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Effect of Micronutrient Application under Different Fertilizer Prescriptions on Post-Harvest Nutrient Status of Soil, Yield and Economics of Bt Cotton

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ABSTRACT

An experiment was conducted to study the effect of micronutrient application under different fertilizer prescription methods on yield, economics and post-harvest nutrient status of soil of Bt cotton at KVK farm, Chamarajanagar district, Southern Dry Zone of Karnataka (Zone 6). The experiment was laid out in randomised complete block design with thirteen treatments and three replications during *kharif* 2016 and *kharif* 2017. The soil was slightly alkaline in reaction (pH: 7.95), low in nitrogen, medium in phosphorus, high in potassium and low in zinc (0.32 mg kg^{-1}) and boron (0.18 mg kg^{-1}). Significantly higher seed cotton yield (2329 kg ha^{-1}) was recorded in the treatment NPK as per SSNM + micronutrient fertilizers foliar application at 80 and 100 DAS, followed by NPK as per UAS-B package + MNM foliar application at 80 and 100 DAS (2215 kg ha^{-1}) and NPK as per SSNM + MNM soil application (2012 kg ha^{-1}) treatments as compared to control. The treatments NPK as per SSNM + micronutrient fertilizers foliar application at 80 and 100 DAS and NPK as per UAS-B + micronutrient fertilizers foliar application at 80 and 100 DAS were significantly superior in economics and showed higher net returns and B : C ratio than any other treatment (Rs.77072, 2.75 and Rs.71714, 2.65, respectively). Post harvest soil showed higher N and P_2O_5 contents in the treatment with UAS-B nutrient management compared to SSNM. Soil available potassium was recorded higher in SSNM treatments. Exchangeable calcium and magnesium content of soil was significantly higher in treatments that received only NPK. Available micronutrients were higher in the treatments which received soil application of micronutrients along with macronutrients applied as per SSNM and UAS-B recommendations. SSNM method with micronutrient foliar application was found to be the better practice for sustaining soil nutrient status.

Keywords : Chitosan nanoparticles, Rice, Characterization, Bacterial leaf blight, *Xanthomonas oryzae*

NUTRIENT management is key function in sustaining crop productivity and soil properties. Bt Cotton being a dynamic crop, requires nutrients throughout the growth due to overlapped vegetative and reproductive stages. Soil fertility may decline due to nutrient exploration from high yielding cotton crop and this in turn, limits the productivity of future crops unless these nutrients are replaced (Ian Rochester, 2007). Added to this, the management practices also influence the nutrient availability to the crop. Due to various reasons like nil or lower doses of organic manure application, cultivation of high yielding Bt cotton hybrids, variations in soil moisture availability, problematic soil conditions, untimely and imbalanced nutrient supplementation especially micronutrients, etc. result in low production. Micronutrients play a vital role in plant growth and productivity by improving the physiological functions. Hence, supplementation of micronutrients along with macronutrients has significantly resulted in increased growth and yield as evidenced by various studies reported by Yaseen *et al*. (2004), Sangh Ravikiran *et al*. (2012) and Singh (2009). Optimizing nutrient schedule to cotton crop poses a challenge as the requirement varies largely across the growth stages. Hence, a balanced application of nutrients to cotton crop is decisive in obtaining higher yields, realising higher returns and sustaining soil nutrient status.

Materials and Methods

A field experiment was conducted during *kharif* 2016 and *kharif* 2017at ICAR-Krishi Vigyan Kendra, Haradanahally Farm, Chamarajanagara (latitude 11⁰53′ N and 76⁰57′ E longitude and altitude 714 m) to study the effect of application of micronutrients under different fertilizer prescription on yield, economics and soil properties under Bt cotton grown with NPK recommendation by UAS-B and SSNM. Bt cotton hybrid, Jadu (Kaveri seeds) was the test crop taken at a spacing of 90 cm x 60 cm in the plots measuring 22.68 m^2 (5.4 m x 4.2 m) with 13 treatments having 3 replications under RCBD. Recommended FYM and NPK as per the UAS-B recommendation (150:75:75 kg $N:P_2O_5:K_2O$ ha^{-1}) and SSNM recommendations taking into consideration the crop uptake -44.5:29.3:74.7 kg $N:P_2O_5:K_2O$ per ton produce (Das *et al*., 1991 and Fauconnier, 1973) and 2 tonnes target yield was applied to all the plots. The treatments comprised of the combination of UAS-B recommended dose of fertilizers and site specific nutrient management with foliar and soil application of varied levels of different micronutrients. The details are given in Table 1.

