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Effect of Micronutrients Application under Different Fertilizer Prescription Methods on Growth and Yield of BT Cotton

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Authors' contributions

This work was carried out in collaboration among all authors. Author SSP designed the study, supervised the work and corrected the manuscript. Author GSY conducted the research, recorded experimental data, collected, analysed the samples and wrote the first draft of manuscript. Author MNT performed the treatment design and corrected the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to study the effect of the application of micronutrients under different fertilizer prescription methods on growth and yield of Bt cotton at KVK farm, Chamarajanagara 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 micronutrients were given as soil application and foliar spray under UAS (B) and SSNM dose of NPK fertilizers prescription. The soil was slightly alkaline in reaction (pH: 7.95), low in zinc (0.32 mg kg^{-1}) and boron (0.18 mg kg^{-1}). The results indicated significantly higher plant height and more number of sympodial branches with UAS (B) Package, UAS (B) + Micronutrients, SSNM and SSNM + Micronutrients. However, significantly higher seed cotton yield (2329 kg ha^{-1}) was recorded with NPK as per SSNM + MNM foliar application at 80 and 100 DAS followed by NPK as per UAS (B) package + MNM foliar application at 80 and100 DAS (2215 kg ha^{-1}) and NPK as per SSNM + MNM soil application (2012 kg ha^{-1}) treatments as compared to control. The

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supplementation of micronutrients with optimized major nutrient applications can bring about an overall augmentation in crop performance both in terms of growth and yield attributes, thereby resulting in a significant higher yield. Application of micronutrients through foliar spray has a significant and positive effect on the growth and yield in Bt cotton under black soils of Chamarajanagara district.

Keywords: Bt cotton; micronutrients; foliar application and seed cotton yield; SSNM.

1. INTRODUCTION

Cotton (*Gossypium hirsutum L.*) is one of the most important fiber crops worldwide because of its adaptability, good fiber quality and high yield. Cotton, also known as white gold and king of fiber crops, is an important cash crop and foremost source of raw material for textile industries. It earns about 33 per cent of total foreign exchange. The yield of cotton is affected due to many reasons *viz*., flower and boll shedding associated with imbalanced nutrition, hormones etc. The area under Bt cotton is increasing continuously but productivity is decreasing over the years. The reasons for decreasing productivity are due to decreasing soil fertility especially micronutrients, imbalanced application of fertilizers and occurrence of physiological disorders like square dropping, square drying, leaf reddening etc. Among these, imbalanced use of macro and micronutrients is the major problem. These nutrients are more important because, in Bt cotton, synchronized boll development altered the source-sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls [1].

Cotton yield in Chamarajanagar district noticed a 4.62 per cent negative growth rate and the production reduced by 27.66 per cent [2]. The yield of cotton is 430 kg ha^{-1} for Karnataka state and it is very low for Chamarajanagar district (282 kg ha^{-1}). Hence, the present experiment was conducted with an aim to study the effect of different methods of application of micronutrients under different fertilizer regimes on growth, yield and quality parameters of Bt cotton.

2. MATERIALS AND METHODS

A field experiment was conducted during rainy season (*Kharif)* 2016 and *Kharif* 2017at ICAR Krishi Vigyan Kendra, Haradanahally Farm, Chamarajanagara (latitude 11^0 53´ N and 76^0 57´ E longitude and altitude 714 m) to study the effect of application of micronutrients under different fertilizer prescription on growth and yield of Bt cotton grown with NPK recommendation by University of Agricultural Sciences, Bengaluru [UAS (B)] and SSNM. Bt cotton hybrid, Jadu (Kaveri seeds) was the test crop taken up at a spacing of 90 cm X 60 cm with 13 treatments replicated thrice under Randomised Complete Block Design in medium black soil. Recommended farmyard manure (FYM) was applied to all the plots, NPK as per the UAS B recommendation (150:75:75 kg N: P_2O_5: K_2O ha^{-1}) and Site Specific Nutrient Management (SSNM) recommendations taking into consideration the crop uptake – 44.5:29.3:74.7 kg N:P_2O_5:K_2O per ton produce [3,4] and 2 tons target yield. 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 the start of experiment. The soil was air-dried, powdered and passed through a 2 mm sieve and was analyzed for physical and chemical properties (Table 2).

