International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 1460-1463

Received: 07-05-2019
Accepted: 09-06-2019

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Response of cotton to site specific nutrient management (SSNM) in Vertisols of TBP command of Karnataka

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Abstract
A field study was conducted to identify critical nutrient and realization of target yield through site specific nutrient management (SSNM) comprising of five treatments *viz*., SSNM for target yield of 4 t ha^{-1}, N-omission, P-omission, K-omission and farmers' practice was carried out at farmers' fields on participatory mode during 2015-16. Results of the study revealed that yield target 4384 kg ha^{-1} was comfortably achieved with SSNM (332.8-78.4-106.4 kg $N\text{-}P_2O_5\text{-}K_2O$ kg ha^{-1}, respectively while N omission followed (3597 kg ha^{-1}) by K omission (3655 kg ha^{-1}) had significantly lower yields among all due to reduced major nutrient uptake than with SSNM. Likely, SSNM had favorable residual soil fertility than with nutrient omission. Significantly higher N, P and K uptake (284, 26 and 222 kg ha^{-1} respectively) was observed in SSNM (4 t ha^{-1}) treatment which was supplied with NPK. N is the most critical element followed by K for higher and sustainable cotton production and soil productivity.

Keywords: Cotton production, N omission, P omission, K omission and SSNM

Introduction
Karnataka, ranks fifth in area, fourth in production and fifth in productivity among the cotton growing states in India. *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 (TBP and UKP) irrigation Commands on black soil. The area under this crop in these commands has been increasing distinctly over the past half-decade. The average yields which hovered around 38 to 45 q/ha initially with the advent of *Bt* cultivars of late are either remaining stagnant of declining over years which is a deterrent to farmers due to squeezing returns and hence needs special attention. Continuous cultivation of cotton and inadequate nutrition are the major reasons for declining productivity. In this context 'feeding the crop' instead of 'feeding the soil' warrants emphasis.

Long term imbalanced and blanket recommendation of fertilizer use that is in vogue in cotton is not only leading to poor harvests, lower fertilizer use efficiency and poor fibre quality but also affecting the soil fertility and production sustenance. Conventional fertilizer recommendation strategies based on Research station trials does not rely on local soil fertility variation and the production potential/target set by the farmer. In this context, Site-Specific Nutrient Management (SSNM) approach is one such option which focuses on balanced and crop need-based nutrient application (Johnston *et al*., 2009) [5].

The dissemination of such technologies would go a long way in improving the productivity and profitability of farming and being major fertilizer consumer cotton is not an exception. It is hypothesized that transgenic cotton yield in Vertisols can be enhanced through targeted yield approach through SSNM based on assessment of crop nutrient requirement as per IPNI recommendations. The objectives of the trials were to identify critical nutrient in crop nutrition and assess the economic feasibility of achieving of targeted yield in *Bt*-Cotton in TBP command on Vertisols.

Materials and methods
On-farm field studies were conducted during *kharif* 2015 in farmers' fields (out of ten three considered vitiated) of Kasabe Camp (16.18344730 N, 77.27857991 E) near Raichur drenched from Tunga Bhadra irrigation command (TBP) under the jurisdiction of University of

Agricultural Sciences, Raichur, Karnataka, India. The soils are neutral to alkaline (pH 7.5-8.4) (Piper, 1966) [7], non-saline (EC 0.19 to 0.32 dS/m), medium in organic carbon (0.37–0.6 %) (Jackson, 1967), low in available N (70-235 kg ha^{-1}) (Subbaiah and Asija, 1956) [8], medium in P_2O_5 (42-75 kg ha^{-1}) and high in K_2O (295-675 kg ha^{-1}) (Jackson, 1967). The potential of *Bt*-Cotton in the region is 3-3.5 t ha^{-1}. N, P and K requirements were calculated by accounting the indigenous nutrient supply, yield target and nutrient demand per tonne of cotton lint yield as per set procedures of IPNI.

The treatments consisted of SSNM (332.8-78.4-106.4, N-P_2O_5-K_2O kg ha^{-1}, respectively) for a target yield of 4 t ha^{-1}, nitrogen omission (N_0), phosphorus omission (P_0), potassium omission (K_0) and farmers' fertilizer practice (340:120:75, N-P_2O_5-K_2O kg ha^{-1}, respectively). Omission plots were maintained to assess nutrient contribution from native soil fertility of each farmer's field. For omission plots, respective nutrient elements (N_0, P_0 or K_0) were omitted and rest of the fertilizers were applied based on recommendation for the region. Seeds of cv. Jaadhu, *Bt*-cotton hybrid were sown on 17th and 27th July, 2016 after receipt of monsoon rains at 90 cm X 60 cm in a gross plot of 9 m x 6 m. Subsequently, crop was irrigated using canal water. Except fertilizer level in SSNM and omitted nutrient elements rest of the cultivation practices were similar to surrounding farmers' field. Entire phosphorus and 50 per cent N and K were applied basally. Remaining N and K were applied twice at 45 and 75 days after planting. Prophylactic plant protection measures were taken up as and when pest and disease were crossed ETL. Growth and yield attributes were recorded, soil and plant were analysed and economics was worked out.

