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Productivity, profitability and uptake of nutrients by BT. cotton (*Gossypium hirsutum* L.) as affected by nutrient omission

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Abstract
A field experiment on nutrient omission on productivity of Bt. cotton (*Gossypium hirsutum* L.) was conducted during 2015-16 on loamy sand at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experiment had 7 treatments laid out in randomized block design with four replications. Treatment comprised omission of N, P, K, S and Zn, optimum plane of nutrient ion (240-40-40-15-02 kg N-P-K-S-Zn/ha) and control (RDF: 240-40 kg N-P/ha). Nitrogen proved the most limiting nutrient and there was a reduction in the seed cotton yield to the tune of 26.3%, 19.1% and 10.7% due to N, P and K omission, respectively. The reduction in the seed cotton yield due to S (8.2%) and Zn (3.4%) omission was marginal. Total uptake of N, P, K and S by Bt. cotton were significantly reduced due to N and P omission treatments. Application of optimum plane of nutrition recorded significantly higher soil available N, P, K and S status after harvest of Bt. cotton. Higher net profit of 80672/ha was earned from cotton in the optimum nutrition i.e. N-P-K-S-Zn.

Keywords: Bt. Cotton, Nitrogen, Nutrient omission, Phosphorus, Potassium, Net profit, Sulphur, Zinc

Introduction
Nitrogen plays a key role among production inputs, which control growth and prevents abscission of squares and bolls, essential for photosynthetic activity and stimulates the mobilization and accumulation of metabolites in newly developed bolls, thus increasing their number and weight. Phosphorus is the second major element and it is an essential constituent of every living cell and for the nutrition of plant. It takes active part in all type of metabolism of plant. It is an essential constituent of majority of enzyme and also structural component of membrane system of cell and mitochondria. Potassium is essential element for the development of chlorophyll. It improves the health and vigour of the plant, enabling it to withstand adverse climatic conditions and increase resistance. Combined application of nitrogen, phosphorus, potassium, sulphur and zinc serve balanced nutrition to plant and resulted in increased growth and yield of Bt. cotton. Blaise *et al.* (2005) [4] reported that application of NPK yielded more seed cotton than the NP, PK or NK. Significant reduction in seed cotton yield was reported due to P and K omissions. Initiatives are made in recent years through nutrient omission approaches to arrive at the soil and fertilizer contribution to the crops performance. Yield in the plot balanced fertilization with good crop management can be used to estimate attainable yield target. Nutrient limited yield is determined from plots in which the nutrient of interest is not added. For example the N limited yield is determined in N omission plot receiving no N fertilizer but sufficient in P and K ensure that they do not limit yield.

Keeping the above facts in view, a field experiment was conducted to assess the contribution of various nutrients towards yield and profitability of cotton vis - a- vis optimum fertilization schedules using nutrient omission plot technique.

Materials and methods
A field experiment on Bt. cotton was carried out during *kharif* season of 2015-16 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat). The soil of the experimental field was sandy loam in texture, low in organic carbon (0.23 %), available nitrogen (151.22 kg/ha) and zinc (0.35 mg/kg), medium in available P (35.51 kg/ha) and sulphur (13.96 kg/ha) and high in

K (288.17 kg/ha). The experiment had 7 treatments, laid out in randomized block design with four replications. The treatments comprised omission of N, P, K. S and Zn, control (Recommended Dose of Fertilizer i.e. RDF: 240-40 kg N-P/ha) and optimum plane of nutrition (240-40-40-15-02 kg N-P-K-S-Zn/ha). 240-40-40-15-02kg N-P-K-S-Zn/ha, respectively was applied as optimum fertilizer dose. The fertilizers used were urea (46% N) for N, SSP (16% P_2O_5) for P, muriate of potash (60% K_2O) for K, gypsum (15% S) for S and zinc oxide (81% Zn) for Zn, so that each fertilizer shall supply only a single nutrient under investigation. One forth part of N and full dose of P, K, S and Zn were applied as basal application to cotton. Remaining N was applied at 30, 60 and 90 DAS in three equal splits. Total rainfall received during crop season was 650 mm. The cost of cultivation and relative economics of cotton crop was calculated on the basis of minimum support price of the inputs and the produce.

