Original Research Article

Effect of potassium and foliar nutrition of secondary (Mg) and micronutrient (Zn & B) on growth and yield attributes and yield of *Bt* -Cotton

A B S T R A C T

A field experiment was conducted during 2015-16 and 2016-17 at Hyderabad to assess the performance of cotton hybrid Bt (MRC 7201 BGII) in response to potassium fertilization (K @0, K @60 and K @ 90 kg ha^{-1}) and secondary (Magnesium) and micro nutrients (Zinc and Boron). Among the potassium levels during 2015 and 2016, K @ 90 kg ha^{-1} recorded significantly more plant height (76.86, 106.13 cm), no. of seeds per boll (30.3, 30.9), seed cotton yield (1941, 2591 kg ha^{-1}), stalk yield (1967, 2755 kg ha^{-1}) and harvest index (58.1, 47.4 %) in comparison to K @0 and K @60, respectively. Among the secondary (Magnesium) and micro nutrients (Zinc and Boron), during 2015 and 2016, treatment $Mg_{1\%}Zn_{0.5\%}B_{0.1\%}$ showed more plant height (74.65, 102.80 cm), dry weight (221.39, 243.54 g), no. of seeds per boll (29.27, 29.87), seed cotton yield (1941, 2591 kg ha^{-1}), stalk yield (1967, 2755 kg ha^{-1}) when compared with all other treatments.

Comment [A1]: Do not use short forms

Key words: *Potassium levels, Secondary nutrients, Micro nutrients, Magnesium, Zinc, Boron*

INTRODUCTION:

Globally, cotton is one of the most important commercial and industrial crop and is the most popularly and widely used fiber in the world providing employment directly or indirectly to millions of people. In India, it accounts for approximately 85% of fiber requirement for textile industry. India is the largest cultivator and producer of cotton in the world. Continuous usage of high analysis fertilizers without organic manures leading to imbalanced fertilizers use which finally resulting in soil fertility changes and problems like declining organic matter, mining of nutrients multi nutrient deficiencies and deficiencies of at least six elements *viz*., nitrogen, phosphorus, potassium, sulphur, zinc and boron are widespread. Among major nutrients, potassium has an important role in the translocation of photosynthates from source to sink. K is not a component of any singular plant part, it also affects many fundamental physiological processes such as cell pH stabilization, regulating plant metabolism by acting as a negative charge neutralizer and regulating the opening and closing of stomata. In cotton crop, potassium plays a major role for normal crop growth and fiber development. Cotton is more sensitive to potassium availability and often shows signs of potassium deficiency in soils, not considered deficient (Cassman *et al.*, 1989). Further, the role and importance of potassium in cotton growth and productivity is increasing due to the widespread potassium deficiency aggravated due to low potassium additions or recommendations.

Secondary (Ca, Mg, S) and micronutrients especially Zn, B are essential for higher productivity of cotton. Their deficiencies not only hamper crop productivity but also deteriorate produce quality. Besides increasing nutrient use efficiency, Magnesium is essential for the production of the green pigment in chlorophyll, which is the driving force of photosynthesis. It is also essential for the metabolism of carbohydrates (sugars). It is necessary for cell division and protein formation. Micronutrients requirement though small, act as catalyst in the uptake and use of macronutrients. Nutritional status of plants has a considerable impact on partitioning of carbohydrates and dry matter between plant shoots and roots. The increasing deficiencies of these nutrients affects the crop growth and yields and low response to their applications are being noticed. Zinc is an element directly affecting the yield and quality because of its role in activity of biological membrane stability, enzyme activation ability and auxin synthesis. Boron plays an essential role in the development and growth of new cells in the growing meristem and also pollen tube growth and increases pollination and seed development.

Besides, actual yield levels are low due to poor agronomic practices, especially fertilization. Squaring, blooming and boll development are the stages where cotton needs the highest nutrients demand. Augmentation of nutrient supply through foliar application at such critical stages may increase yield (Bhatt and Nathu, 1986). Foliar nutrition when used as a supplement the crop gets benefitted from foliar applied nutrients when the roots are unable to meet the nutrient requirement of the crop at its critical stage (Ebelhar and Ware, 1998). Hence the present study was undertaken to find the response of *Bt* cotton to different levels of potassium and secondary and micronutrient supplementation for highest yield.

MATERIALS AND METHODS:

These investigations were carried out during *Kharif*, 2015-16 and 2016-17 at College Farm, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17^{o}19’ N latitude and 78^{o}23’ E longitude. It is in the Southern Telangana agro-climatic zone of Telangana. According to Troll’s climatic classification, it falls under semi-arid tropics (SAT).

