International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 2167-2174

Received: 21-07-2017
Accepted: 22-08-2017

NA Byale
College of Agriculture, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India

BM Nandede
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

YA Rajwade
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Correspondence
NA Byale
College of Agriculture, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India

Influence of fertilizers' application on available nutrients in soil, uptake pattern, growth and yield of BT cotton under Rainfed condition

NA Byale, BM Nandede and YA Rajwade

Abstract
An experiment was conducted to assess the influence of fertilizers application on nutrients' availability in soil, uptake pattern, and growth and yield of bt cotton under rainfed condition in *kharif* season of 2011-2012. The experiment was laid out in randomized block design with ten treatments (T_1 to T_{10}) and replicated thrice. Data on available nutrients N, P, K, S, Zn, B, and Mg in soil, uptake pattern of N-P-K and growth parameters were collected. The application of fertilizers significantly influenced the soil nutrients availability, uptake pattern and growth parameters as well as seed cotton yield. Available nutrients N, P, K, S, Zn, B, Mg in soil, Uptake pattern of NPK and biometric observations and yield of cotton were highest with nutrient combination of T_{10} (Recommended dose for Bt cotton.(125:62.5:62.5)+S), except available P in T_5 (N+P+K), Mg, T_2 (RDF P + Potassium)and Zn T_9 (Recommended dose of nitrogen + phosphorus + potassium + sulphur + magnesium + zinc +boron (spray)). Therefore, T_{10} followed by T_9 was found to be preventive for cotton reddening. Treatment T_{10} produced highest seed cotton yield (19.22 q ha^{-1}) followed by T_9 (19.04 q ha^{-1}). Therefore, considering plant pigments yield, T_{10} can be recommended for growing of Bt cotton under rainfed condition.

Keywords: Cotton, growth and yield, nutrient availability, fertilizer application, nutrient uptake.

1. Introduction

Cotton is the most important commercial crop of India and popularly known as "White Gold" (Bharambe, 2010) [1]. It has national importance due to its influence on Indian economy. The crop is cultivated for its use as a source of food, fiber and fuel. The area under cotton crop is constant over last 8-10 years (Fig.1). With yield fluctuations, pest and diseases and climate change limiting production, need of high yielding cotton varieties was evident. India ranks third in terms of production and productivity of cotton (CCI, 2011) [2]. To raise the level of income, high yielding varieties like Bt cotton are being cultivated by Indian farmers (Ref.). India occupies top most position among the cotton growing countries of the world. However, several factors such as, leaf reddening by abiotic stress related to disturbed soil ion equilibrium leading to potassium shortage and accumulation of sodium ions in cotton leaves leads to reduction in cotton yield (Koleva *et al.*, 2005) [3]. Research has been carried out in respect to abiotic stress constraints such as nutrient deficiency, salinity and high temperature etc. However very little information is available on nutrients imbalance leading to leaf reddening in cotton. It affects the dry matter yield and reduction in cotton yield up to 60%. Therefore, this study was aimed to assess the effect of fertilizers application on soil nutrients availability, uptake pattern, and growth and yield of bt cotton under rainfed condition.

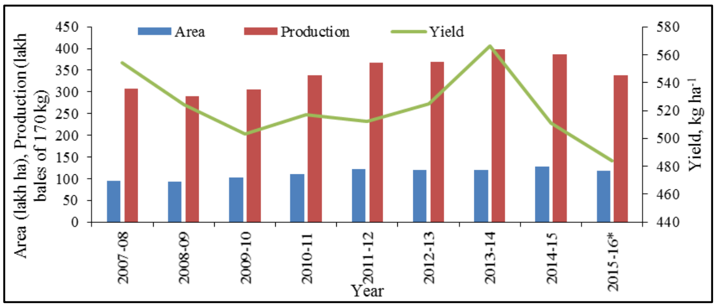

Fig 1: Area, production and productivity of cotton in India

2. Materials and methods

2.1 Experimental details

A field experiment was conducted during *kharif* (June-September) season *of* 2011-2012 with ten treatments and three replications in Randomized Block Design (RBD). The Bt cotton variety Rasi -2 (169 days) was sown/ dibbled at the spacing of 60 × 60 cm in check row planting method. The each plot was of size 4.8 m × 4.2 m. The soil of experimental site was slightly alkaline, medium in organic carbon, non-calcareous in nature, low in available N (136 kg ha^{-1}) and P (7.8 kg ha^{-1}), high in available K (629 kg ha^{-1}), and low in available Sulphur with sufficient available micronutrients. The complete dose of nitrogen, phosphorus, potassium, sulphur and zinc, was applied in soil at the time of sowing. The Zn and Boron were applied through $ZnSO_4$ and borax, respectively. The quantity and source of fertilizer for each plot was calculated on the basis of recommended dose and is given in Table 1. Details of the treatments are given in Table 2.

