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Effect of magnesium, zinc, iron and boron application on yield and quality of cotton (*Gossypium hirsutum*)

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ABSTRACT

An experiment was carried out during 2003 and 2004 to study the effect of standard fertilizers for secondary and micronutrients, viz Mg, Zn, Fe and B on growth, yield and quality of upland cotton (*Gossypium hirsutum* L.) in South zone. Pooled data for 2 years indicated that specific fibre quality parameters, such as ginning per cent and uniformity ratio were significantly enhanced by micronutrient fertilization. Soil applied with $FeSO_4$ @ 50 kg/ha registered highest ginning percentage of 39.2% and uniformity ratio of 50.2 relative to control values of 36.3% and 47.5, respectively. Fibre length was also significantly improved by soil application of borax @ 5 kg/ha. Besides quality, foliar sprays of $MgSO_4$ @ 0.5% at 60, 75 and 90 days after planting and soil applied borax @ 5 kg/ha also raised the seed cotton yield by more than 18% (1 630 and 1 640 kg/ha, respectively) in comparison to control (1 380 kg/ha). Other quality traits, viz seed index, fibre strength, micronaire and fibre elongation and fibre quality index were not influenced by the application of micronutrient fertilizers.

Key words: Fibre quality, Fibre quality index, Ginning percentage, *Gossypium hirsutum*, Micronutrient fertilizers, Seed cotton yield, Uniformity ratio

Amongst the management practices for improving the fibre quality, external supplementation of plant nutrients has to be emphasized keeping in view of its role in improving plant nutrition. Moreover, since soil is supplied with the bulk of the major nutrients only through fertilizers over the years without impurities, deficiencies in both secondary and micronutrients do occur and in many cases are quite apparent requiring urgent attention to break the limits of yield barrier and to maximize crop profitability. Quantum of micronutrient deficiencies of Zn (49%), B (37%), Fe (12%), Mn (4%) and Cu (30%), respectively in Indian soils (Singh 2009). In addition, lack of organics addition in ample quantities also significantly decreases the DTPA-extractable Zn, Fe and Mn (Li *et al*. 2007). Cotton (*Gossypium hirsutium* L.) crop accumulates an average of 36 kg Mg/ha, 890 g Fe/ha, 340 g B/ha, 130 g Zn/ha and 51 g Cu/ha. On average, the seed within harvested seed cotton removes 12 kg Mg/ha, 136 g Fe/ha, 41 g B/ha, 96 g Zn/ha and 20 g Cu/ha. For crops yielding about 1 800 kg/ha, 70% of the Zn and P taken up was removed in the seed, also 38% of Cu, 34% of Mg, 17% of Fe and 12% of B (Rochester Ian 2007). Since very little information on micronutrient fertilization on fibre yield and quality is available in cotton, hence, the present investigation was carried out to study the effect of standard micronutrient fertilizers of Mg, Zn, Fe and B applied through soil and foliar on growth, yield and quality of American upland cotton.

MATERIALS AND METHODS

A field trial was conducted during winter irrigated seasons (August–February) of 2003 and 2004 at Regional Station, Central Institute for Cotton Research, Coimbatore. The soil was clay loam in texture, low in available N (233 kg/ha), medium in available P (20.3 kg /ha) and high in available K (1050 kg/ha) with a *p*H 8.5 and EC 0.23 dS/m. The DTPA extractable micronutrient status of soil was having 0.49, 1.10, 2.54, 2.31 and 0.08 ppm of zinc, copper, manganese, iron and hot water extractable boron, respectively. The experiment was laid out in a randomized block design with 3 replications. Since the soil is deficient in Zn, Fe and B, the micronutrient fertilizers involving these nutrients were taken up in the study in addition to Mg which is important secondary nutrient for

