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Effect of foliar application of nutrients on nutrient content, uptake and yield of *Bt* Cotton

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Abstract
A field experiment was conducted on farmers field at Kautha, Tq. Kandhar, Dist. Nanded, Maharashtra during *Kharif*-2018 to find out the effect of foliar nutrition on leaf reddening of *Bt* (*Gossypium spp*.) cotton under rainfed condition. The experimental result indicated that among the various treatments application of 100 per cent RDF + foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% and micronutrient grade II @ 0.5% followed by 100% RDF + 19:19:19 @ 1%+ $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5% at critical growth stages helps in increase the leaf nutrient status, uptake of N, P, K, S, B, Fe, Mn, Zn, Cu and increases the yield of *Bt* cotton under rainfed condition.

Keywords: *Bt* cotton, nutrient content, uptake and yield

Introduction
Cotton is an important commercial crop of India grown under diverse agro-climatic conditions and play vital role in Indian economy. Popularly known as 'White Gold' and 'King of Fibre' contribute about 85 per cent of raw material to textile industries. It is grown in both irrigated as well as rainfed tracts and in rainfed areas yield of cotton mainly depends on timing and intensity of rainfall. The rainfed cotton frequently grown on shrink-swell type of soil. It is grown mainly for fibre production and seed yield is considered to be secondary importance. Now a days farmers are unable to gain maximum production of *Bt* cotton as compared to area under cultivation due to several constraints *viz.* uneven distribution of rainfall throughout the growing period of cotton, imbalanced application of inorganic fertilizers without knowing soil nutrient status and nutrient requirement of cotton. In *Bt* cotton due to synchronized boll development rapid translocation of nutrients toward bolls from the leaves occur causes deficiency of nutrients that's why It is necessary to supply optimum amount of macro and micronutrients to maximize the yield of *Bt* cotton (Hebbar *et al.* 2007) [4]. Foliar feeding is often effective when roots are unable to absorbs sufficient amount of nutrients from the soil due to soil moisture stress and higher degree of fixation at critical growth stages *Bt* cotton which would help to improve nutrient status in leaf. Considering the above fact the experiment was conducted to overcome this problem by foliar application of macro and micronutrients.

Material and Methods
A field experiment was conducted to study the effect of foliar nutrition on leaf reddening of *Bt* cotton (*Gossypium spp.)* under rainfed condition on farmers field at Kautha, Tq. Kandhar, dist. Nanded, Maharashtra, India during *Kharif-2018.* The experiment was laid out in Randomized Block Design with eight treatments and three replications. The *Bt* cotton variety Ajeet-155 was sown 24 plots of size 5x 4 m^2 each. The seeds were dibbled at the spacing of 120 x 45 cm. The soil of experimental plot was montomorillonitic calcic haplusterts, deep black were pH- 7.9, Electrical conductivity (EC) 0.30 ds m^{-1}, Organic carbon (OC) 0.60%, $CaCO_3$ 9.5%, Available nutrients (Kg ha^{-1}) N- 175.61, P- 13.44, K- 427.84. Recommended dose of fertilizer (100:50:50 NPK ha^{-1}) were supplied through Urea, SSP, and Muriate of potash respectively. Twenty per cent nitrogen and full P, K were applied at the time of sowing as basal dose the remaining eighty per cent N was applied through urea in two equal split dosage. The composite soil sample before sowing was taken for their initial values. The soil pH and EC were analyzed using 1:2.5 (soil: water) suspension, available N by alkaline $KMnO_4$ method as described by Subbiah and Asija (1956) [14], available P by Olsen *et al.* (1954) [9] and available K by flame photometer as described by Jackson (1967) [6]. Foliar application of multi-nutrients were carried out at critical growth stages of cotton *viz.*70, 90 and 120 DAS respectively. The treatments were T_1- Control (N_{100} P_{50} K_{50}), T_2 – 100% RDF + water spray, T_3- 100% RDF + Urea @ 2% foliar spray, T_4- 100% RDF + 19:19:19 @ 1% foliar spray, T_5- 100% RDF + KNO_3 @ 2% foliar spray, T_6- 100% RDF + $MgSO_4$ @ 1% foliar spray,