The soil physico-chemical properties were analyzed using standard procedures. The growth and yield parameters like plant height (at harvest), number of monopodial and sympodial branches, total dry matter, harvested bolls $plant^{-1}$, boll weight, seed index, seed cotton yield and stalk yield were recorded at different intervals of the crop life cycle.

Table 1. List of treatments

Treatment	Details
T_1	Absolute control
T_2	UAS (B) Recommended nutrient management

Treatment	Details
T_3	T_2 + MNM foliar application at 80 &100 DAS ($ZnSO_4$, $FeSO_4$, $MnSO_4$, $CuSO_4$ @ 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 (SSNM)
T_9	T_8 + MNM foliar application at 80 & 100 DAS ($ZnSO_4$, $FeSO_4$, $MnSO_4$, $CuSO_4$ @ 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})

SSNM – Site Specific Nutrient Management; MNM – Micronutrient mixture; DAS – Days after sowing

Table 2. Initial soil characteristics

Parameter	Value	Parameter	Value
Soil reaction (pH)	7.95	Exchangeable Calcium (meq 100 g^{-1})	21.50
Electrical Conductivity (dS m^{-1})	0.452	Exchangeable Magnesium (meq 100 g^{-1})	6.00
Organic Carbon (g kg^{-1})	4.24	DTPA Iron (mg kg^{-1})	3.75
Available Nitrogen (kg ha^{-1})	193.00	DTPA Zinc (mg kg^{-1})	0.32
Available P_2O_5 (kg ha^{-1})	55.10	DTPA Manganese (mg kg^{-1})	2.70
Available K_2O (kg ha^{-1})	376.50	DTPA Copper (mg kg^{-1})	2.10
Available Sulfur (mg kg^{-1})	8.49	Hot water extractable Boron (mg kg^{-1})	0.18

3. RESULTS AND DISCUSSION

The results of this experiment revealed that, all the treatments showed significantly better growth attributes than the absolute control (Table 3). Increased plant height, more monopodial and sympodial branches and increased dry matter was noticed with the treatment T_9 receiving foliar spray of all micronutrients with SSNM (138.94 cm, 3.35, 20.17, 361.09 g $plant^{-1}$, respectively) followed by treatment T_3 receiving foliar spray of all micronutrients with UAS (B) package (135.02 cm, 3.45, 20.42, 351.9 g $plant^{-1}$, respectively). Application of micronutrients showed improved crop growth compared to non-application of micronutrients, irrespective of the fertilizer recommendation adopted. Plant height was increased by an average of 9 to 10 per cent compared to control after the application of micronutrients in cotton crop [5]. Further, among the soil and foliar methods of application of micronutrients, foliar application was found better in improving growth parameters compared to soil application of micro-nutrients under both UAS (B) and SSNM practices. Accordingly, adequate absorption and utilization of micronutrients are essential to accelerate plant growth and result in higher yield [6, 7]. The efficiency of improving plant growth was higher due to foliar application of a solution containing micronutrients when compared with soil application of the micronutrient fertilizers.

Spraying of micronutrients significantly increased plant height and number of sympodial branches in treated plants compared to untreated plants. Supply of micronutrients through foliar spray led to higher uptake of boron and zinc that promotes the synthesis of growth promoting hormones, especially the production of auxins that may have resulted in enhanced growth and increased the number of internodes that promoted the development of main shoot as well growth of sympodial branches. Boron plays a pivotal role in nitrogen metabolism, membranes functioning, photosynthesis and cell division [8].

The application of micronutrients improved all these physiological processes, resulting in improved growth due to enhanced protein synthesis and efficient supply of metabolites. Manganese acts as an activator for many enzymes which promotes plant growth, number of nodes and flower production. Also, these increases may be due to the influence of zinc on auxin level. As for iron, it is an essential element for plant growth, photosynthesis and other light dependent processes. All these factors are collectively responsible for increased growth attributes [9].