The soil of the experiment site was medium black. A composite soil sample was collected from the experimental site before start of the experiment. The soil was air-dried, powdered and passed through 2 mm sieve and was analyzed for physical and chemical properties. The results are furnished in Table 2.

The soil physico-chemical properties were analysed by following standard procedures. The seed cotton yield, post-harvest nutrient status and economics of crop cultivation were recorded.

Table 1

List of treatments

Treatment	Details
T_1	Absolute control
T_2	UAS (B) Recommended nutrient management
T_3	T_2 + MNM foliar application at 80 &100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)
T_4	T_2+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS
T_5	T_2 + Zinc Sulphate (15 kg ha^{-1}) and Borax (10 kg ha^{-1}) soil application
T_6	T_2 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha^{-1})
T_7	T_2 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$ + 5kg $CuSO_4$ ha^{-1})
T_8	Site specific nutrient management
T_9	T_8 + MNM foliar application at 80 & 100 days after sowing ($ZnSO_4$, $FeSO_4$, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)
T_{10}	T_8+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS
T_{11}	T_8 + Zinc Sulphate (15 kg ha^{-1}) and Borax (10 kg ha^{-1}) soil application
T_{12}	T_8 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha^{-1})
T_{13}	T_8 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$+ 5kg $CuSO_4$ ha^{-1})

TABLE 2
Initial soil characteristics

Parameters	Value
Soil reaction (pH)	7.95
Electrical Conductivity (dSm^{-1})	0.452
Organic Carbon ($g\ kg^{-1}$)	4.24
Available Nitrogen ($kg\ ha^{-1}$)	193.00
Available P_2O_5 ($kg\ ha^{-1}$)	55.10
Available K_2O ($kg\ ha^{-1}$)	376.50
Available Sulphur ($mg\ kg^{-1}$)	8.49
Exchangeable Calcium (cmol (p+) kg^{-1})	21.50
Exchangeable Magnesium (cmol (p+) kg^{-1})	6.00
DTPA Iron ($mg\ kg^{-1}$)	3.75
DTPA Zinc ($mg\ kg^{-1}$)	0.32
DTPA Manganese ($mg\ kg^{-1}$)	2.70
DTPA Copper ($mg\ kg^{-1}$)	2.10
Hot water extractable Boron ($mg\ kg^{-1}$)	0.18

RESULTS AND DISCUSSION

Primary Nutrients

The pooled analysis of two years data revealed a significantly higher available N content of soil 180.68 kg ha^{-1} in T_6 which was on par with T_3 (180.68 kg ha^{-1}), T_5 (180.53 kg ha^{-1}), T_{12} (180.35 kg ha^{-1}), T_4 (180.31 kg ha^{-1}) and T_{13} (180.25 kg ha-1) compared to control (T_1 94.94 kg ha^{-1}). Post harvest soil showed higher N content in treatment with UAS-B management practice compared to SSNM practice and this may be due to uptake which was higher in case of SSNM treatments. The results are in line with the findings of Kasturikesan and Amitava (2011). Application of fertilizers through SSNM was lower than that of UAS-B management practice and this resulted in more accumulation of nutrients in post harvest soil under UAS-B management practice. The values were further higher with higher levels of MNM as soil and foliar application (Table 3).