T_7- 100% RDF + foliar spray of DAP @ 1% +KNO_3 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5%, T_8 – 100% RDF + Foliar spray of 19:19:19 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5%. The leaf samples with petiole collected at flowering, boll formation and boll development stages of cotton, samples were decontaminated by using 2% teepol solution and 0.1 N HCL followed by dipping in distilled water and dried at 70^0 C in hot air oven and dry samples were grind in grinder. Plant extract was prepared and analyzed for total N by modified Kjeldahl method by using keplus digestion and distillation unit, total P determined spectophotometrically by Vandomolybdate phosphoric acid yellow colour method by di-acid extract described by (Jackson, 1967) [6], total K determined on flame photometer, total sulfur was determined by barium chromate colorometric method given by Palaskar *et al.* (1981) [10] and Total boron by Azomehine H method using spectrophotometer. Total Zn, Cu, Mn and Fe were estimated by standard procedure Piper 1966 [11]. The uptake of nutrients (Kg ha^{-1}) were worked out by multiplying the percentage of these nutrients with the corresponding yield of the respective constituent.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x Total dry matter production (Kg ha}^{-1})}{100}$$

Yield data was collected from experimental plot in terms of Kg ha^{-1} from each plot and yield/ ha in quintals was calculated on the basis of total yield.

Results and Discussion

Leaf Nutrient content

Total Nitrogen

It was evident from the results that the leaf nutrient concentration was influenced due to various foliar applications of nutrients at critical growth stages of crop presented in (table 1). The maximum concentration of nitrogen (2.95%) in leaves of cotton was recorded with 100% RDF + foliar application of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% combine with micronutrient grade II @ 0.5% and the treatment T_1 (RDF) recorded lowest nitrogen concentration (1.07%). Moreover it was found at par with T_8 comprised of 100% RDF + Foliar spray of 19:19:19 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5%. Similar results were also recorded by Malode and Tamgadge (2016) [7] they revealed that treatment containing urea @ 2 per cent and DAP @ 2 per cent recorded maximum nitrogen content (1.61 and 1.61 per cent) at flowering and boll development stage respectively.

Total Phosphorus

Data revealed that maximum phosphorus in leaves of *Bt* cotton(0.49%) recorded due to application of 100% RDF + foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% combine with micronutrient grade II @ 0.5% and found at par with T_8. Similar finding also reported by Rehab *et al.* (1991) [12] they concluded that foliar application of folifertil which comprises of micro and macronutrients found to be increases the concentration of N, P, Zn, Fe, Mn and Cu in cotton leaf.

Total Potassium

The K concentration in leaf sample varied with treatments and it was ranged from 1.02 to 2.65 per cent. Maximum K content (2.65%) in leaf sample of cotton crop was noticed in treatment T_7 -RDF + foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5% and found at par with T_8 and minimum leaf potassium (1.02%) recorded due to application of 100 per cent RDF only (T_1).

Table 1: Effect of foliar nutrition on leaf nutrient content of *Bt* cotton

Treatment	N content (%)	P content (%)	K Content (%)	S Content (%)	B content (mg kg^{-1})	Fe Content (mg kg^{-1})	Mn Content (mg kg^{-1})	Cu Content (mg kg^{-1})	Zn Content (mg kg^{-1})
T_1- Control (100% RDF)	1.07	0.14	1.02	0.18	22.18	66.16	44.20	27.86	38.96
T_2 – 100% RDF + Water spray	1.22	0.16	1.08	0.20	22.88	67.50	44.50	29.36	39.76
T_3 – 100% RDF + 2% urea	2.73	0.38	1.60	0.25	32.29	70.08	46.53	33.10	40.26
T_4 -100% RDF + 1% 19:19:19	2.35	0.41	2.05	0.27	33.32	72.70	49.00	33.26	42.73
T_5 – 100% RDF + 2% KNO_3	2.59	0.45	2.49	0.28	34.17	74.00	54.36	34.63	43.66
T_6 - 100% RDF + 1% $MgSO_4$	2.70	0.45	2.20	0.29	33.09	73.83	54.56	34.43	42.90
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.95	0.49	2.65	0.32	35.19	76.70	55.80	35.90	47.33
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.87	0.46	2.59	0.30	34.91	74.43	55.60	35.43	47.16
CD at 5%	0.201	0.027	0.125	0.031	3.419	0.910	1.285	1.496	0.977