The data presented in Table 4 reveals that the application of micronutrients along with inorganic fertilizers as UAS (B) and SSNM recommendations recorded significantly increased yield parameters of Bt cotton. Significantly more bolls per plant, higher boll weight and seed index were recorded in the treatment T_9 (32.58, 4.43 g and 14.17 respectively) in pooled data which was on par with T_3 (31.33 g, 4.26 and 13.95, respectively). Higher seed cotton yield was also recorded in treatments T_9 (127.59 g plant^{-1}) and T_3 (121.12 g plant^{-1}). The improvement in yield attributes is a manifestation of better growth, higher photosynthetic activity and transport of photosynthates from source to sink. The improvement in growth as a result of improved physiological processes in plant maybe due to enhanced supply of nutrients by application of micronutrients along with macronutrients.

Table 3. Growth attributes of Bt cotton as influenced by different nutrient management practices

Treatments	Plant height (cm)	Monopodial branches	Sympodial branches	Total dry matter (g plant^{-1})
T_1	60.72	1.75	10.10	216.48
T_2	96.38	2.42	14.16	255.55
T_3	135.02	3.45	20.42	351.90
T_4	107.71	2.69	15.79	279.80
T_5	104.92	2.62	15.39	274.26
T_6	126.26	3.13	18.46	322.50
T_7	110.77	2.76	16.23	289.96
T_8	101.50	2.54	14.89	266.90
T_9	138.94	3.35	20.17	361.09
T_{10}	110.22	2.75	16.91	285.33
T_{11}	105.18	2.63	15.42	275.01
T_{12}	127.98	3.17	18.71	326.70
T_{13}	115.06	2.86	16.85	298.56
S.Em±	3.91	0.10	0.55	10.25
CD (P=0.05)	11.11	0.28	1.56	29.12

Table 4. Yield attributes and yield of Bt cotton as influenced by different nutrient management practices

Treatments	Harvested bolls plant^{-1}	Boll weight (g)	Seed cotton yield (g plant^{-1})	Seed index	Seed cotton yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1	18.32	2.39	60.55	9.04	989	2169
T_2	20.92	2.84	80.93	11.53	1521	2410
T_3	31.33	4.26	121.12	13.95	2215	3450
T_4	23.63	3.21	91.40	12.22	1665	2665
T_5	22.96	3.12	88.83	11.92	1617	2611
T_6	28.07	3.82	108.56	13.06	1982	3139
T_7	24.36	3.31	94.24	12.62	1717	2801
T_8	22.15	3.01	85.67	11.64	1559	2533
T_9	32.58	4.43	127.59	14.17	2329	3507
T_{10}	24.23	3.30	93.86	12.31	1708	2725
T_{11}	23.02	3.13	91.54	12.00	1622	2620
T_{12}	28.48	3.87	98.92	13.25	2012	3187
T_{13}	25.39	3.45	104.56	12.84	1791	2887
S.Em±	0.88	0.12	3.43	0.51	62.09	99.01
CD (P=0.05)	2.51	0.34	9.75	1.41	176.37	281.23

Similar results were reported where increased yields were recorded as a result of foliar application of nutrients in cotton [10]. Number of bolls per plant and number of cotton seeds per boll were increased in plants given with combined soil application of zinc and boron [11]. Though application of NPK for 2 tonnes per hectare target yield through SSNM recommendation resulted in better yield parameters than UAS (B) practice, both the treatments were on par with each other. 75 per cent and 100 per cent of recommended dose of fertilizer (RDF) application performed similarly in terms of growth, yield and quality as reported by [12].

Lower values for the yield parameters were obtained in T_2 with UAS (B) practice alone (2.84 g, 20.92 and 11.53 of boll weight, bolls per plant and seed index, respectively) and T_8 (SSNM alone; 3.01 g, 22.15 and 11.64 of boll weight, bolls per plant and seed index, respectively) apart from absolute control plot that showed the lowest values of 2.39 g, 18.32 and 9.04 for boll weight, bolls per plant and seed index, respectively.

Seed Cotton yield and stalk yield in absolute control were 989 and 2169 kg ha^{-1}, respectively which increased significantly to 1521 and 2410 kg ha^{-1} in treatment T_2 with UAS (B) practice alone and 1559 and 2533 kg $ha^{-1,}$ respectively in treatment T_8 with SSNM practice alone.