Higher soil P_2O_5 content of 59.45 kg ha^{-1} (pooled data) was recorded in the treatment T_2 followed by T_5: 52.9 kg ha^{-1} compared to absolute control treatment which showed 29.15 kg ha^{1} (pooled data) (Table 3). Higher P_2O_5 content in post harvest soil recorded in UAS-B management practice compared to SSNM practice may be due to higher uptake in SSNM treatments. The results were in line with the findings of Kasturikesan and Amitava (2011). The values were higher for soil application of micronutrients compared to foliar application. Higher dose of P fertilizer application resulted in buildup of P in soil (Singh *et al*., 2015 and Dwivedi *et al*., 2003). Another reason for lower available N and P under SSNM treatments might be due to the supply of these nutrients at lower levels compared to UAS-B recommendation and higher uptake by the crop (Jyoti and Hebsur, 2017).

With respect to available potassium status the treatment T_1 *i.e.,* control showed significantly lower values (177.30 kg ha^{-1}) (pooled data). Similar results were recorded in 2016 and 2017 (198.50 and 156.10 kg ha^{-1}, respectively) which increased significantly due to site specific nutrient management (T_{11}: 284.15 kg ha^{-1}) and this might be due to application of higher dose of potassium fertilizer under SSNM. This was followed by treatment T_8 (271.55 kg ha^{-1}) in pooled data (Table 3). Treatment T_1 showed lower available K content where Mg values were higher, due to antagonistic effect as reported by Deshpande *et al*. (2014) and Waikar *et al*. (2015). The lowest values for soil macro nutrients obtained in control treatment is due to lack of nutrient application. Similar results were reported by Singh *et al*., 2015 as lower K content under these systems may be ascribed to relatively lower K application rate.

The higher available NPK status in post harvest soil with or without micronutrient application might be attributed to the addition of these nutrients at higher levels UAS-B and based on nutrient removal by particular yield target as well as soil test values (SSNM). Besides, addition of these nutrients through organic source (FYM) also contributed to soil nutrient pool upon decomposition and also improved the soil chemical and biological properties. Increase in available N and P with application of micronutrients in sulphate form was due to increased solubility of these nutrient sources (Sujatha *et al*., 2007; Jamal *et al*., 2010 and Heydarnezhad *et al*., 2012).

TABLE 3

Primary and secondary nutrient status of post harvest soil as influenced by nutrient management practices

Treatments	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Ca (cmol (p+) kg^{-1})	Mg (cmol (p+) kg^{-1})	S (mg kg^{-1})
T_1	94.94	29.15	177.30	13.95	5.43	6.72
T_2	162.2	59.45	257.50	13.73	5.34	6.65
T_3	180.68	47.90	236.00	12.71	4.91	8.37
T_4	180.31	49.30	246.65	13.47	5.24	6.96
T_5	180.53	52.90	251.45	13.56	5.26	7.11
T_6	180.68	49.55	222.25	12.99	5.05	7.68
T_7	168.75	50.95	260.40	13.27	5.14	7.74
T_8	154.15	41.10	271.55	13.63	5.28	7.08
T_9	156.13	46.10	241.55	12.56	4.84	7.50
T_{10}	176.2	48.95	256.40	13.37	5.19	7.78
T_{11}	143.25	48.60	284.15	13.53	5.26	6.85
T_{12}	180.35	48.25	257.95	12.92	4.99	8.50
T_{13}	180.25	47.45	249.30	13.18	5.11	8.20
S. Em±	1.91	0.48	2.32	0.15	0.06	0.11
C. D	5.57	1.41	6.79	0.43	0.18	0.33

Treatments :

T_1 : Absolute control

T_2 : UAS (B) Recommended nutrient management

T_3 : T_2 + MNM foliar application at 80 &100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)

T_4 : T_2+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_5 : T_2 + Zinc Sulphate (15 kg ha^{-1}) and Borax (10 kg ha^{-1}) soil application

T_6 : T_2 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha^{-1})

T_7 : T_2 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$ + 5kg $CuSO_4$ ha^{-1})

T_8 : Site specific nutrient management

T_9 : T_8 + MNM foliar application at 80 & 100 days after sowing ($ZnSO_4$, Fe SO_4 ; $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%) ;

T_{10} : T_8+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_{11} : T_8 + Zinc Sulphate (15 kg ha^{-1}) and Borax (10 kg ha^{-1}) soil application