Results

Seed cotton yield per ha varied significantly due to different treatments effects and among all, SSNM treatment recorded the highest yield of 4384 kg per ha. Farmers' practice recorded next higher value (4072 kg/ha) and P omission (4006 kg/ha) was on par with it while K omission had next lower value. Significantly lower seed cotton yield among all was recorded with An omission treatment (3707 kg/ha). Nitrogen uptake by the plant varied significantly due to different manorial treatments. Among all, significantly higher nitrogen uptake was recorded with SSNM treatment (284 kg/ha) owing to higher nitrogen content (2.4 %). Omission of P and K had comparable N content and uptake as that of SSNM treatment. Farmers' practice had next lower N uptake while N omission had the lowest N uptake among all (173 kg/ha) due lower N content (1.43 %). Significant variations existed in P uptake in different nutritional treatments. Among all, significantly higher phosphorus uptake was recorded with SSNM treatments (26.0 kg/ha), and farmers' practice and K omission treatments were at par while N omission treatment had next lower value but P emission had the lowest P uptake among all (16.8 kg/ha). Potassium uptake by the plant did not very significantly among different treatments. However, higher potassium uptake was recorded with SSNM treatment (222 kg/ha) followed by farmers' practice (212 kg/ha). The lower potassium uptake was recorded with K omission treatment (211 kg/ha). The potassium content in plant was higher in case of SSNM treatment (0.78 %) followed by phosphorus omission treatment (0.70 %) and the lowest was in case of potassium omission treatment (0.44 %).

Discussion

Set yield target was achieved, in fact exceeded, in all the farmers' fields with SSNM (4215 to 4510 kg ha^{-1}) with lowest SE among all while, nutrient omission recorded lower yields than target except with P omission (3943 kg ha^{-1}) which was close to target but had exhibited largest SE among all (Table 1 and Fig 1). Lower yields with an omission are on expected line (Manjunath *et al.* 2014) [6]. Yield increases with SSNM over omission of nitrogen, phosphorus and potassium were to the tune of 18.3, 9.4 and 15.9 per cent, respectively. Haung *et al.* (1999) reported the yield rise by 19.8 % with SSNM over control. Hussain *et al.* (2014) [3] reported N is the most limiting nutrient with seed cotton yield reduction to the tune of 28 % followed by K (14.5 %) and P (6.5 %) omissions.

Better performance with P omission, in general, could be attributed to medium to high soil available P which may be due to the fact that these soils were continuously under drill sown rice couple seasons back which could have made soil P readily available to the crop in commensuration with its periodic requirement. Or else, the *Bt* cultivar used in the study might not be distinctively responding to applied P in presence of moderate to high soil available P. The point of interest, nevertheless, was the relatively poor performance of crop in the absence of K unlike P though the soils were rich in soil available potassium. The seed cotton yield was low and was next only to N omission. The uniformity of results across different farmers' fields (lower SE) could be due to response of *Bt* cotton to readily available K from fertilizer source. Further, importance of K also lies in the fact that its direct involvement in transportation of photosynthates to growing fruiting parts which is more important in highly productive genotypes like *Bt* cotton.

Further, achieving of target yield with farmers' practice could be attributed to more or less similar levels of application of N and P_2O_5 (340:120 kg ha^{-1}, respectively under farmers' practice) as that in SSNM for a yield target of 4 t ha^{-1} and the difference in yield over SSNM was probably due to lower K supply (75 kg ha^{-1}) under farmer's practice than under SSNM (114 kg ha^{-1}). Thus, next to N it was K which was more important in cotton nutrition in TBP irrigation command.

In spite of application of fertilizer for targeted yield by adjusting soil availability status and crop requirement there occurred variation in seed cotton yield among different farmers' fields both with SSNM and nutrient omission (Fig. 1). This may be attributed primarily to managerial differences among farms and also to soil physical and biological variations which are bound to be there as soil is a highly heterogeneous body.