After harvest, treatment wise seed and stalk samples were collected for N, P, K, S and Zn nutrient content analysis and accordingly nutrient uptake by plant was calculated using the following formula.

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%) x Biological yield (kg/ha)}}{100}$$

Nitrogen was determined by Micro Kjelldahl method, P was estimated in aliqiots colorimetrically using Vanadomolybdate yellow colour method, K was determined with flame photometer, S was determined by and Zn was determined by method. After harvest of cotton crop, the soil samples (0-15 cm) were collected and analyzed for available N, P, K, S and Zn by adopting standard standard analytical methods. Statistical analysis of data was carried out using standard analysis of variance.

Results and discussion

Growth and yield attributes, stalk and seed cotton yield

Nutrient omission significantly influenced growth and yield components of Bt. cotton (Table 1). Among different nutrient omission treatments, N and P omission resulted in severe reduction in plant height, number of monopodial and sympodial branches per plant, bolls per plant, weight of seeds per boll, 100 seeds weight and seed cotton yield per plant. Omission of K also resulted in drastic reduction of plant height, number of sympodial branches per plant and seeds per boll. The effect of S and Zn omission on growth and yield attributes was not pronounced as that of macro nutrients i.e. N, P and K.

The seed cotton yield was significantly affected by nutrient omission treatments (Table 1). Seed cotton yield ranged from 2171 to 2944 kg/ha. The reduction seed cotton yield was 26.3, 19.1 and 10.7 % due to N, P and K omission, respectively. The corresponding figure for control plot (RDF) was 14.7%. N omission resulted in drastic reduction in growth, yield components and yield, highlighting the importance of N in cotton production in N deficient soils. These findings corroborate the results of Hussain *et al.*, (2013) [8]. P omission resulted in a yield reduction of 19.1% of cotton highlighting the fast depletion of soil P resources. Charles *et al.* (2005) [5] from long term experiment reported that yield losses when P was not applied during the preceding ten years accounted to 57% compared to standard fertilization (N, P, K and S with micronutrients). The reduction in seed cotton yield due to K omission was 10.7%, but was statistically at par with optimum fertilization, signifying the importance of K nutrition in cotton production. Yield losses to the tune of 20% due to K omission have been reported by Biradar *et al*., (2011) [2]. It appears that K supplies from soil remained more or less constant. It might also be due to the fact that cotton being deep rooted plant, absorbed more K from the deeper soil layers (Gulick *et al.*, 1989) [7]. Seed cotton yield reduction due to S and Zn omission was 8.15 and 3.3%, respectively but was statistically at par with optimum fertilization. Several workers have reported a non-significant response of cotton to S (Prasad, 2010) [9] and Zn (Yin *et al.*, 2011) [10] application. The reduction in seed cotton yield was mainly attributed to the lesser number of sympodial branches per plant, bolls per plant, weight of seed per bolls and 100 seeds weight (Table 1). Hussain *et al.*, (2013) [8] reported that omission of N, P and K resulted in drastic reduction of seed cotton yield as compared to optimum plane of nutrition i.e. application of N, P, K, S and Zn. The results are supported by Gadhiya *et al.*, (2009) [6] indicated that application of N-P-K 240-20-40 kg/ha registered significantly the highest seed cotton yield compared to P-K, N-K and N-P application.

Growth and biomass production i.e. plant height and number of monopodial branches per plant were significantly lowered by the limited indigenous nutrient supply. This was reflected in the reduction of stalk yield. Stalk yield ranged from 3548 to 4259 kg/ha (Table 1). The stalk yield was strongly related to the N supply, omission of which resulted in 25.8 % reduction in stalk yield. The reduction in stalk yield was and 16.6, 2.8 % due to P and K omission, respectively. Gadhiya *et al.* (2009) [6] reported that combine application of all three major nutrients gave significantly higher cotton stalk yield than rest of the treatments.