The soil was sandy clay loam in texture, neutral in reaction, non saline, low in organic carbon, available N, high in available P and medium in available K. The experiment was laid out in a Split plot design comprising of 3 Main treatments and 8 Sub plot treatment and replicated thrice. The treatment details included Potassium rates-3 (Basal application) : M_1 – 0 kg K_2O ha^{-1}, M_2 – 60 kg K_2O ha^{-1} and M_3 – 90 kg K_2O ha^{-1}(main plots) and Sub plot includes foliar sprays with different combinations of Mg, Zn and B (2 sprays- first at flowering and second at boll opening stage) *i.e.,* S_1- Mg (0 %) + Zn (0 %) + B (0%) {Control}, S_2- Mg (1 %) + Zn (0 %) + B (0 %), S_3- Mg (0%) + Zn (0.5 %) + B (0 %), S_4- Mg (0%) + Zn (0 %) + B (0.1 %) , S_5- Mg (1 %) + Zn (0.5 %) + B (0 %), S_6- Mg (1 %) + Zn (0 %) + B (0.1 %), S_7- Mg (0%) + Zn (0.5 %) + B (0.1%) and S_8- Mg (1 %) + Zn (0.5 %) + B (0.1 %) with source of fertilizer are K - MOP, Mg- Epsom salt, Zn- $ZnSO_4$ and B-Borax.

During the crop period rainfall of 375.3 mm was received in 27 rainy days in first year and 740.9 mm in 37 rainy days in second year, respectively as against the decennial average of 616.2 mm. Second year received in 37 rainy days for the corresponding period indicating 2016-17 as wet year comparatively.

Field was ploughed once with tractor drawn mould board plough followed by cultivator and later with disc harrow. The land within each plot was levelled in order to maintain uniform irrigation water application. Cotton crop was sown on July 11, 2015 and June 26, 2016 by dibbling seeds in opened holes with a hand hoe at depth of 4 to 5 cm as per the spacing in treatments *viz.*, 90 cm X 60 cm. The recommended dose of 120-60 NP kg ha^{-1} were applied in the form of urea and single super phosphate respectively. Entire dose of phosphorus was applied as basal at the time of sowing, while nitrogen were applied in 4 splits, one at the time of sowing as basal and remaining three splits at 30, 60 and 90days after sowing (DAS) respectively. Main treatments of Potassium (0, 60 & 90 kg ha^{-1}) were imposed to the field as basal dose. Whereas, foliar sprays with different combinations of Mg, Zn and B were applied twice to crop, *i.e.,* at flowering and at boll opening stage of the cotton.

Pre emergence herbicide pendimethalin @ 2.5 ml l^{-1} was sprayed to prevent growth of weeds. Post emergence spray of quizalofop ethyl 5% EC @ 2 ml l-1 and pyrithiobac sodium 10% EC @ 1 ml $l^{-1.}$ Hand weeding was carried out once at 35 DAS. First irrigation was given immediately after sowing of the crop to ensure proper and uniform germination. Later irrigations were scheduled uniformly by adopting climatological approach *i.e.,* IW/CPE ratio of 0.80 at 5 cm depth. During crop growing season sucking pest incidence was noticed. Initially at 25 DAS spraying of monocrotophos @ 1.6 ml l^{-1} was done. During later stages, acephate @ 1.5 g l^{-1} and fipronil @ 2 ml l^{-1} were sprayed alternatively against white fly and other sucking pests complex during the crop growth period as and when required.

The number of opened bolls on five labelled plants from net plot were counted at each picking, averaged and expressed $plant^{-1}$. Harvested bolls of each picking from labeled plants of each treatment was weighed, averaged and expressed as boll weight in g $boll^{-1}$. The cumulative yield of seed cotton from each picking in each treatment from net plot was weighed and expressed in kg ha^{-1}. Data on different characters *viz*., yield components and yield, were subjected to analysis of variance procedures as outlined for randomized block design, factorial concept (Gomez and Gomez, 1984). Statistical significance was tested by F–value at 0.05 level of probability and critical difference was worked out wherever the effects were significant.

RESULTS AND DISCUSSION

Plant height (cm)

Data recorded on plant height varied significantly by graded levels of potassium, secondary and micronutrient supplementation and their interaction during both the years of experimentation Table.1. During both the years of study, plant height increased as the age of crop advance and influenced significantly by varied levels of potassium. In 2015, higher plant height was observed in K@90 kg ha^{-1} (76.86 cm) and significantly superior over K@60 and 0 kg ha^{-1}. Similar trend was noticed during 2016 also, while lowest plant height was recorded with 0 K levels (98.40 cm). The probable reason for this might be due to the better nutrient uptake and faster mobilization in turn increased photosynthetic activity (Rajendran *et al.,* 2011), enzymatic activity and biochemical process like cell division (Shivamurthy and Biradar, 2014).