T_{12} : T_8 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha^{-1})

T_{13} : T_8 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$+ 5kg $CuSO_4$ ha^{-1})

UAS-B recommendations : FYM 12.5 t ha^{-1} and 150:75:75 kg N:P_2O_5: K_2O ha^{-1}

SSNM recommendations : FYM 12.5 t ha^{-1}. N, P_2O_5 and K_2O - taking in to consideration the crop uptake and 2 tonnes ha^{-1} yield target

The available major nutrients status of soil after the harvest of crop increased significantly in UAS-B practice as compared to SSNM which might be due to better utilization of nutrients by the crop under SSNM compared to UAS practice where comparatively higher quantity of fertilizers were added. In SSNM treatments where crop yields were higher, the soil nutrient status depleted after crop harvest due to higher uptake, better utilization of nutrients and also less amount of fertilizers applied compared to UAS practice.

Secondary Nutrients

Pooled analysis of the data revealed that exchangeable calcium was significantly higher in absolute control treatment (13.95 cmol p + kg^{-1}) which was on par with T_2: 13.73 cmol (p+) kg^{-1}, T_5 : 13.56 cmol (p+) kg^{-1}, T_8: 13.63 cmol (p+) kg^{-1} and T_{11}: 13.53 cmol (p+) kg^{-1}. Lowest exchangeable calcium content was recorded in T_6: 12.99 cmol (p+) kg^{-1}, T_9: 12.56 cmol (p+) kg^{-1} and T_{12}: 12.92 cmol (p+) kg^{-1}. Similar trend was observed in both the years. The highest soil exchangeable magnesium was recorded in T_1: 5.43 cmol (p+) kg^{-1} which was at par with T_2: 5.34, T_5: 5.26 and T_{11}: 5.26 cmol (p+) kg^{-1}. However low soil exchangeable magnesium was recorded in T_9: 4.84 cmol (p+) kg^{-1} and T_3: 4.91 cmol p + kg^{-1} (Table 3).

But soil available sulphur was recorded higher in T_{12}: 8.5 mg kg^{-1} which was on par with treatments T_3: 8.37 mg kg^{-1} and T_{13}: 8.2 mg kg^{-1}. Lower soil available sulphur was recorded in treatment T_2: 6.65 mg kg^{-1}, T_1: 6.72 mg kg^{-1} and T_{11}: 6.85 mg kg^{-1}. Remaining treatments were on par with each other.

Exchangeable calcium and magnesium content of soil was significantly higher in treatments that received only NPK due to lesser uptake of these elements as compared to micronutrient applied treatments. Micronutrient supplementation either through soil or foliage had produced higher yield which corresponds with higher uptake, thus the content of these secondary nutrient elements were lower. The results are in conformity with the results of Shivamurti Naik (2012) and Shashidhar *et al*. (2009). On the contrary, available sulphur status of the soil after the harvest of the crop in the treatments that received micronutrient application as sulphate salts was higher than other treatments. The results corroborate with the findings of Sujatha *et al*. (2007) and Vandana *et al*. (2009).

Micronutrients

Pooled analysis of two years data (2016 and 2017) revealed that DTPA - Fe content was significantly higher in T_6 (4.12 mg kg^{-1}) and T_{12} (4.24 mg kg^{-1}) as compared to all other treatments. Similarly statistically at par DTPA - Fe content was recorded in treatments T_3: 3.81 mg kg^{-1}, T_7: 3.85 mg kg^{-1}, T_9: 3.80 mg kg^{-1} and T_{13}: 3.80 mg kg^{-1}. The DTPA – Mn content in absolute control was 3.45 mg kg^{-1} which increased significantly to 5.14 mg kg^{-1} in T_6 followed by treatments T_{12}: 4.87 mg kg^{-1}, T_{13}: 4.35 mg kg^{-1} and T_7: 4.23 mg kg^{-1}. DTPA - Zn was significantly higher in treatments that received soil application of zinc sulphate T_5: 1.18 mg kg^{-1} followed by T_{11}: 1.08 mg kg^{-1}. DTPA - Cu content was significantly higher in T_{12}: 2.39 mg kg^{-1}, T_{13}: 2.32 mg kg^{-1} and T_6: 2.19 mg kg^{-1} as compared to all other treatments. Hot water extractable boron content was significantly higher in treatments that received boron through soil application in T_7: 0.27 mg kg^{-1} and T_5: 0.27 mg kg^{-1} compared to all other treatments (Table 4).