Table 1: Quantity and source of fertilizers application

Treatment No.	Nutrients applied	Quantity, (kg ha^{-1})	Source of nutrient	Quantity, g $plot^{-1}$
T_1	Control	-	-	-
T_2	P +K	40+40	SSP+MOP	503+137
T_3	N+K	80+40	Urea +MOP	345+137
T_4	N+P	80+40	Urea +SSP	345+503
T_5	N+P+K	80+40+40	Urea+SSP+MOP	282
T_6	N+P+K+S	80+40+40+30	Urea+SSP+MOP+Elemental sulphur	345+503+137+50.5
T_7	N+P+K+S+ Mg	80+40+40+30	Urea+SSP+MOP+Elemental sulphur+$MgSO_4$	345+303+137+50.5
T_8	N+P+K+S+ Mg+Zn	80+40+40+30	Urea+SSP+MOP+Elemental sulphur+$MgSO_4$+$ZnSO_4$	345+303+137+50.5
T_9	N+P+K+S+ Mg+Zn+B	80+40+40+30	Urea+SSP+MOP+Elemental sulphur + $MgSO_4$ + $ZnSO_4$ + Borax	345+303+137+50.5
T_{10}	RDF + S	125:62.5:62.5+30	Urea+SSP+MOP+Elemental sulphur	546+787+787+50.5

SSP – Single super phosphate, MOP- Murate of potash, RDF- Recommended dose of fertilizers

Table 2: Details of Treatment

Symbol	Treatment
T_1	Control
T_2	Recommended dose of phosphorus + Potassium.
T_3	Recommended dose of nitrogen + potassium
T_4	Recommended dose of nitrogen +phosphorus
T_5	Recommended dose of nitrogen + phosphorus + potassium
T_6	Recommended dose of nitrogen + phosphorus + potassium + sulphur
T_7	Recommended dose of nitrogen + phosphorus + potassium + sulphur + magnesium (1%- 2 spray)
T_8	Recommended dose of nitrogen + phosphorus + potassium +sulphur + magnesium + zinc
T_9	Recommended dose of nitrogen + phosphorus + potassium + sulphur + magnesium + zinc +boron (spray)
T_{10}	Recommended dose for Bt cotton.(125:62.5:62.5)+S

2.2 Biometric observations

Height of plant was measured in cm from the base of plant i.e. ground level to the base of the last fully opened leaf at the apey. It was recorded at critical growth stages of crop. The actual leaf area was recorded with the help of leaf area meter in cm^2 and converted into dm^2, expressed on per plant basis.

2.3 Soil-plant analysis

The soil samples were collected from each plot at square formation, boll development, boll bursting and at harvest stages for determination of physico chemical properties and nutrient content. The plant samples were also collected at corresponding stages. Soil samples were brought to laboratory, dried under shade and then in oven for 70 °C for 4 h till constant weights were obtained. The soil and plant samples grinded, sieved and placed in polythene bag, labeled properly and used for subsequent analysis. In soil, available nitrogen was determined by alkaline permanence method (Subbiah and Asija, 1956) [4] phosphorus by Olsen's method (1954) [5] and potassium measured on flame photometer (Piper, 1966) [6]. Available sulphur in soil was extracted with 0.15% $CaCl_2$ as an extractant and estimated turbidimetrically on a spectrophotometer at 340 nm (Tabatabai and Bremner, 1970) [7]. Available magnesium was determined by using Varsenate method in ammonium acetate extract of soil by titration with EDTA (Jackson, 1973) [8]. Zinc was determined by using DTPA extract as described by Lindsay and Norvell (1969) [9]. Available Boron was determined by water suspension. Boron analyzed by colorimeter method using reagent such as azomethine-H (Brever and Trough, 1947) [10]. Digestion of plant samples carried out as described by piper (1973) [6]. The phosphorus was estimated by Vanadomolybdophosphoric acid yellow colour method prepared with spectrophotometer (Jackson, 1973) [8]. Potassium was determined with flame photometer (Jackson, 1973) [8]. Sulphur concentration in plant was determined with barium sulphur using turbidimetric (Tabatabai and Bremner, 1970) [7]. The Zn content in plant was determined from the extract obtained from digestion of plant samples with HNO_3I and $HClO_4$ using Atomic Absorption Spectrophotometer (Jakson, 1973) [8]. It was estimated using plant digest and buffer solution along with azomethine-H reagent with spectrophotometer at 420 nm wavelength.

3. Results Discussion

3.1 Effect of nutrients application on nutrients availability in soil

3.1.1 Available nitrogen (N)

Effect of nutrients application on available N is shown in Fig. 2. Available nitrogen increased from planting to square formation stage and decreased later with crop growth and stages. At square formation stage, highest available nitrogen content was recorded in T_{10} treatment (195.9 kg/ha) followed by T9 (180.2 kg ha^{-1}). Similar trend for available nitrogen content at boll bursting stage was observed in different treatments. Similar results were obtained by Katkar *et al.* (2005) [11]. Across the treatments, during boll bursting and boll development stages, the effect of different fertilizer combinations on available nitrogen content was non-significant. The available N content in T1 (control) was lowest at all the stages of crop growth. These results are in line with the results of work carried out by Raja Rajan *et al.* (2005) [12].