Among secondary nutrient (Mg) and micronutrients (Zn and B), $Mg_{1\%}$ $Zn_{0.5\%}$

$B_{0.1\%}$ has recorded highest plant height (86.03 cm and 120.61 cm) during 2015 and 2016 years respectively. Contrary to above, control treatment $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ has recorded significantly lower plant during both the years when compared with other treatments.

Morphological changes in plants might have induced due to accelerated mobility of photosynthates from source to sink as influenced by the application of secondary and micro nutrients. Sufficient supply of these nutrients leads to increased plant height. These results are in line witht the findings of Karademir and Karademir (2020), Raj and Chandrasekar (2019) and More *et al.* (2018). Interactions between major (Potassium) and secondary (Magnesium), micro nutrients (Zinc and Boron) were found statistically significant at all stages of crop growth during both the years.

Numbers of seeds boll^{-1}

There was significant variation in the number of seeds boll^{-1} was observed with graded potassium levels, secondary and micro nutrient supplementation and their interaction (Table.2). Number of seeds boll^{-1} at ranged from 28.4 to 30.3 and 29 to 30.9 with mean of 29.3 to 29.8 during 2015 and 2016, respectively.

Among varied potassium levels, K@90 kg ha^{-1} registered more numbers of seeds boll^{-1} (30.3) over 60 kg ha^{-1} (29.1) and K@0 kg ha^{-1} (28.4), but onpar with K@60 kg ha^{-1} during the year, 2015. The same trend was observed for the year, 2016 in which more numbers of seeds boll^{-1} were recorded in K@90 kg ha^{-1} (30.9) and lowest number was recorded in K@0 kg ha^{-1} (29.0). The increased number of seeds per boll was due to improved growth parameters like higher dry matter production and translocation of photosynthates from source to sink (Basavanneppa *et al.*, 2015).

Significantly more numbers of seeds boll^{-1} was observed in $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (29.7 and 30.27) during the both years of investigation respectively. Lowest number of seeds boll^{-1} were obtained with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ treatment (29 and 29.57) during 2015 and 2016. The increased number of seeds per boll was due to improved growth parameters like higher plant height, monopodial and sympodial branches, higher drymatter production and translocation of photosynthates from source to sink. Similar findings were also reported by Shivamurthy and Biradar (2014) and Rajendran *et al.* (2011). Numbers of seeds boll^{-1} has shown significant variation with interaction effect between major and secondary and micro nutrients during both years.

Seed Cotton Yield:

Data pertaining to seed cotton yield presented in Table No.3. Scrutining of data indicating that yield of cotton was significantly influenced by both potassium graded levels, secondary and micro nutrient supplementation and also their interaction effect. Potassium levels have exerted significant influence on seed cotton yield during both the years. Significantly higher seed cotton yield was recorded with the basal application of potassium @ 90 kg ha^{-1} (1941 kg) followed by 60 kg ha^{-1} (1292 kg) for the year, 2015. And potassium @ 90 kg ha^{-1} recorded higher seed cotton yield (2591 kg) followed by potassium @ 60 kg ha^{-1} (2116 kg) during 2016. Significantly lower seed cotton yield was registered with treatment comprising of potassium @ 0 kg ha^{-1} (1051 kg and 1580 kg) during both years. Higher seed cotton yield might be due to better partitioning of dry matter and photo assimilates towards reproductive structures and there by higher biomass (Shivamurthy and Biradar, 2014), which resulted in higher squares number $plant^{-1}$. There by more number of bolls and boll weight realized to higher yield $plant^{-1}$, there by higher yield. Similar results were reported by Ratna Kumari *et al.* (2009).

Significantly higher seed cotton yield obtained with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ resulted (1512kg) which is on par with $Zn_{0.5\%}$ $B_{0.1\%}$ treatment (1510 kg) followed by $Mg_{1\%}B_{0.1\%}$(1478 kg) when compared with all other treatments during 2015. While in 2016, significantly higher cotton yield was obtained with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ resulted (2324 kg) followed by $Zn_{0.5\%}$ $B_{0.1\%}$ treatment (2324 kg) and $Mg_{1\%}B_{0.1\%}$((2222 kg) when compared with rest of all treatments. And significantly lower yield was obtained with control treatment *i.e.,* Mg $_{0\%}$ Zn $_{0\%}$ $B_{0\%}$ (1309 kg and 1885 kg) during 2015 and 2016, respectively. Highest yield obtained in $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ was due to increased photosynthetic efficiency of the leaves, development of strong cell wall, increases in pollen growth, boll number, better partitioning of dry matter and photo assimilates towards reproductive structures and increase in square, flower and resulting in enhanced boll setting and boll weight and finally increased seed cotton yield. Similar results were recorded by Karademir and Karademir, (2020). Interaction effect between potassium and Magnesium, Zinc and boron, Magnesium and Zinc, Zinc and boron, Magnesium and boron, Potassium, Magnesium, Zinc and boron on seed cotton yield was found significant.