The extent of increase in seed and stalk yield was higher with the application of micronutrients under both UAS (B) and SSNM practices. However, seed cotton yield and stalk yield were higher (2329 and 3507 kg ha^{-1}, respectively) in the treatment T_9 with site specific nutrient management + MNM foliar application at 80 and 100 days after sowing ($ZnSO_4$, Fe SO_4, $MnSO_4$, $CuSO_4$ @ 0.3% each and Borax @ 0.2%). It was on par (2215 and 3450 kg ha^{-1}, respectively) with T_3 treatment (UAS (B) practice + 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%) and T_{12} treatment (2012 and 3187 kg ha^{-1}, respectively) with site specific nutrient management + MNM soil application (15 kg $ZnSO_4$ + 10 kg Borax + 15 kg $FeSO_4$ + 20 kg $MnSO_4$ + 10 kg $CuSO_4$ ha^{-1}).

The significant increase in cotton yield due to application of micronutrients along with macronutrients might be attributed to improvement in growth parameters (Table 3) and yield attributes (Table 4). Yield of a crop is an outcome of improvement in growth and yield attributing parameters. The improved growth and yield components observed in the present investigation may be due to higher uptake of nutrients due to enhanced supply of nutrients with addition especially through foliar application. The supply of all essential nutrients in adequate amount might have helped for the improvement in photosynthesis and translocation of photosynthates from source to sink. The balanced use of macro and micronutrients resulted in a significant increase in yield and cotton quality [13].

Infertility of flowers and premature falling of flowers are the consequence of Zn and B insufficiency in plants and ultimately reduction in yield occurs. The lower yields in absolute control treatment followed by UAS (B) alone and SSNM alone treatments showed that no application of micronutrients is one of the foremost factors that brings down the potential of high yielding Bt cotton. For that reason, foliar feeding of micronutrients is highly advisable for cotton regions with micronutrient deficit soils. Thereby, foliar application of micronutrients, particularly of Zn, B, Fe, Mn, and Cu is an effective method for increasing the yield of cotton [14, 15].

The lower yields obtained in the treatments without micronutrient applications may be because cotton yield and quality are adversely affected by the boron deficiency as it has a primary role in regulating lint quality and boll development. The deficiency of zinc is also a well-documented issue that decreases the crop yields by significantly decreasing plant performance. These micronutrients are involved in indispensable functions like translocation and incorporation of sugar compounds and nitrogen in complex carbohydrates (fiber) and proteins [16]. Boron and zinc application improved the transport and deposition of assimilates in fruiting body resulting in enhanced fruit yield and quality [17].

Though application of micronutrients resulted in better yield, foliar application was found to perform better than the soil application of micronutrients. Foliar application of nutrients, especially micronutrients, at critical stages (at flowering and boll development stage) registered significantly higher seed cotton yield compared to other methods of application [18]. The highest seed cotton yield was obtained from the combined application of the recommended NPK rate with one percent Micnelf™ MS–16, a micronutrient mixture. Application of 0.2 to 0.4 % solution of Fe, Zn and Mn or 0.2 % solution of two or all these elements at 75 DAS as foliar spray gave significantly higher yield in cotton. Zn, Fe and Mn with the concentration of 0.2 % gave the highest seed cotton yield [19, 6].

The practice of foliar application of plant nutrients gives quick benefits and economizes nutrient elements as compared to soil application. Foliar application is often effective when roots are unable to absorb sufficient nutrients from the soil due to high soil pH, unavailability by fixation, losses from leaching, low soil temperature and lack of soil moisture.

SSNM recommendation could be considered as balanced dose of N, P and K. However, imbalanced fertilizer application possibly shifts the balance between the vegetative and reproductive growth, thus delaying maturity, promote boll shedding and reducing yield [20].

4. CONCLUSION

On the basis of present investigation, it can be concluded that micronutrient application plays a vital role in improvement of growth and yield of Bt cotton. Further, foliar application of micronutrients has a great effect in improving the efficiency and utilisation of nutrients and thereby, improves the growth and seed cotton yield. And hence, foliar nutrition in cotton can be considered as a viable practice for enhancing production and productivity of Bt cotton in Southern Dry Zone of Karnataka. Further, the micronutrient supplementation with optimized major nutrient applications can bring about an overall augmentation in crop performance both in terms of growth and yield attributes, thereby resulting in a significant higher yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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