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cotton. Nine treatment combinations involving standard micro-fertilizers were tried involving soil and foliar applications, namely (1) $MgSO_4$ @10 kg/ha (soil), (2) $MgSO_4$ @ 0.5% as foliar at 60, 75 and 90 days after planting, (3) $ZnSO_4$ @ 50 kg /ha (soil), (4) $ZnSO_4$ @ 0. 5% as foliar at 60, 75 and 90 days after planting, (5) $FeSO_4$ @ 50 kg /ha (soil), (6) $FeSO_4$ @ 0.5% as foliar at 60, 75 and 90 days after planting (7) Borax @ 5 kg /ha (soil), (8) Borax @ 0.5% as foliar at 60, 75 and 90 days after planting and (9) control. 'Sumangala' cotton (*Gossypium hirsutum* L.) was sown under irrigated condition. All the treatments received a common dose of NPK @ 60: 13: 25 kg/ha. Half the N along with full dose of P and K was applied as basal along with micronutrients fertilizer as per the treatments and the rest of N was top-dressed at 45 days after planting. The micronutrients fertilizers were foliar sprayed @ 0.5% at 60, 75 and 90 days after planting as per treatment. Pre-emergence application of fluchloralin @1 kg/ha was also applied on the plots, followed by 2 hand weedings to keep the experimental plot weed free. Growth attributes, yield parameters and seed cotton yield were recorded during the investigation. The quality parameters, viz ginning per cent, seed index, lint index, 2.5% span length, maturity ratio, uniformity ratio, micronaire, fibre strength and fibre elongation were analyzed. Fibre quality index (FQI= LT/√M, where L, 2.5% span length (mm); T, fibre bundle tenacity at 3.2 mm gauge (g/tex) and M, micronaire value), count (C=0.196 FQI – 16) and count strength product (CSP=1.740 FQI + 1600) were also worked out. The quality parameters (except ginning percentage, seed index and lint index) were analyzed by using high volume instruments (HVI, Statex-Fibrotex model). The pooled analysis was made from 2 years data to assess the effect of micronutrient fertilizers along with $MgSO_4$ and methods of application (soil VS foliar) on yield, quality and other parameters. Post-harvest soil samples were collected and were analyzed for soil *p*H, EC and available N, P and K status. Economics was also calculated on the basis of prevailing market price of inputs and outputs.

RESULTS AND DISCUSSION

Growth and yield

Growth attributes of cotton were not significantly influenced by the soil application of micronutrient fertilizers in comparison to absolute control at 45 days after planting (foliar application was imposed after 45 days after planting at 60,75 and 90 days after planting). Foliar application of $MgSO_4$ @ 0.5% at 60, 75 and 90 days after planting significantly influenced the leaf area index, bolls/plant and dry weight at 90 days after planting by 26, 30 and 27% over the control (Table 1). However, other growth characters did not differ with following micronutrients application.Yield traits were significantly influenced by the application of micronutrients. $MgSO_4$ @ 0.5% as foliar at 60, 75 and 90 days after planting and borax @ 5 kg/ha through soil significantly increased bursted bolls/plant (16 and 17%) and single plant yield (15.7 and 15.0%). Boron application

Table 1 Effect of micronutrient fertilizers on per plant growth and harvest attributes parameters at 45 and 90 DAP (pooled data)