Total Sulfur and Boron content

Data regarding concentration of sulfur and boron presented in table 1 revealed that foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% combine with micronutrient grade II @ 0.5% along with 100% RDF recorded the maximum concentration of sulfur (0.32%) and boron (35.19 mg kg^{-1}) whereas, minimum sulfur (0.18%) and boron (22.18 mg kg^{-1}) concentration was recorded with the application of RDF only (T_1). In case of sulfur concentration T_7 found at par with T_8, T_6 and T_5.

Iron, manganese, copper and zinc content

Treatment T_7 recorded the Maximum concentration of leaf iron (76.70), manganese (55.80), copper (35.90) and zinc (47.33). It might be due to foliar application of tracer nutrients helps in effective absorption of nutrients through leaves of *Bt* cotton. Whereas, application of 100% RDF recorded the minimum concentration of these micronutrient. Similar observation was recorded by Temiz *et al*. (2009) [15] reported that application of foliar potassium, and micronutrients additions increased Zn, Cu, Fe, S, Mn, Mg, Na, Ca and K rates in the leaf compared with untreated control.

Uptake of N P K (kg ha^{-1})

The uptake of nitrogen calculated on dry matter basis of cotton. The dry matter uptake of nitrogen varied in range of 57.48 to 94.96 kg ha^{-1}. The data showed that maximum uptake of nitrogen was noticed with treatment T_7 (94.96 kg ha^{-1}) followed by treatment T_8 (91.10 kg ha^{-1}) further, as per variation in treatments the uptake of nitrogen was decreased,

while, lowest uptake of nitrogen was noticed with treatments T_1 (57.48 kg ha^{-1}) where only RDF was applied. The data indicated that the highest P uptake was noticed in treatment T_7 (18.74 kg ha^{-1}) which was significantly superior over rest of the treatments. Whereas, treatment T_8 and T_5 found at par with each other. Lowest P uptake was noticed in treatment T_1-RDF (4.78 kg ha^{-1}).

The uptake of K is presented in table 2 the potassium uptake of cotton was in range between 48.36 to 89.42 kg ha^{-1}. From the data it was observed that treatment T_7 (89.42 kg ha^{-1}) comprised of RDF + foliar application of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5% found significantly superior over all other treatments followed by treatment T_8 (82.16 kg ha^{-1}). Further, the influence of different treatment on uptake of K followed in the order $T_7 > T_8 > T_5 > T_4 > T_6 > T_3 > T_2 > T_1$.

The increased uptake of major nutrients was mainly due to the fact that micronutrients involved in nitrogen fixation and translocation into plant parts, which might have leads to higher dry matter production. In case of potassium uptake, better plant growth leading to higher uptake of nutrients and further on stimulatory effect of zinc in absorption of potassium and synergetic effect of applied nutrients.

Table 2: Effect of foliar nutrition on uptake of Nitrogen, Phosphorus and Potassium

Treatment	Nutrient uptake (kg ha^{-1})		
	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1- Control (100% RDF)	57.48	4.78	48.36
T_2 – 100% RDF + Water spray	59.13	5.87	49.03
T_3 – 100% RDF + 2% urea	86.28	14.18	59.28
T_4 -100% RDF + 1% 19:19:19	77.63	15.67	69.24
T_5 – 100% RDF + 2% KNO_3	86.49	16.71	82.65
T_6 - 100% RDF + 1% $MgSO_4$	80.08	16.32	68.74
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	94.96	18.74	89.42
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	91.10	17.56	82.16
CD at 5%	4.518	1.102	4.005