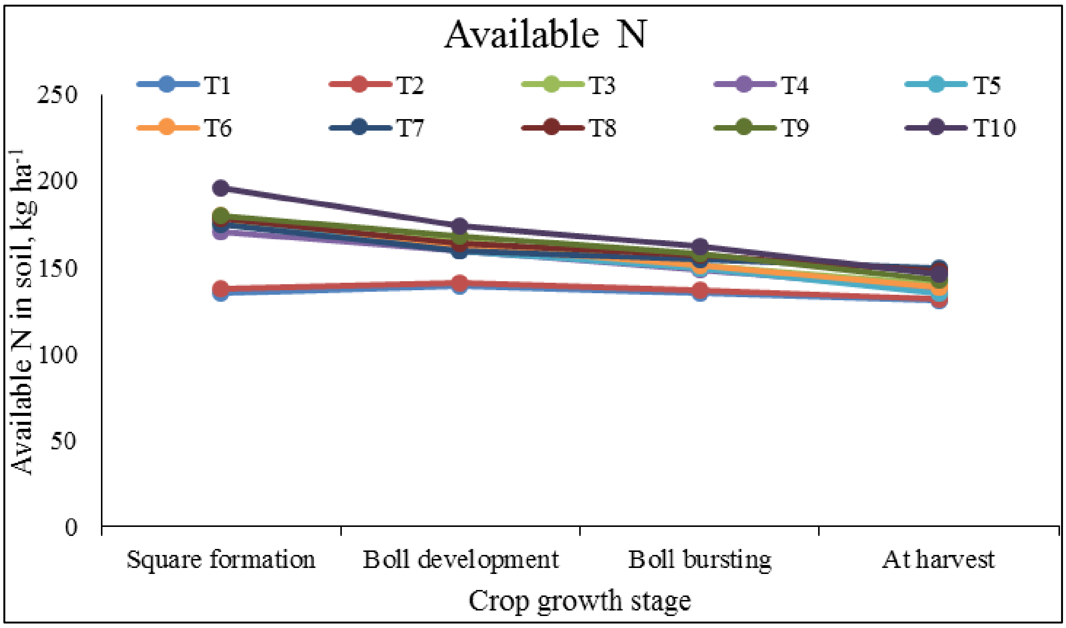

Fig 2: Effect of nutrients application on Available N

3.1.2 Available phosphorus (P)

Available P in soil decreased square formation stage to harvest in all the treatments. The highest value of available phosphorus of was recorded in T_{10} treatment (15.25 kg ha^{-1}) at square formation stage followed by treatment T_9 (13.25 kg ha^{-1}). Available phosphorus content in soil in T_4, T_5, T_7 and T_8 treatments was at par. Further alteration in treatment T_6 and T_2 showed a considerable reduction in available P while treatment T_3 and T_1 (control) showed lowest available P in soil. Similarly, at boll development stage, treatment T_{10} showed maximum available P of 14.26 kg/ha followed by treatment T_9. The available phosphorus in treatments T_5, T_7 and T_{10} was at par. Similar values of available phosphorus were recorded with supply of N+P (T_4) and N+P+K+S (T_6). Treatment T1 (control) had lowest available P at all the stages. Effect of nutrients application on available phosphorus is shown in Fig. 3.

