK (L, M & H)	90.3	115.0	134.6	1.53	1.93	2.20	11.5	16.3	20.3
T_4: Soil test based (STL) NPK ± 25%	96.4	118.8	136.5	1.67	2.13	2.40	11.7	16.6	21.2
T_5: Soil test based NK ± 50% & ± 25% P	98.3	121.3	138.4	1.73	2.27	2.53	12.1	16.8	22.1
T_6: STL-NK ± 25% & 50% STL- P	95.6	117.8	135.8	1.63	2.20	2.27	11.6	16.8	20.7
T_7: STCR - NPK for targeted yield of 40 q ha^{-1}	104.9	127.7	145.5	2.07	2.40	2.73	12.3	17.4	22.7
T_8: STCR-NK & 50% STCR-P	103.9	126.6	144.6	2.00	2.47	2.67	12.3	17.3	23.5
Mean	93.3	115.9	134.1	1.69	2.08	2.31	11.7	16.4	20.8
S.Em±	0.45	0.39	0.35	0.07	0.15	0.08	0.31	0.25	0.28
CD at 5%	1.37	1.18	1.05	0.22	0.45	0.25	0.93	0.77	0.85

Plant height

There is a direct relationship between yield and growth of the plant. To agree with this relation, the basic growth attributes like plant height, number of sympodial and monopodial branches had shown similar variation in plant vigour with respect to yield attributes. The plant height (Table 3) was influenced significantly by different fertilizer recommendation approaches at 75, 115 DAS and at harvest of the Bt cotton crop. Significantly higher plant height of 104.9 cm, 127.7 cm and 145.5 cm at 75 DAS, 115 DAS and at harvest, respectively, was recorded due to application of nutrients on STCR basis in treatment T_7 and 103.9, 126.6 and 144.6 cm in T_8: STCR-NK ± 50% STCR-P. These results are in line with the report of Saraswathi *et al*. (2015) [11] and Apoorva *et al*. (2010). This might be due to higher availability of nitrogen in these treatments as nitrogen plays vital role in cell division and cell elongation (Brar *et al.* 2000) [5]. Further, potassium added which might have significant effect in improving the resistance capacity of the crop to drought and alleviate its negative effects besides improving translocation efficiency. Similarly, application of phosphorus facilitated plant response to nitrogen and potassium fertilization (Kalaichelvi *et al.* 2006) [7] besides its direct role in production and development of fruiting parts *i.e.*, flowers and bolls.

Monopodial and sympodial branches

There was a significant improvement in growth parameters due to application of fertilizers on STCR and STL basis, at different growth stages of crop. The highest monopodial and sympodial branches was recorded in treatment receiving nutrients according to STCR equation, viz; STCR-NPK for targeted yield of 40 q ha^{-1} (T_7: 2.07, 2.4 and 2.73 & 12.3, 17.4 and 22.7) at 75, 115 DAS and at harvest, respectively. The lower number of monopodial and sympodial branches was recorded in treatment T_1: un-fertilizer control at 75, 115 DAS and at harvest. These findings are in compliance with the report of Manjunatha *et al*. (2014) [8] and Brar *et al.* (2000) [5] who reported that, increased nutrient levels significantly increased monopodial and sympodial branches of Bt cotton.

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