Treatment	45 DAP				90 DAP				At harvest					
	Height (cm)	Squares	LAI	Dry weight (kg/ha)	Height (cm)	Squares	LAI	Dry weight (kg/ha)	Bolls	Sympodia	Boll weight (g)	Burst bolls	Single plant yield(g)	Seed cotton yield (kg/ha)
$MgSO_4$ @ 50 kg/ha-soil	22.7	5.3	1.5	176	63.4	11.9	2.7	1 709	12.8	15.3	4.7	10.3	48.8	1 595
$MgSO_4$ @ 0.5% -foliar	25.1	5.3	1.2	166	70.3	15.6	2.9	2 114	16.6	16.8	4.6	11.6	53.0	1 630
$ZnSO_4$ @ 50 kg/ha-soil	25.5	5.0	1.1	160	67.5	15.0	2.8	1 906	13.8	15.2	4.5	10.9	51.7	1 575
$ZnSO_4$ @ 0.5% -foliar	25.9	5.9	1.2	224	62.5	12.8	2.5	1 625	15.8	15.3	4.7	10.8	52.1	1 545
$FeSO_4$ @ 50 kg/ha-soil	25.4	6.0	0.9	153	66.2	14.0	2.4	1 654	13.8	15.5	4.6	11.4	51.9	1 500
$FeSO_4$ @ 0.5% -foliar	26.3	5.0	1.1	152	69.2	12.8	2.7	1 657	15.2	15.6	4.5	11.2	51.6	1 555
Borax @ 5 kg/ha-soil	25.3	4.1	1.0	132	58.8	13.3	2.7	1 982	14.5	16.7	4.6	11.7	52.7	1 640
Borax @ 0.5% -foliar	22.5	4.3	1.0	137	65.2	14.0	2.5	1 638	13.0	14.6	4.7	10.1	46.7	1 370
Control	26.3	5.4	1.1	163	66.2	14.8	2.3	1 663	12.8	16.3	4.7	10.0	45.8	1 380
SEd ±	3.0	2.0	0.2	16.0	7.5	4.2	0.2	144	1.7	1.0	0.2	0.7	3.2	120
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	0.5	295	3.5	2.0	NS	1.5	6.5	245

increased the number of bolls by an average of 29% compared with the control (Christos Dordas 2006). Foliar sprays of 1% $MgSO_4$ also resulted in higher yield attributes at Faridkot (AICCIP 2010). Since the field was alkaline in reaction (*p*H 8.5), the availability of Mg is not a limiting factor, yet excess K (1 050 kg/ha) in soil might have caused the antagonistic effect on the absorption of magnesium (Tisdale *et al.* 2007, Hegde and Sudhakar Babu 2009). In addition, irrigation water with high exchangeable sodium (sodium adsorption ratio of 8.7) to crop plants might increase Mg deficiency (Astaraei and Chauhan 1992) and was thus, corrected by foliar sprays of $MgSO_4$ @ 0.5% at 60, 75 and 90 days after planting. High soil K and poor quality water is in fact, not an uncommon phenomenon in many cotton growing areas.

Application of Borax @ 5 kg/ha to soil gave the significantly highest seed cotton yield of 1 640 kg/ha (18.8% higher), followed by foliar sprays of $MgSO_4$ @ 0.5% at 60, 75 and 90 days after planting (Table 1). The results are in accordance with the findings of Rerkasem *et al.* (2004). Cotton is sensitive to low level of B and basal application of 2 kg boron/ha through broadcast on surface soil was found significantly superior than top-dressing in boron deficient soils (Singh 2006). The optimum dose of B in calcareous soil and heavy textured soils ranged from 1.5 to 2.0 kg/ha (Singh 2009) and significant yield increase by application of 1.12 kg of B/ha was also reported by Gurmus (2005). Boron is being given special importance because of role in flowering process. Adverse effect on the yield can occur even though B deficiency symptoms are not evident on the foliage and it is known as hidden hunger (Satya *et al.* 2009). Foliar sprays of $MgSO_4$ @ 0.5% at 60, 75 and 90 days after planting registered the second highest seed cotton yield 1 630 kg/ha (18.1% higher). Magnesium sulphate (2%) as foliar sprays on 50th and 80th day corrects the red leaf symptom malady and increase the seed cotton yield (Karivaradaraju 2008). Foliar sprays of 1% $MgSO_4$ resulted in 43% higher seed cotton yield at Faridkot (AICCIP 2010). Higher growth attributes observed in the above treatments, effectively converted photosynthates into economic parts (yield attributes) and these yield parameters may have contributed for the enhanced yield. Since deficiency of specific micronutrient limits the yield even in presence of major nutrients alone, thus, all nutrients should be applied at an optimum level for yield optimization.