The results o*Bt*ained in the present research trial are in agreement with the result reported by Hosmani *et al.* (2013) [5] they reported that among the foliar spray of liquid fertilizer foliar spray of Bio-20 @ 3ml/lit containing macronutrients along with micronutrients recorded the maximum uptake of N (110.80 kg ha^{-1}), P (30.16 kg ha^{-1}) and K (112.25 kg ha^{-1}). Similar result were also observed by Sanghravikiran *et al.* (2012) [13] they revealed that application of 125 per cent RDF with foliar spray of 0.5% tracel micronutrient recorded the highest uptake of potassium (115.52 kg ha^{-1}) and nitrogen (111.94 kg ha^{-1}) as compared with other treatments.

Uptake of sulfur and boron

The data on effect on different foliar application of nutrients along with RDF on uptake of sulfur and boron presented in table 3. Data revealed that uptake of sulfur found in range of 8.04 to 12.33 kg ha^{-1}. Maximum uptake of sulfur found in treatment T_7 (12.33 kg ha^{-1}) which found at par with treatment T_8 and lowest uptake of sulfur found in treatment T_1 (8.04 kg ha^{-1}) where only RDF was applied.

The data on uptake of boron presented in table 3 data revealed that the uptake of boron by cotton was varied range from 20.57 to 32.82 g kg^{-1}. However, treatment T_7 (32.82 g kg^{-1}) recorded the maximum uptake of boron and found significantly superior over rest of the treatments. Whereas, treatment T_8, T_5 found at par with each other. Minimum uptake of boron recorded with treatment T_1 (20.57 g kg^{-1}).

Increased uptake of sulfur due to application of sulfur through $MgSO_4$ in which sulfur may be result of assimilation pattern of N and S in plants. Uptake of boron was higher in treatment T_7 due to application of boron through micronutrient Grade II. Boron availability helped to improve the overall growth of crop. It increased the total uptake as well, although magnitude of increase depends upon the concentration and total dry matter accumulation. This might be due to enhanced root development, uptake and translocation of nutrients in plant in presence of zinc and boron.

Table 3: Effect of foliar nutrition on uptake of sulfur and boron

Treatment	Nutrient uptake	
	S uptake (Kg ha^{-1})	B uptake (g kg^{-1})
T_1- Control (100% RDF)	8.04	20.57
T_2 – 100% RDF + Water spray	8.75	22.24
T_3 – 100% RDF + 2% urea	9.60	22.14
T_4 -100% RDF + 1% 19:19:19	9.47	27.20
T_5 – 100% RDF + 2% KNO_3	10.37	28.77
T_6 - 100% RDF + 1% $MgSO_4$	10.35	27.80
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSo_4$ + 0.5% Micronutrient grade II	12.33	32.82
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	11.23	29.82
CD at 5%	1.238	1.588

Uptake of zinc, iron, manganese and copper

The uptake of zinc varied from (22.07 to 25.99 g kg^{-1}) maximum uptake of zinc recorded with treatment T_7 (25.99 g kg^{-1}) followed by treatment T_8 (25.30 g kg^{-1}) and lowest value recorded with treatment T_1 (22.07 g kg^{-1}). Increased zinc uptake might be due to supply of these nutrients from the applied micronutrient fertilizers.

Table 4: Effect of foliar nutrition on Zn, Mn, Fe and Cu uptake

Treatment	Nutrient uptake (g kg^{-1})			
	Zn uptake (g kg^{-1})	Mn uptake (g kg^{-1})	Fe uptake (g kg^{-1})	Cu uptake (g kg^{-1})
T_1- Control (100% RDF)	22.07	64.41	70.11	9.55
T_2 – 100% RDF + Water spray	22.35	65.34	73.12	9.81
T_3 – 100% RDF + 2% urea	22.80	70.04	72.57	11.31
T_4 -100% RDF + 1% 19:19:19	23.93	70.81	73.47	11.45
T_5 – 100% RDF + 2% KNO_3	24.55	75.82	75.50	12.50
T_6 - 100% RDF + 1% $MgSO_4$	23.55	75.43	75.08	12.44
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	25.99	82.02	76.12	13.80
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSo_4$ + 0.5% Micronutrient grade II	25.30	79.44	76.02	13.15
CD at 5%	1.218	0.934	1.586	0.566