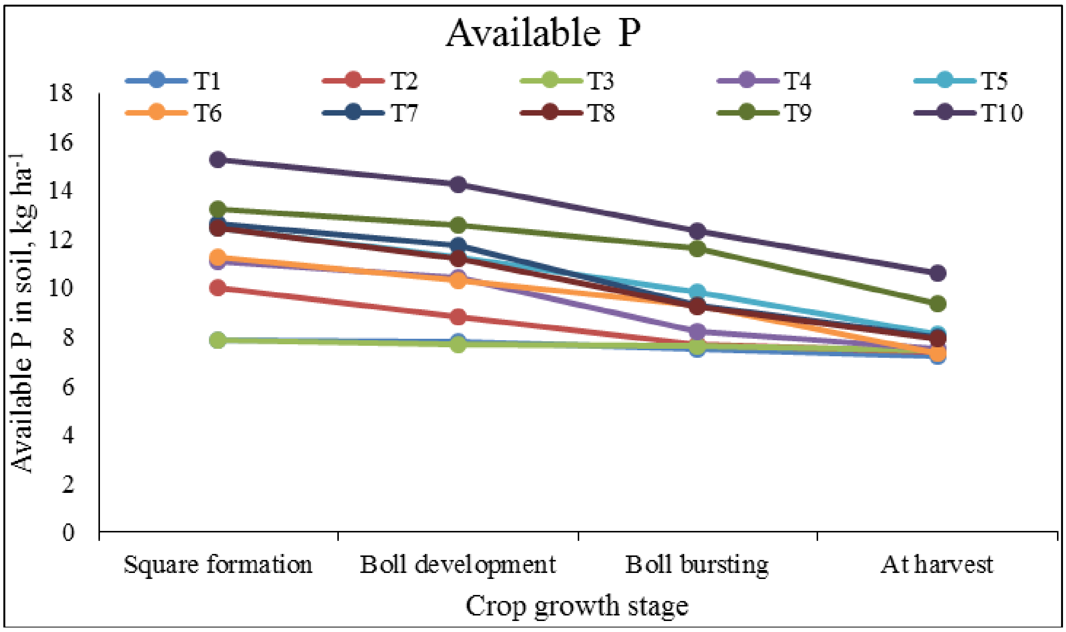

Fig 3: Effect of nutrients application on available phosphorus

The available phosphorus at harvest also was recorded maximum in treatment T_{10} followed by treatment T_9. In general, it was clearly seen from observations that treatment T_{10} showed highest availability of P in soil throughout the growing period followed by treatment T_9. The significant variation in available P due to application of different levels of nutrients in soil, recorded in this study, is in-line with the results reported by Katkar *et al.* (2005) [11].

3.1.3 Available potassium (K)

Effect of nutrients application on available K in soil is shown in Fig. 4. Available K was maximum at square formation stage and decreased at subsequent stages of crop. The available K was highest (798 kg ha^{-1}) at square formation stage in treatment T_5. Similar values of available K were recorded in treatments T_9 and T_{10}. However, a considerable decrease in available K was recorded in treatments T_2, T_3, T_7 and T_8. The supply of N+P in T_4 treatment led to reduction in available K upto 609 kg/ha. However, it was significantly higher than the available K recorded in control. It was clearly seen from Fig. 3 that treatment T_{10} showed highest available K of 760 kg/ha at boll bursting stage. The available K in soil at harvest stage was also maximum with treatment T_{10} followed by treatment T_2, T_3, T_5, T_7, T_8 and T_9.The available K was found to declined further upto 514.2 kg ha^{-1} with treatment T_4 (N+P) which was similar to that recorded in control.

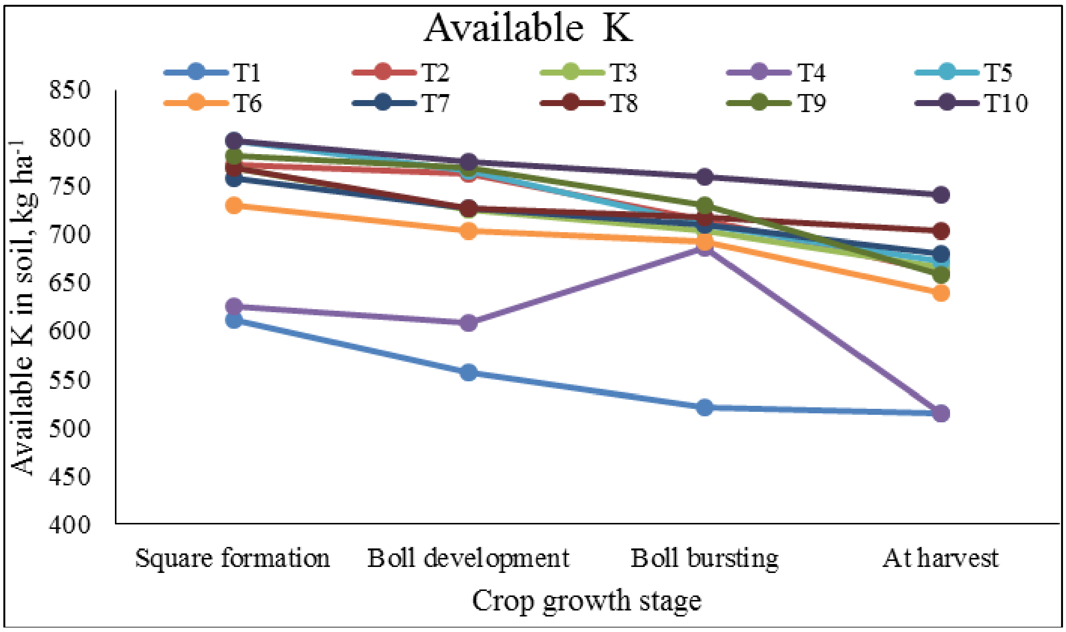

Fig 4: Effect of nutrients application on available potassium

3.1.4 Effect of nutrients application on micro nutrients

Highest available Sulphur (S) was noted at square formation stage and decreased subsequently upto harvest. Treatment T_{10} showed highest available S of 12.4 mg/kg at square formation stage followed by treatment T_9. The available S at boll development stage was also recorded maximum (11.75 mg/kg) in T_{10} followed by a slight decline upto 11.35 mg/kg in treatment T_9 (Table 3).

Effect of nutrients application on available zinc (Zn) is shown in Table 3. Maximum available Zn in soil was recorded at square formation stage and declined with of crop growth. Further, available Zn at boll development and boll bursting stages also showed similar trend.

It is observed from the data that treatment T_9 showed maximum available Boron (B) (0.48 ppm) in soil at square formation stage. Further, the treatment T_9 also showed highest available B in soil 0.45 ppm at boll development stage.