Stalk yield:

Perusal of data indicated significant effect of major nutrient, graded potassium levels, secondary nutrient (Magnesium) and micro nutrients (Zinc and Boron) and their interaction on stalk yield during 2015 and 2016 (Table 4). The data on stalk yield indicated that significantly higher stalk yield was produced with basal application of potassium @ 90 kg ha^{-1} (1941 kg) when compared with other treatments *i.e.,* potassium @ 60 kg ha^{-1}(1292 kg) for the year, 2015. The lower stalk yield was obtained with control plot *i.e.* potassium @0 kg ha^{-1} (1287 kg). The similar trend was followed during the year, 2016 in which the basal application of K@ 90 kg ha^{-1} obtained maximum stalk yield of 2755 kg which is followed by K@ 60 kg ha^{-1} (2591 kg) and lower stalk yield was obtained with control treatment K@ 0 kg ha^{-1} (2116). Increased stalk yield was due to higher dry matter production. These results are in line with Ratna Kumari *et al.* (2009).

Significantly higher stalk yield was obtained with treatment consisting of $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (1622 kg) which is followed by $Zn_{0.5\%}$ $B_{0.1\%}$ (1619 kg) and lower stalk yield was obtained with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ (1339 kg) for the year 2015. During 2016, $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (2708 kg) followed by $Zn_{0.5\%}$ $B_{0.1\%}$ (2598 kg). The treatment consisting of $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ (2072 kg) has recorded lower stalk yield when compared with rest of the treatments. Similar results were recorded by Karademir and Karademir, (2020) and Santhosh *et al.*(2016). Interactions between major (Potassium levels) and secondary (Magnesium), micro nutrients (Zinc and Boron) were found statistically significant during both years.

Table1: Plant height (cm) at harvest stage of cotton is influenced by secondary and micro nutrient supplementation under graded levels of potassiu

Comment [A2]: Change the title of the table

Treatment / Sub plots (secondary & micro nutrients)	Main plots (Potassium levels)							
	K@ 0 kg ha^{-1}		K@ 60 kg ha^{-1}		K@ 90 kg ha^{-1}		Mean	
	2015	2016	2015	2016	2015	2016	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	66.08	100.67	63.10	104.67	79.43	92.84	69.54	99.39
$Mg_{1\%}$	78.55	117.17	73.00	94.33	76.85	102.67	76.13	104.72
$Zn_{0.5\%}$	76.25	102.83	81.13	92.67	76.15	96.33	77.84	97.28
$B_{0.1\%}$	74.48	93.00	78.83	117.17	75.68	119.17	76.33	109.78
$Mg_{1\%}$ $Zn_{0.5\%}$	76.68	101.67	83.30	103.17	81.15	104.67	80.38	103.17
$Mg_{1\%}$ $B_{0.1\%}$	76.23	102.00	84.35	108.00	64.80	86.00	75.13	98.67
$Zn_{0.5\%}$ $B_{0.1\%}$	81.15	112.50	76.48	104.33	81.78	126.33	79.80	114.39
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	82.03	110.50	86.93	122.33	89.13	129.00	86.03	120.61
Mean	72.67	98.40	74.41	103.86	76.86	106.13	74.65	102.80
	2015		**2016**					
	SEm(±)	**CD (p=0.05)**	**SEm(±)**	**CD (p=0.05)**				
Main plots (A)	0.32	1.26	0.37	1.46				
Sub plots (B)	0.81	2.31	1.10	3.15				
Interaction (A x B)	1.40	3.99	1.91	5.45				
Interaction (BxA)	1.34	3.93	1.82	5.29				

Table no.2 Number of seed per boll of cotton is influenced by secondary and micro nutrient supplementation under graded levels of potassium

Comment [A3]:

Comment [A4]: Change the title language

Treatment	Main plots (Potassium levels)							
Sub plots (secondary & micro nutrients)	K@ 0 kg ha^{-1}		K@ 60 kg ha^{-1}		K@ 90 kg ha^{-1}		Mean	
	2015	2016	2015	2016	2015	2016	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	28.0	28.6	28.9	29.5	30.1	30.6	29.00	29.57
$Mg_{1\%}$	28.1	28.7	28.9	29.5	30.1	30.7	29.03	29.63
$Zn_{0.5\%}$	28.3	28.9	28.9	29.5	30.2	30.7	29.13	29.70
$B_{0.1\%}$	28.1	28.7	29.2	29.8	30.4	30.9	29.23	29.80
$Mg_{1\%}$ $Zn_{0.5\%}$	28.6	29.2	28.5	29.1	30.5	31.0	29.20	29.77
$Mg_{1\%}$ $B_{0.1\%}$	28.7	29.3	29.4	30.0	30.5	29.0	29.53	29.43
$Zn_{0.5\%}$ $B_{0.1\%}$	28.7	29.2	29.3	29.9	30.4	31.0	29.47	30.03
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	28.8	29.3	29.8	30.4	30.5	31.1	29.70	30.27
Mean	28.4	29.0	29.1	29.7	30.3	30.9	29.27	29.87
	2015		**2016**					
	SEm(±)	**CD (p=0.05)**	**SEm(±)**	**CD (p=0.05)**				
Main plots (A)	0.04	0.16	0.11	0.45				
Sub plots (B)	0.23	0.67	0.25	0.72				
Interaction (A x B)	0.41	1.16	0.44	1.25				
Interaction (BxA)	0.38	1.09	0.42	1.25				

Table no.3 Seed cotton yield (kg ha^{-1}) is influenced by secondary and micro nutrient supplementation under graded levels of potassium

Comment [A5]: Modify the language

Treatment	Main plots (Potassium levels)							
Sub plots (secondary & micro nutrients)								
	K@ 0 kg ha^{-1}		K@ 60 kg ha^{-1}		K@ 90 kg ha^{-1}		Mean	
	2015	2016	2015	2016	2015	2016	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	915	1423	1257	1799	1755	2432	1309	1885
$Mg_{1\%}$	956	1427	1265	2025	1854	2449	1358	1967
$Zn_{0.5\%}$	1016	1491	1246	2072	1880	2486	1381	2016
$B_{0.1\%}$	1040	1497	1298	2154	1894	2534	1411	2062
$Mg_{1\%}$ $Zn_{0.5\%}$	1123	1586	1314	2160	1962	2619	1466	2122
$Mg_{1\%}$ $B_{0.1\%}$	1111	1653	1316	2187	2006	2667	1478	2169
$Zn_{0.5\%}$ $B_{0.1\%}$	1109	1776	1338	2202	2083	2688	1510	2222
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	1141	1787	1302	2328	2093	2858	1512	2324
Mean	1051	1580	1292	2116	1941	2591	1428	2096
	2015		**2016**					
	SEm(±)	**CD (p=0.05)**	**SEm(±)**	**CD (p=0.05)**				
Main plots (A)	7.67	30.15	12.85	50.44				
Sub plots (B)	11.45	32.67	17.54	50.05				
Interaction (A x B)	19.82	56.58	30.38	86.70				
Interaction (BxA)	20.07	60.43	31.18	94.68				

Table no.4 Stalk yield (kg ha^{-1}) of cotton is influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment / Sub plots (secondary & micro nutrients)	Main plots (Potassium levels)							
	K@ 0 kg ha^{-1}		K@ 60 kg ha^{-1}		K@ 90 kg ha^{-1}		Mean	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	879	2072	1257	2432	1880	2347	1339	2284
$Mg_{1\%}$	1244	1799	1265	2449	1755	2712	1421	2320
$Zn_{0.5\%}$	1088	2025	1246	2486	1854	2556	1396	2356
$B_{0.1\%}$	1105	2154	1298	2534	1894	2573	1432	2420
$Mg_{1\%}$ $Zn_{0.5\%}$	1470	2160	1314	2619	1962	2938	1582	2572
$Mg_{1\%}$ $B_{0.1\%}$	1508	2187	1316	2667	2006	2876	1610	2577
$Zn_{0.5\%}$ $B_{0.1\%}$	1435	2202	1338	2688	2083	2903	1619	2598
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	1470	2328	1302	2858	2093	2938	1622	2708
Mean	1287	2116	1292	2591	1967	2755	1507	2487
	2015		**2016**					
	SEm(±)	**CD (p=0.05)**	**SEm(±)**	**CD (p=0.05)**				
Main plots (A)	7.94	31.21	15.90	62.44				
Sub plots (B)	12.55	35.82	26.27	74.97				
Interaction (A x B)	21.74	62.05	45.51	129.85				
Interaction (BxA)	21.83	65.42	45.43	135.63				

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