The data on uptake of Mn presented in table 4 data showed that uptake of Mn by cotton varied range from 64.41 to 82.02 g kg^{-1}, further uptake of Mn by cotton was noticed significantly superior with treatment T_7 (82.02 g kg^{-1}) whereas, minimum uptake recorded with treatment T_1-RDF (64.41). The data on uptake of iron presented in table 4, data revealed that uptake of Fe by cotton varied ranges from 70.11 to 76.12 g kg^{-1}. However, treatment T_7 (76.12 g kg^{-1}) recorded the maximum uptake of Fe and found at par with treatment T_8 (76.02 g kg^{-1}) and T_5 (75.50 g kg^{-1}) and T_6 (75.0 g kg^{-1}) lowest value recorded with treatment T_1 (70.11 g kg^{-1}).

This could be due to iron improved the plant growth and prevent nutritional disorders and consequently caused to increase the uptake of iron.

The data regarding Cu uptake presented in table 4. showed that copper uptake by cotton was varied in range of 9.59 to 13.80 g kg^{-1} and treatment T_7 - RDF + foliar application of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5% (13.80 g kg^{-1}) found significantly superior over rest of the treatments followed by treatment T_8 while, lowest uptake of copper recorded with treatment T_1.

The micronutrient uptake significantly increased with foliar application of macro and micro nutrients combination and this could be due to higher dry matter production. Similar finding was also reported by Namdev *et al*. (1992) [8] they noticed that foliar spraying of 1% Micnelf containing Zn, Cu, Fe, Mn, Mo and B recorded highest content and uptake of micronutrients.

Cotton yield

The data regarding cotton yield were recorded at harvest stage influenced by different treatments are mentioned in table 5.

Table 5: Effect of foliar nutrition on yield of cotton

Treatments	Cotton yield (qt/ha)
T_1- Control (100% RDF)	8.85
T_2 – 100% RDF + Water spray	8.91
T_3 – 100% RDF + 2% urea	10.58
T_4 -100% RDF + 1% 19:19:19	11.43
T_5 – 100% RDF + 2% KNO_3	11.96
T_6 - 100% RDF + 1% $MgSO_4$	11.27
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	12.45
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	12.37
CD at 5%	1.190

Treatment T_7 comprised of RDF + foliar application of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5% found to be recorded maximum cotton yield (12.45qt/ha) and this treatment found at par with treatments T_8, T_5, T_4 and T_6. Minimum yield recorded with treatment T_1-RDF (8.85 qt/ha). Increase in yield of cotton might be due to foliar application of macro and micronutrients which are constituents of enzymes which regulate various metabolic reactions (oxidation and reduction) in the plant. These reactions are essential to plant development and reproduction. Moreover, it control the trace of macro and micronutrients in plant at boll formation and boll development stage, it reduce the formation of anthocyanin pigment in plant and increases the chlorophyll content in plant.

Similar results were also recorded by Guertal *et al.* (1996) [3] they reported that micronutrient spray from seedling stage to boll formation stage up to 100 days after sowing was found to influence cotton yield positively. Above result is also in line with Basha *et al.* (2017) [1] they concluded that foliar spray of 2% KNO_3 and 1% $MgSO_4$ along with RDF recommended for getting higher yield of cotton.

Conclusions

It is concluded that application of multinutrients *viz*. 100% RDF + foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% and micronutrient grade II @ 0.5% followed by 100% RDF + 19:19:19 @ 1%+ $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5% at critical growth stages found to be effective for control the stress of nutrients and increases the nutrient uptake and yield of *Bt* cotton under rainfed condition.

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