The data on available Mg in soil revealed maximum available Mg 16.73 meq/100 g at square formation stage with treatment T_2 followed T_8 (16.51 me/100 g). The available Mg in soil was significantly reduced in all other treatments. The available Mg at boll development, boll bursting and at harvest stage was also recorded maximum with treatment T_2. The values of available Mg with treatment T_7, T_8 and T_9 were slightly reduced and were at par at boll development and subsequent stages. The available Mg was found to reduce significantly in all other treatments. It is interesting to note that the treatment T_3 (N+K) showed lowest available Mg in soil throughout the growing period of crop.

Table 3: Effect of fertilizer application on micro nutrients' availability in soil

Treatment No.	Available Sulphur (mg kg^{-1})				Available Zn in soil				Available B in soil, ppm				Available Mg in soil (Meq/100 g)			
	Square formation	Boll development	Boll bursting	At harvest	Square formation	Boll development	Boll bursting	At harvest	Square formation	Boll development	Boll bursting	At harvest	Square formation	Boll development	Boll bursting	At harvest
T_1	9.1	8.82	8.28	7.44	0.54	0.51	0.45	0.4	0.42	0.4	0.37	0.35	15.65	15.48	15.23	15.15
T_2	11.8	9.69	8.89	7.65	0.56	0.53	0.51	0.45	0.47	0.44	0.35	0.34	16.73	16.52	16.21	16.17
T_3	9.25	8.69	7.95	6.69	0.55	0.57	0.53	0.52	0.46	0.43	0.41	0.35	12.66	12.45	12.26	12.16
T_4	11	10.23	9.65	8.32	0.55	0.53	0.5	0.48	0.45	0.42	0.4	0.37	15.23	15.16	14.59	14.48
T_5	11.4	10.15	9.78	8.33	0.55	0.56	0.52	0.51	0.45	0.42	0.38	0.36	1.33	13.11	13.34	12.78
T_6	11.7	10.33	9.69	8.45	0.57	0.55	0.53	0.53	0.44	0.41	0.37	0.35	15.6	15.37	15.15	15.09
T_7	11.9	10.55	9.55	8.75	0.56	0.54	0.52	0.53	0.46	0.43	0.35	0.34	15.74	15.26	15.16	14.59
T_8	11.8	10.68	9.39	8.81	0.66	0.63	0.61	0.55	0.45	0.41	0.36	0.34	16.51	16.15	16.07	15.6
T_9	12.3	11.35	10.15	9.85	0.68	0.65	0.62	0.6	0.48	0.45	0.42	0.4	14.62	14.38	14.27	13.62
T_{10}	12.4	11.75	10.45	9.98	0.58	0.54	0.51	0.45	0.41	0.35	0.37	0.35	15.48	15.27	14.39	14.16
Mean	11.2	10.2	9.3	8.4	0.58	0.55	0.53	0.51	0.45	0.42	0.38	0.31	15.15	14.93	14.83	14.55
SE $\pm$	0.17	0.14	0.06	0.21	0.014	0.018	0.05	0.202	0.012	0.014	0.014	0.041	15.15	14.93	14.83	14.55
CD at 5%	0.51	0.44	0.2	0.63	0.041	0.056	0.15	0.0599	0.036	0.042	0.041	NS	0.11	0.1	0.18	0.18

3.2 Effect of fertilizer application on nutrient uptake pattern

3.2.1 Nitrogen (N) uptake

Fertilizer application had significant effect on nitrogen uptake at square formation and boll bursting stage (Fig. 5). The highest uptake 17.25 kg/ha was recorded at square formation stage in treatment T_{10} followed by 15.30 kg/ha in treatment T_8 and T9. Similarly, at boll bursting stage treatment T_{10} showed highest uptake of 76.81 kg/ha. The N uptake increased with crop development and growth stages. Similar results are also reported by Shrinivasan (2003) [13]. The uptake of nitrogen at all the growth stages of crop was increased with increasing nutrients was in conformity to the findings reported by Patil and Malewar (1994) [14] and Devraj *et al.* (2008) [15]. Similar pattern in uptake of nitrogen was also reported by Suresh and Suryaprabha, (2003) [16]; Rajarajan *et al.* (2005) [12]; Hullihalli and Patil (2006) [17]. The mean, SE and CD at 5% level of significance for nitrogen are given in Table 4.