Nutrient uptake

Total N uptake varied from 53.8 to 94.0 kg/ha by plant at harvest stage. N and P omission treatments as well as application of RDF (NP only) had significantly reduced N uptake by cotton at harvest. N stimulates growth and dry matter production and thus resulted in higher uptake of N. These results are in agreement with Bhalerao *et al.*, (2012) [2]. P uptake decreased significantly in RDF, N and P omission plots as compared to rest of the treatments. Hussain *et al.*, (2013) [8] reported that N omission also reduced the P uptake significantly by cotton and wheat crops in cotton-wheat cropping system. The total K uptake was ranged from 42.6 to 30.2 kg/ha. Significantly lower K uptake was observed in control (application of RDF @ 240-40 kg N-P/ha), N and P omission treatments. N omission had more severe impact on K uptake than the K omission itself. Higher K accumulation in different plant parts of cotton and K uptake have also been reported in K applied treatments (Aladakatti *et al.*, 2011) [1]. K uptake in S and Zn omission plots was at par with optimum fertilization plot. Higher content of N, P and K in both cotton and stalk as well as higher yield of seed cotton and stalk consequently resulted in more uptake of N, P and K by Bt cotton crop.

Soil fertility

Soil available N, P_2O_5, K_2O and S were significantly affected by nutrient omission treatments (Table 4). Among the nutrient omission treatments, application of optimum plane of nutrition (T_1) recorded significantly higher soil available N, P_2O_5, K_2O and S status as compared to N omission treatment (T_2) with respect to soil available N and P_2O_5 and control treatment (T_7) with respect to soil available K_2O and S. the lowest soil available N and P status was noted with N

omission treatment (T_2), P_2O_5 with P omission treatment and K and S status with control treatment (T_7). This might be due to application of 240 kg N + 40 kg P_2O_5 + 40 kg K_2O + 15 kg S + 2 kg Zn/ha, which accumulated in soil resulted in building up of nutrients in the soil. Similar findings have been reported by Gadhiya *et al.* (2009) [6].

Economics

Bt. cotton profitability was considerably affected by nutrient omissions (Table 2). Cost of cultivation differed marginally on account of nutrient omission but resulted in large differences in the seed cotton yield and net profit. Consistently higher net results of ₹ 80,671 were realized in balanced fertilization treatment (T_1) followed by Zn omission treatment (T_6). The highest B:C ratio of 2.73 was also realized in the optimum nutrition plots. The lowest net profit and B:C ratio were realized in N omission treatment (T_2). Hussain *et al.* (2013) [8] observed that application of 150 kg N, 26.4 kg P, 50 kg S and 3 kg Zn/ha gave higher net returns and B:C ratio.

Table 1: Growth and yield attributes, stalk and seed cotton yield of Bt. cotton as influenced by different nutrient omission treatments

Treatments	Plant height (cm)	Monopodial branches per plant	Sympodial branches per plant	Bolls per plant	Weight of seeds / boll (g)	Weight of 100 seeds (g)	Seed cotton per plant (g)	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)
T_1: N-P-K-S-Zn	146.5	4.9	24.4	58.3	4.18	9.20	254.3	2944	4259
T_2: P-K-S-Zn (-N)	118.3	3.5	16.2	42.7	2.99	7.73	162.4	2171	3157
T_3: N-K-S-Zn (-P)	125.1	4.0	18.5	47.9	3.15	8.04	191.8	2383	3548
T_4: N-P-S-Zn (-K)	131.9	4.2	20.9	52.9	3.60	8.64	224.5	2629	4140
T_5: N-P-K-Zn (-S)	138.6	4.4	22.4	55.7	3.76	8.90	242.1	2704	4061
T_6: N-P-K-S (-Zn)	143.3	4.5	23.3	57.0	3.91	9.09	250.8	2844	4168
T_7: Control (RDF)	128.4	4.1	19.4	49.8	3.30	8.16	206.5	2509	3629
S.Em. ±	5.53	0.21	0.83	2.21	0.14	0.34	10.96	132.64	208.12
C.D.(P= 0.05)	16.42	0.63	2.47	6.56	0.42	1.01	32.56	394.08	618.37
C.V. (%)	8.30	10.13	8.04	8.49	8.00	7.97	10.01	10.21	10.81