Available micron]utrients (DTPA extractable and hot water soluble) in the soil after the harvest of cotton crop were higher in the treatments which received soil application of micronutrients along with major nutrients applied as per SSNM and UAS-B recommendations. On the other hand, micronutrient content was lower in the treatment where micronutrients were not included in the nutrient management schedule (T_2 and T_8). The results are in conformity with the findings of Havlin *et al*. (2005), Heydarnezhad *et al*. (2012). The increase in micronutrient content might also be attributed to addition of FYM.

Yield and Economics

The treatment T_9 and T_3 were significantly superior in yield (2329 and 2215 kg ha^{-1}, respectively) and economics and recorded higher net returns and B : C ratio than any other treatments (Rs.77072, 2.75 and Rs.71714, 2.65, respectively) (Table 5). This may be attributed to the higher yields realized in these treatments because of balanced application of macro and micronutrients compared to other treatments. The net returns and B C ratio of other treatments were almost on par with each other. The lowest net returns and B C ratio was recorded in the treatment T_1 (16585 and 1.48, respectively). All other treatments were significantly superior over absolute control (T_1). Despite the net returns and B:C ratio being higher in other treatments where micronutrients were given as soil application over control treatment or T_2 or T_8 treatments, the

TABLE 4

DTPA-extractable Iron, manganese, boron, zinc and copper content (mg kg^{-1}) of post harvest soil as influenced by nutrient management practices

Treatments	Fe	Mn	B	Zn	Cu
T_1	3.67	3.45	0.17	0.24	1.62
T_2	3.51	3.38	0.17	0.20	1.40
T_3	3.81	3.47	0.18	0.23	1.77
T_4	3.59	3.60	0.17	0.26	1.63
T_5	3.40	3.43	0.27	1.18	1.70
T_6	4.12	5.14	0.30	1.02	2.19
T_7	3.85	4.23	0.27	0.65	2.03
T_8	3.62	3.42	0.14	0.22	1.44
T_9	3.80	3.50	0.15	0.26	1.90
T_{10}	3.69	3.58	0.19	0.20	1.84
T_{11}	3.77	3.65	0.24	1.08	1.74
T_{12}	4.24	4.87	0.26	0.98	2.39
T_{13}	3.80	4.35	0.23	0.75	2.32
S. Em±	0.04	0.04	0.002	0.006	0.016
C. D	0.13	0.11	0.006	0.02	0.046

Treatment :

T_1 : Absolute control

T_2 : UAS-B Recommended nutrient management

T_3 : T_2 + MNM foliar application at 80 &100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)

T_4 : T_2+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_5 : T_2 + Zinc Sulphate (15 kg ha $^{-1}$) and Borax (10 kg ha $^{-1}$) soil application

T_6 : T_2 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha $^{-1}$)

T_7 : T_2 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$ + 5kg $CuSO_4$ ha $^{-1}$)

T_8 : Site specific nutrient management

T_9 : T_8 + MNM foliar application at 80 & 100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)

T_{10} : T_8+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_{11} : T_8 + Zinc Sulphate (15 kg ha $^{-1}$) and Borax (10 kg ha $^{-1}$) soil application

T_{12} : T_8 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha $^{-1}$)

T_{13} : T_8 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$+ 5kg $CuSO_4$ ha $^{-1}$)

UAS-B recommendation : FYM 12.5 t ha^{-1} and 150:75:75 kg N:P_2O_5: K_2O ha^{-1}
SSNM recmmendations : FYM 12.5 t ha^{-1}. N, P_2O_5 and K_2O - taking in to consideration the crop uptake and 2 tonnes ha^{-1} yield target