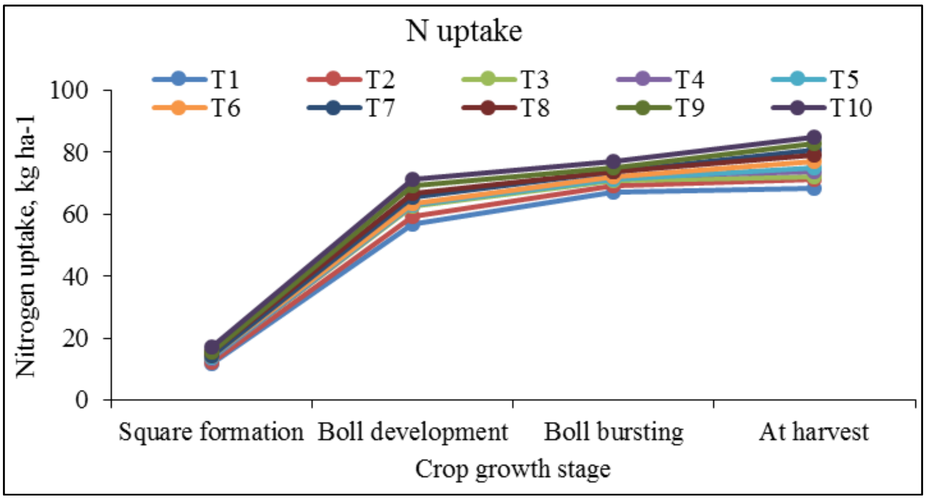

Fig 5: Effect of fertilizer application on nitrogen uptake

Table 4: Effect of nutrients application on nitrogen, phosphorous and potassium uptake

Tr. No.	Nitrogen uptake, kg/ha				Phosphorous uptake, kg/ha				Potassium uptake, kg/ha			
	SF	BD	BB	H	SF	BD	BB	H	SF	BD	BB	H
Mean	13.89	63.89	72.22	76.39	4.16	10.55	14.72	19.44	22.22	66.11	73.06	103.34
SE $\pm$	0.55	1.38	2.22	2.61	0.52	1.66	2.22	2.77	1.66	0.97	5.0	6.60
CD at 5%	1.95	4.16	NS	7.5	1.38	5.27	6.38	8.6	4.72	2.90	15.27	19.72

3.2.2 Phosphorous (P) uptake

The phosphorus uptake at various stage of crop growth showed significant variation due to various treatments (Fig. 6). The maximum P uptake 6.06 kg/ha recorded at square formation stage with treatment T_{10} followed by 5.09 kg ha^{-1} in treatment T9. Similar values of P uptake were recorded in T_6, T_7 and T_8 treatments. However, the P uptake was reduced significantly as the treatments were altered to T_3, T_4 and T_5. Further minimum P uptake was recorded in treatment T_2 which was similar as in control. Treatment T_{10} resulted in maximum P uptake of 14.46 kg ha^{-1} at boll development stage. Further it is also seen from the data that highest P uptake of 19.58 kg ha^{-1} recorded was with treatment T_{10} at boll bursting stage. The P uptake at harvest also showed similar pattern. In general it was seen that the uptake of phosphorus was increased with increase in age of crop and reached to maximum at harvest. The values of P uptake recorded in present study are similar to those as reported by Hullihalli and Patil (2006) [17], Rajarajan *et al.* (2005) [12] also reported increase in P uptake with increasing level of fertilizer. Similar results are also reported by Suresh and Suryaprabha (2003) [16]. The mean, SE and CD at 5% level of significance for phosphorous are given in Table 3.

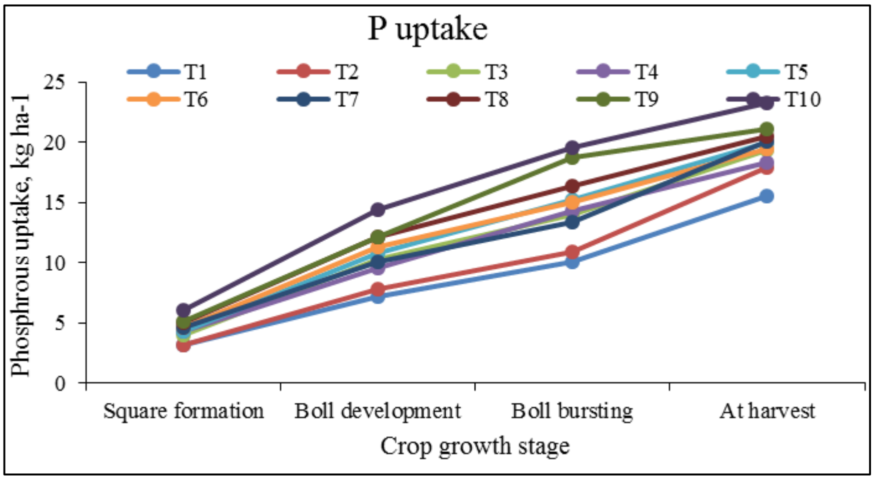

Fig 6: Effect of fertilizer application on phosphorus uptake

3.2.3Potassium (K) uptake

Effect of fertilizer application on potassium uptake is shown in Fig. 7. Maximum uptake 26.67 kg/ha was recorded in treatment T_{10} at square formation stage. Similar values of K uptake were noted in treatments T_5, T_6, T_7, T_8 and T_9. However, the K uptake decreased significantly as the treatments were altered to T_2, T_3 and T_4The K uptake at boll development stage, boll bursting and at harvest also showed similar pattern. The increase in uptake of K with increase in nutrients recorded in this study is in line with the findings reported by Suresh and Suryaprabha (2003) [16]. The values of K uptake observed in this study confirmed the findings of Rajarajan *et al*. (2005) [12], Hullihalli and Patil (2006) [17]. The mean, SE and CD at 5% level of significance for potassium are given in Table 3.