It is interesting to note that the residual soil fertility status among farmers varied significantly among different nutritional supply situations with relatively better nutrients availability under SSNM in comparison to nutrient omission (Fig.1). Soils with lower initial nutrient availability had still lower nutrient availability of that element at the end of the season under omission treatment with SSNM faring slightly better thereby indicating advantage of better residual fertility with balanced nutrition (Aladakatti *et al.*, 2012 and Ashaq Hussain *et al.*, 2014) [1, 3]. Accordingly, N in 2nd and 5th farmers, P in 1st, third and 5th farmers and K in 1st farmer had lower post harvest soil nutrient values in consonance with initial soil status.

Table 1: Variability in seed cotton yield across farmers' field

Treatment	Yield (kg/ha)	Range (kg/ha)	S.Em.±
NPK based SSNM target yield (4t/ha)	4384	4215-4510	56.4
Nitrogen omission	3,597	3432-3984	99.6
Phosphorus omission	3,943	3569-4396	136.6
Potassium omission	3,655	3396-3954	92.0
Farmers' practice	4072		
SEm±	111		
CD (p=0.05)	244		

SSNM – Site specific nutrient management

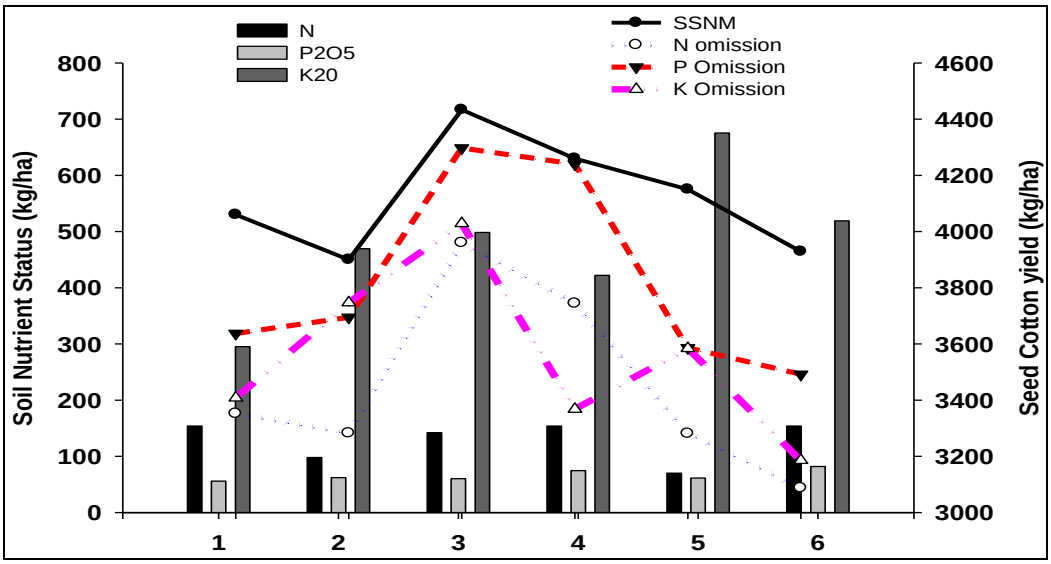
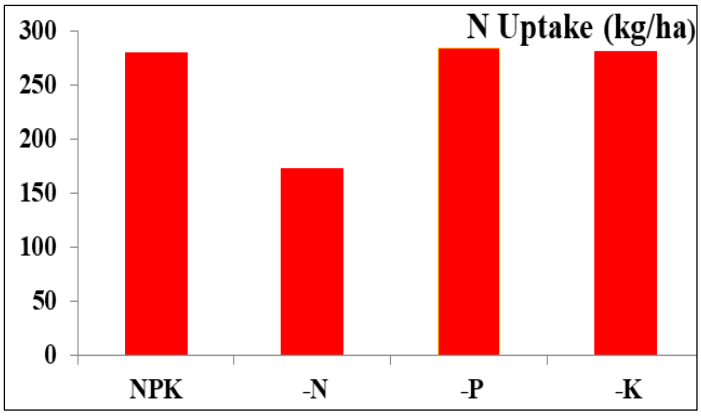
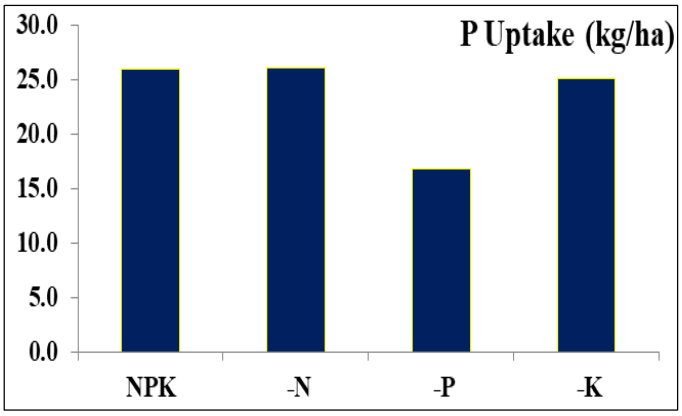