Fibre quality parameters

Important quality parameters, viz seed index, lint index, micronaire value, fibre strength and fibre elongation were not significantly influenced by micronutrient fertilization (Table 2). Yet ginning percentage, 2.5% span length and uniformity ratio was significantly enhanced by micronutrient supply through soil. Ginning percentage is a measure of lint yield from seed cotton and uniformity ratio is the measure of uniformity in fiber length. $FeSO_4$ @ 50 kg/ha to soil registered significantly higher ginning percentage of 39.2% (8% higher) and uniformity ratio 50.2 (5.7% higher) as compared those in control (36.3% and 47.5 for ginning percentage and uniformity ratio respectively). As much as

Table 2 Effect of micronutrient fertilizers on quality parameters of cotton (pooled data)

Treatment	GP	Lint index	Seed index (g)	2.5% SL (mm)	Uniformity ratio (%)	Maturity ratio	Micronaire (μ/inch)	Strength (g/tex)	Elongation (%)	FQI	Count	CSP
$MgSO_4$ @ 50 kg/ha-soil	37.7	6.3	10.6	27.3	48.0	0.77	4.4	20.1	5.5	262	35.4	2 056
$MgSO_4$ @ 0.5% -foliar	38.1	6.5	10.7	27.5	49.5	0.76	4.5	20.4	5.2	264	35.7	2 059
$ZnSO_4$ @ 50 kg/ha-soil	37.4	6.2	10.3	27.5	48.9	0.74	3.9	20.0	5.4	279	38.7	2 085
$ZnSO_4$ @ 0.5% -foliar	37.6	6.2	10.1	27.6	49.5	0.77	4.1	20.3	5.5	278	38.5	2 084
$FeSO_4$ @ 50 kg/ha-soil	39.2	6.8	10.7	27.6	50.2	0.78	4.4	20.3	5.6	267	36.3	2 065
$FeSO_4$ @ 0.5% -foliar	37.3	6.2	10.2	27.7	49.3	0.79	4.5	20.1	5.3	262	35.4	2 056
Borax @ 5 kg/ha-soil	37.9	6.1	10.1	27.9	49.2	0.76	4.4	19.8	5.2	263	35.5	2 058
Borax @ 0.5% -foliar	37.1	6.2	10.5	27.8	49.3	0.77	4.3	20.2	5.1	270	37.0	2 070
Control	36.3	6.0	10.6	27.0	47.5	0.76	4.0	20.1	5.6	271	37.1	2 072
SEd ±	0.9	0.5	0.4	0.4	1.0	0.03	0.3	1.0	0.1			
CD(P=0.05)	1.8	NS	NS	0.8	2.0	NS	NS	NS	NS			

GP, Ginning percentage; SL, span length; FQI, fibre quality index; CSP, count strength product

Table 3 Influence of micronutrient fertilizers on final soil status and economics (pooled data)

Treatment	*p*H	EC (dSm/1)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
$MgSO_4$ @ 50 kg/ha-soil	8.5	0.20	205.0	31.7	1 126	21 750	31 900	10 150	1.47
$MgSO_4$ @ 0.5% -foliar	8.4	0.23	165.0	19.2	1 170	22 125	32 600	10 475	1.47
$ZnSO_4$ @ 50 kg/ha-soil	8.4	0.23	214.2	16.7	1 083	23 500	31 500	8 000	1.34
$ZnSO_4$ @ 0.5% -foliar	8.4	0.23	152.5	22.2	1 053	23 000	30 900	7 900	1.34
$FeSO_4$ @ 50 kg/ha-soil	8.5	0.20	180.0	24.7	1 050	20 100	30 000	9 900	1.49
$FeSO_4$ @ 0.5% -foliar	8.4	0.20	195.8	25.7	1 138	21 300	31 100	9 800	1.46
Borax @ 5 kg/ha-soil	8.5	0.20	164.2	28.0	1 052	19 950	32 800	12 850	1.64
Borax @ 0.5% -foliar	8.4	0.23	165.8	25.5	1 213	23 250	27 400	4 150	1.18
Control	8.5	0.20	186.7	22.5	1 088	19 500	27 600	8 100	1.42
SEd ±	0.0	0.03	37.3	6.8	50				
CD(*P*=0.05)	NS	NS	NS	NS	102				