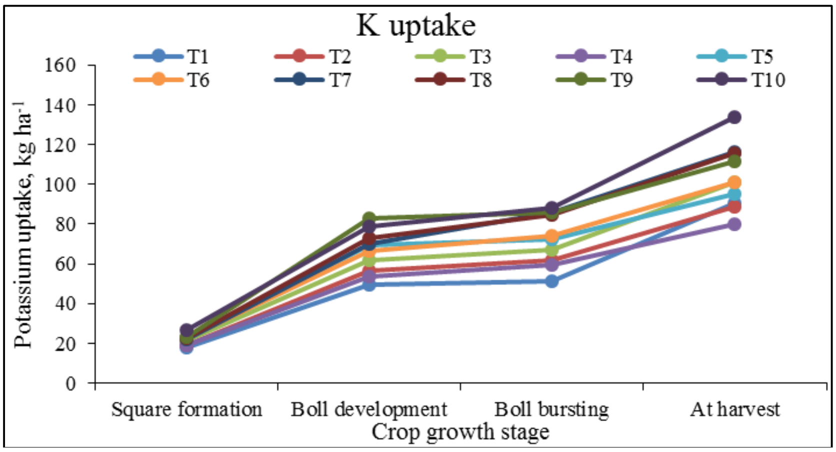

Fig 7: Effect of fertilizer application on potassium uptake

3.3 Effect of nutrients application on growth parameters of plant

3.3.1 Effect of nutrients application on plant height

The height of plant increased with age of plant in all treatments and crop growth stages. Maximum height of plant (69.3 cm) was recorded in T_{10} at boll bursting stage. Similar values were observed in treatment T_6, T_7, T_8 and T_9. The height of plants was lower in T_2, T_3, T_4 and T_5 treatments. The height of plant had significant effect in all treatments. However, the height of plant recorded all treatments was significantly higher than recorded in control. Findings are supported by Gurao *et al*. (2006) [18], Patil and Malewar (1994) [14], Awasaya *et al*. (2006) [19], Devraj *et al*. (2008) [15], Sharma *et al*. (19987) [20] and Katkar *et al*. (2005) [11]. The increase in plant height due to increase in nitrogen application was also reported by Bhaskar *et al*. (1993) [21]. The Mean, standard error and CD at 5% level of significance for square formation, boll development and boll bursting stage were 31.5, 1.3, 3.75; 49.4,3.2, 9.4; and 65.3, 1.7, 5.1, respectively.

3.3.2 Effect of nutrients application on Leaf area per plant

Leaf area increased with increase in age of plant in all growth stages and treatments. Leaf area for all treatments at Square formation, boll development and boll bursting stage ranged from 0.15 to 0.324, 0.397 to 0.702 and 0.626 to 0.1008 dm^2, respectively. The treatment T_{10} also showed highest value of leaf area of 1.008 dm^2 at boll bursting stage followed by 0.957 dm^2 in treatment T_9. The increase in leaf area/plant with increasing age of plant and increasing the nutrient observed in this study is in accordance with the results reported by Rao and Janwade (2006) [22], Babalad and Itnal (2004) [23].

3.3.3 Effect of fertilizer application on seed cotton yield

Highest seed cotton yield 19.22 q ha^{-1} was recorded in T_{10} treatment followed by T_9 (19.04 q ha^{-1}). The seed cotton yield in treatments T_8, T_7, T_6 and T_5 was 16.65, 16.42, 15.75 and 15.18 q ha^{-1}, respectively which was at par. Lowest yield (11.89 q ha^{-1}) was obtained in control. Mean, SE and CD at 5% level for seed cotton yield at harvest stage were 15.65, 1.445 and 4.294 q ha^{-1} respectively. Effect of nutrient application on seed cotton yield is shown in Fig. 8.

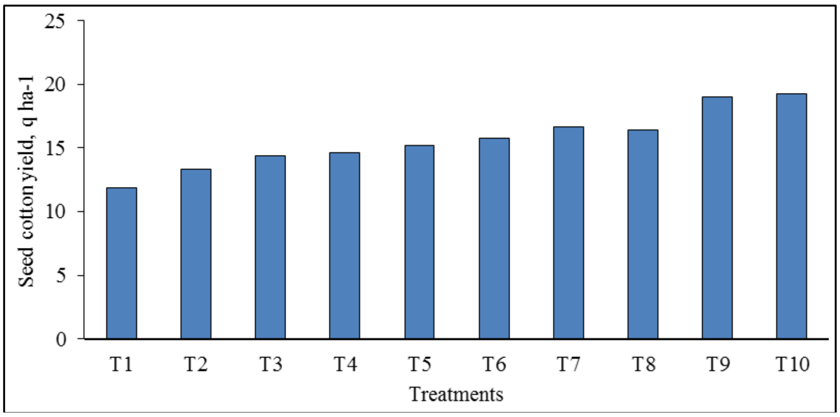

Fig 8: Effect of nutrient application on seed cotton yield

Conclusions

1. Application of fertilizers influenced the soil nutrients' availability, uptake pattern and growth parameters and cotton yield. Available nutrients viz., N, P, K, S, Zn, B, Mg in soil, nutrient uptake of NPK and biometric observations and yield of Bt cotton were maximum with nutrient combination of T_{10} (Recommended dose (125:62.5:62.5) +S).
2. Therefore, T_{10} followed by T_9 was found to be preventive for cotton reddening. T_{10} produced highest 19.22 q ha^{-1} followed by T_9 with 19.04 q ha^{-1} seed cotton yield. Therefore, considering plant pigments yield, T_{10} can be recommended for growing of Bt cotton under rainfed condition.