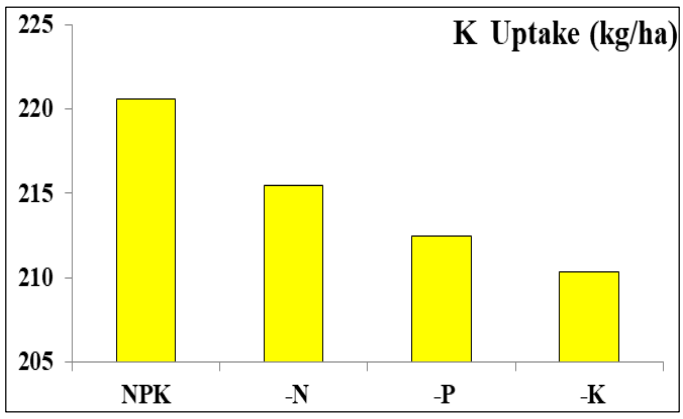
Fig 1: Soil fertility status and seed cotton yield in farmers field (six farmers).



(A)

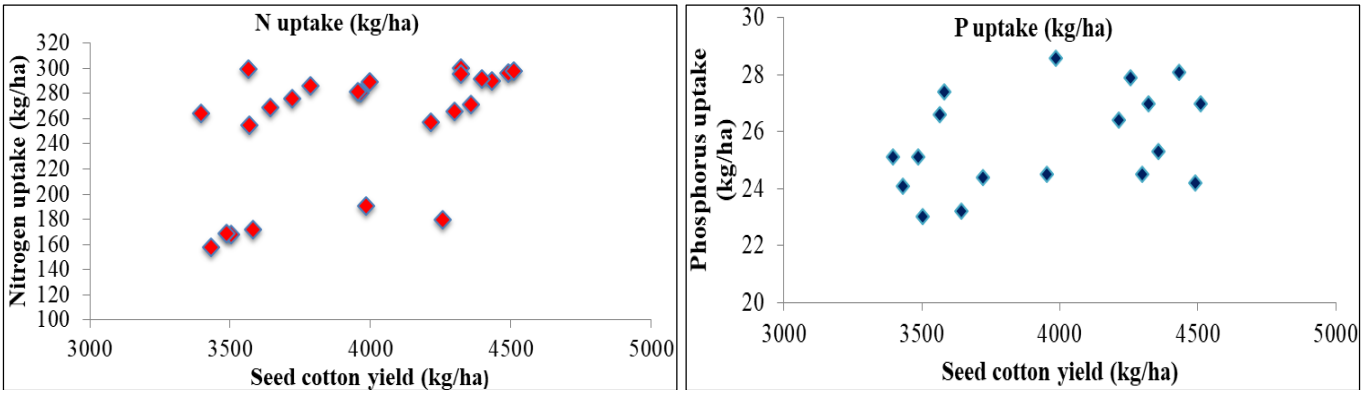


(B)

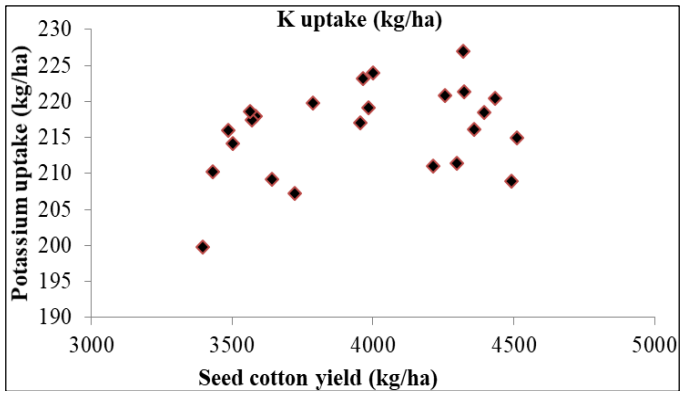


(C)

Fig 2(A, B, C): Crop NPK uptake (kg/ha) (Values are average of 6 farmers).



3(A) **(B)**



(C)

Fig 3(A, B, C): Relationship between seed cotton yield and crop NPK uptake

Conclusion

Thus, the study highlighted need for balanced fertilization and superiority of SSNM in cotton production in achieving set targets (4.0 t ha^{-1}) with better residual fertility status. SSNM assures sustainability in cotton production besides soil productivity sustenance. However, nitrogen followed by potassium is the critical element in TBP irrigation command for attaining higher cotton yields.

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