Table 2: Economics of Bt. cotton as influenced by different nutrient omission treatments

Treatments	Cost of cultivation (₹/ha)	Net return (₹/ha)	BCR
T_1: N-P-K-S-Zn	46557	80672	2.73
T_2: P-K-S-Zn (-N)	45603	48243	2.06
T_3: N-K-S-Zn (-P)	44617	58414	2.31
T_4: N-P-S-Zn (-K)	45438	68375	2.50
T_5: N-P-K-Zn (-S)	45966	70974	2.55
T_6: N-P-K-S (-Zn)	46215	76729	2.66
T_7: Control (RDF)	44721	63714	2.42
S.Em. ±	-	5666.1	0.1
C.D.(P= 0.05)	-	16834.9	0.3
C.V. (%)	-	17.0	10.1

Table 3: N, P and K uptake in cotton seed and stalk as influenced by different nutrient omission treatments

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Seed	Stalk	Total	Seed	Stalk	Total	Seed	Stalk	Total
T_1: N-P-K-S-Zn	53.8	40.2	94.0	14.2	10.0	24.2	20.0	22.6	42.6
T_2: P-K-S-Zn (-N)	32.2	21.6	53.8	10.1	6.8	16.9	14.3	15.9	30.2
T_3: N-K-S-Zn (-P)	40.5	28.9	69.4	10.4	6.2	16.6	15.8	18.1	33.9
T_4: N-P-S-Zn (-K)	46.5	37.1	83.6	12.6	9.3	21.9	16.3	19.3	35.6
T_5: N-P-K-Zn (-S)	47.9	37.3	85.2	12.7	9.1	21.8	18.0	20.8	38.8
T_6: N-P-K-S (-Zn)	52.0	38.6	90.6	13.5	9.4	22.9	19.0	21.6	40.6
T_7: Control (RDF)	44.1	31.2	75.3	11.6	7.9	19.5	15.4	16.8	32.2
S.Em. ±	2.3	1.7	-	0.7	0.5	-	0.9	1.3	-
C.D.(P= 0.05)	6.8	5.1	-	2.1	1.6	-	2.8	3.8	-
C.V. (%)	10.1	10.5	-	11.6	12.7	-	11.1	13.4	-

Table 4: Nutrient status of soil after harvest of crop as influenced by different nutrient omission treatments

Treatments		Available nutrient in soil				
		N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	S (mg/kg)	Zn (mg/kg)
T_1	N-P-K-S-Zn	165.7	39.3	310.3	17.25	0.38
T_2	P-K-S-Zn (-N)	146.5	36.4	303.7	16.20	0.36
T_3	N-K-S-Zn (-P)	160.3	35.3	306.5	16.86	0.37
T_4	N-P-S-Zn (-K)	162.4	38.7	286.4	17.07	0.37
T_5	N-P-K-Zn (-S)	163.3	39.1	309.1	15.00	0.36
T_6	N-P-K-S (-Zn)	164.6	39.2	311.3	17.15	0.36
T_7	RDF	161.6	37.4	283.9	14.91	0.35
S.Em. ±		3.37	0.86	6.14	0.42	0.01
C.D.(P= 0.05)		10.01	2.56	18.24	1.23	NS
C.V. (%)		4.19	4.54	4.07	5.08	4.58

Conclusion

From the present study on Bt. cotton, it is concluded that N is the most limiting nutrient and its omission resulted in drastic reduction in seed cotton yield and net returns and P omission proved the second most limiting nutrient in cotton production and K omission resulted in marginal yield responses in Bt. cotton. S and Zn omission had not significant yield reduction. Thus, balanced fertilization (N-P-K-S-Zn) in Bt. cotton is very important to maintain soil fertility and profitability of cotton.

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