one third of the world's surface soils are calcareous, primarily in arid and semi-arid regions, Fe deficiency is common in most of the field crops and respond for external application (FAO 2005). In the determination of quality of cotton, fibre length occupies dominant position, which directly influences the spinnability of the cotton, 2.5% of span length was also significantly increased by borax @ 5 kg/ha (3.3% higher) applied through soil. Application of B significantly increased staple length, however, cultivars varied in their response as reported by Ahmad *et al*. (2009). Numerically, the highest FQI (279) was noticed under $ZnSO_4$ @ 50 kg/ha to soil, followed by the same fertilizer as foliar @ 0.5% at 60, 75 and 90 days after planting. Similar trend was also observed with the spinnable count and count strength product. The products of the count of the yarn and it fibre strength is known as count strength products and is normally used to indicate the spinning value of cotton. The numerically highest count of 38.7 (4.3% higher) and count strength product of 2 085 (0.6% higher) were also calculated with soil application of $ZnSO_4$ @ 50 kg /ha (Table 2).

Soil nutrient status

Influence of micronutrient fertilization on post harvest assessment of soil *p*H, EC, available N, P and K status revealed that none of the nutrients (Mg, Zn, Fe and B) and their method of application (soil and foliar) influenced soil *p*H, EC, available nutrients (N & P) except K (Table 3). Foliar application of borax @ 0.5% on 60, 75 and 90 days after planting registered the highest available K in post-harvest soil, and might be due to production of less seed cotton yield, less demand for K (especially for cotton stalk) that restored the soil at relatively high soil available K. Negative balance of K is reported with high yield of cotton and external application through fertilizer is far lesser than what is removed (Blaise *et al*. 2005).

Economics

Based on prevailing market price of inputs and produce, it was revealed that highest cost of cultivation (Rs 23 500/ ha) was calculated under $ZnSO_4$ @ 50 kg/ha through soil. Soil application of borax @5 kg/ha and $MgSO_4$ @ 0.5% as foliar at 60, 75 and 90 days after planting resulted 18.8 and 18.1% higher gross returns and 58.6 and 29.3% higher net returns, respectively (Table 3). Higher seed cotton yield was harvested with borax @ 5 kg/ha as soil application and $MgSO_4$ @ 0.5% as spray at 60, 75 and 90 days after planting helped in realization of more returns. Borax @ 5 kg/ha as soil application also gave higher B : C ratio (1.64), indicating that realizing of higher gross returns/unit cost of investment towards external supplementation of micronutrients. Economic benefit computed ranged from Rs 2.75 to 3.10 for every rupee invested on foliar nutrition practices on *Bt* cotton (Saravanan 2009).

Most of the micronutrient fertilizers involving Zn, Fe and B applied through foliar or soil could not influence on growth characters, yield attributes, yield and quality parameters of cotton with few exception. Ginning percentage and uniformity ratio were enhanced by $FeSO_4$ @ 50 kg/ha to soil and 2.5% span length by borax @ 5 kg/ha as soil application. $MgSO_4$ @ 0.5% on 60, 75 and 90 days after planting as foliar and borax @ 5 kg/ha to soil increased seed cotton yield significantly over control. It is inferred that cotton responds to boron and magnesium and external application would be a viable option to break the yield barrier and improve the quality.

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