TABLE 5

Yield and economics of Bt-cotton at harvest as influenced by nutrient management practices

Treatments	Seed cotton yield (kg ha^{-1})	Gross returns (Rs.ha^{-1})	Net Returns (Rs.ha^{-1})	B C Ratio
T_1	989	51418	16585	1.48
T_2	1521	79085	37195	1.89
T_3	2215	115189	71714	2.65
T_4	1665	86573	44033	2.04
T_5	1617	84092	39752	1.90
T_6	1982	103088	53673	2.09
T_7	1717	89301	43648	1.96
T_8	1559	81049	38588	1.91
T_9	2329	121118	77072	2.75
T_{10}	1708	88805	45694	2.06
T_{11}	1622	84320	39409	1.88
T_{12}	2012	104615	54629	2.09
T_{13}	1791	93121	46897	2.02
S.Em ±	62.09	3229	1754	0.07
CD (P = 0.05)	176.37	9171	4982	0.21

Treatment :

T_1 : Absolute control

T_2 : UAS (B) Recommended nutrient management

T_3 : T_2 + MNM foliar application at 80 &100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)

T_4 : T_2+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_5 : T_2 + Zinc Sulphate (15 kg ha $^{-1}$) and Borax (10 kg ha $^{-1}$) soil application

T_6 : T_2 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha $^{-1}$)

T_7 : T_2 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10kg $MnSO_4$ + 5kg $CuSO_4$ ha $^{-1}$)

T_8 : Site specific nutrient management

T_9 : T_8 + MNM foliar application at 80&100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%)

T_{10} : T_8+ Zinc Sulphate (0.5%) and Borax (0.2%) foliar application at 80 & 100 DAS

T_{11} : T_8 + Zinc Sulphate (15 kg ha $^{-1}$) and Borax (10 kg ha $^{-1}$) soil application

T_{12} : T_8 + MNM soil application (15kg $ZnSO_4$ + 10kg Borax + 15kg $FeSO_4$ + 20kg $MnSO_4$ + 10kg $CuSO_4$ ha $^{-1}$)

T_{13} : T_8 + MNM soil application (7.5kg $ZnSO_4$ + 5kg Borax + 7.5kg $FeSO_4$ + 10 kg $MnSO_4$+ 5kg $CuSO_4$ ha $^{-1}$)

UAS-B recommendation : FYM 12.5 t ha^{-1} and 150:75:75 kg N:P_2O_5: K_2O ha^{-1}
SSNM recommendations: FYM 12.5 t ha^{-1}. N, P_2O_5 and K_2O - taking in to consideration the crop uptake and 2 tonnes ha^{-1} yield target

cost of cultivation was more as higher quantity of these nutrients were applied than that of T_9 and T_3 treatments. The highest monetary returns in T_9 and T_3 may be due to the enhanced growth and yield attributes thereby leading to increased yields and higher returns. The results are in conformity with the findings of Basavaneppa *et al*. (2016) and Hosamani *et al*. (2013) who reported increased net income and B:C ratio as a result of application of macronutrients based on yield target, site specific nutrient management and application of micronutrients in Bt Cotton. Significantly higher net returns and B:C ratio was obtained with SSNM practice than blanket recommendation as reported by Shivaraja *et al*. (2017). Foliar application of micronutrients fetched higher B:C ratio than the control plots (Hallikeri *et al*., 2002). Also, higher net returns and B:C ratio were reported by Kulvir Singh *et al*. (2015) and Prakash (2018) which support the results of the present experiment. Similar results were reported with higher net returns and B:C ratio due to combined foliar application of zinc, iron manganese and boron (Sangh Ravikiran *et al*., 2012).

Application of fertilizers as per SSNM method stands pertinent as it results in incremental yields and also sustains soil nutrient status compared to blanket NPK recommendation. The foliar means of application of nutrients, especially micronutrients at specific crop growth stage facilitates the crop to meet nutrient demand at critical stages thereby resulting in an economically higher yield and returns resulting in higher profits.

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