References

1. Bharambe PR. Integrated inputs management for productivity of Bt cotton. Proceedings of National symposium on Bt cotton: Opportunities and prospects. Central Institute for Cotton Research, Nagpur, 2009, 22-34.
2. CCI. Cotton Corporation of India Ltd. Mumbai, Government of India. www.cotcrop.gov.in/statistics.aspx #area, 2011.
3. Koleva SD, Edreva A, Velikova V, Gural A. Effect of reddening of cotton (G. hirsutum L.) leaves on the ulterstructure of mesophyll cells. Photosynthetica. 2005; 43(2):313-316.
4. Subbiah, Asija GL. Rapid procedure of Estimation of Available Nitrogen in Soil. Current science. 1956; 125:259-260.
5. Olsen SR, Colle CV, Watanabe FS, Dean LA. Estimation of Available Phosphorus in soil by Extraction with Sodium Bicarbonate. U.S. Department of Agriculture circular, 1954; 939.
6. Piper CS. Soil plant Analysis, Hans Publication, Bombay, 1966.
7. Tabatabai NA, Bremner JM. Simple turbidimetric methods of determination of total sulphur in plant. Agronomy journal. 1970; 62:805-808.
8. Jackson ML. Soil Chemical Analysis, Pretice Hall of India Pvt. Ltd. New Delhi. 1973, 498.
9. Lindsay WL, Narvell WA. Development of DTPA soil test for zinc, iron, Mn and Cu. Soil Science, Amar. Journal. 1978; 42:421-428.
10. Brever LC, Trough E. Boron availability in relation to soil reaction and organic matter content. Soil Science Society Amer. Proc. 1947; (10):113-116.
11. Katkar RN, Wankhade ST, Turkhade Lambe SP. Effect of integrated nutrient management in cotton grown on shallow soil on growth, cotton yield and physico-chemical properties. PKV Res. J. 2005; 39(2).
12. Raja Rajen A, Janaki P, Appani K, Vadivel A. Effect of fertilizer NPK and FYM on yield of cotton and nutrient status in black soil. Madras Agric. J. 2005; 92(4-6):266-270.
13. Shrinivasn G. Response of cotton (Gossypium hirsutum) to split application of major nutrients. Indian J. of Agron. 2003; 48(1):59-61.
14. Patil VD, Malewar GV. A statistical approach in yield, nitrogen relationship in a newly developed cotton hybrid (NHB 12). J. Indian Soc. Cotton. Improv. 1994; 19(1):54-60.
15. Devraj, Sharma AP, Duhan BS, Pramila kumari. Effect of organic source of nutrients on cotton productivity and nutrient use efficacy under irrigated condition. J. cotton Res. Dev. 2008; 22(1):69-73.
16. Suresh S, Suryaprabha. Crop yield and properties of vertisols as influenced by inorganic and organics under day farming in cotton-bajra sequence. International J. Agril. Science. 2003; (1):26-29.
17. Hulihalli UK, Patil VC. Effect of nutrient management practices on yield and nutrient uptake by cotton (G. herbaceum L.). PKV Res. J. 2006; 30(2):146-150.
18. Gurao B, Deshpande RM, Sarika V. Nutrient management studies in deshi cotton. J. of soils and crops. 2006; 76:222-226.
19. Awasaya HL, Jonson PL, Sawogi SK, Nanda HC, Kulkarni. INM in upland cotton (Gossipium hirsutim L.) under vertisols of Chattisgarh. J .Agri. 2006; 2:67-70.
20. Sharma JC, Sharma AP, Taneja AD. Effect of phosphorus application on the yield parameter and dry matter yield of different parts of the cotton plant (Gossypium hirsutum L.). J. Cotton Res. 1987; 1(1):67-71.
21. Bhaskar KS, Gaikwad ST, Ananthakumar. Response of upland cotton (Gossypium hirsutum L.) to the levels of fertilizers in shallow soils. Indian J. Agron. 1993; 38(1):89-92.
22. Rao S, Janawade AD. Studies on integrated nutrient management in irrigated hybrid cotton, J. Cotton Res. Dev. 2006; 20(2):212-215.
23. Babalad HB, Itnal CJ. Integrated nutrient management in cotton and soybean intercropping system on vertic inceptisols under rainfed condition. International symposium on strategies for sustainable cotton production – A global vision. Crop production. 2004; 2:92-97.