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EFFECTS OF FOLIAR APPLICATION OF NUTRIENTS ON GROWTH AND YIELD OF BT COTTON (*GOSSYPIUM HIRSUTUM* L.)

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Abstract

Field experiments were conducted for three years during *Kharif* 2009-2011 to study the effect of foliar application of nutrients (N, Mg, Fe, Zn, Mn and B) on growth and yield parameters of *Bt* cotton. Pooled data indicated highest seed cotton yield (3421.4 kg/ha) with application of $MgSO_4$ 1.0%+ $ZnSO_4$ 0.5%. Better net returns (₹100760/ha) and improved B:C (4.06) ratio for $MgSO_4$ 1.0% + $ZnSO_4$ 0.5% clearly supported its application benefits to realize higher yield .

Introduction

The area under *Bt* cotton has increased to 121.9 lakh hectares with an adoption rate of 92% of the total cotton area in India. Being an important *Kharif* season cash crop in Punjab, cotton occupies a significant place primarily towards agrarian economy of south western districts. It is highly suited as an alternate to paddy and can play a major role in the diversification. During 2011-2012, it was cultivated on 515 thousand ha with a production of 1621 thousand bales and lint yield of 535 kg/ha (Anon. 2013). In Punjab, *Bt* cotton is presently covering 94 per cent of total acreage (Kranthi 2012). However, certain physiological problems have also mushroomed with *Bt* cotton cultivation leading to decline in productivity. Of these reddening of leaves also called "*LALYA*" is prime malady. Besides that, square drying, premature floral abscission and failure to set the bolls are among some other abiotic disorders associated with poor productivity in the era of *Bt* cotton cultivation. Brackish underground water of the south western cotton zone is further aggravating such problems (Singh *et al*. 2013). For cotton crop yielding about 1800 kg/ha, 70% of the Zn and P taken up was removed in the seed, apart from 38% of Cu, 34% of Mg, 17% of Fe and 12% of B (Rochester 2007). Soil application of Zn, B, Fe, Mn, and Cu on calcareous soils is less efficient, as these nutrients remain inaccessible to plant roots due to the higher soil pH (Rashid and Ryan 2004, Sajid *et al.* 2008). However, an alternative approach under such circumstances is foliar application of nutrients (Rab and Haq 2012) primarily for two reasons. First, it eliminates the effects of soil pH on the availability of these nutrients (Ali 2012). Second, it is more effective and less costly (Ali *et al*. 2007). For reasons mentioned above, it has gained significant attention in agriculture worldwide (Liew *et al*. 2012). External supplementation of plant nutrients needs to be therefore emphasized keeping in view their role in improving yield. Quantum of micronutrient deficiencies of Zn (49%), B (37%), Fe (12%), Mn (4%) and Cu (30%) reported in Indian soils demand urgent attention (Singh 2009). Since little information is available on application of aforesaid nutrients through foliar sprays and consequently their effect on growth and yield of *Bt* cotton, hence, the present investigation was carried out for three years to draw conclusive inferences.

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Materials and Methods

The experiment was conducted during *Kharif* season of the years 2009, 2010 and 2011 at Punjab Agricultural University, Regional Research Station, Faridkot which lies in Trans-Gangetic agro-climatic zone, representing the Indo-Gangetic alluvial plains (30º40′ N and 74º44′ E) of Punjab situated at 200 m above mean sea level. The soil of the experimental field was loamy in texture, slightly alkaline (pH 8.5), normal in EC (0.43 mmhos/cm), medium in O.C (0.48%), low in available P (7.5 kg/ha) but high in available K (750 kg/ha). The experiment comprised of 9 foliar treatments of nutrients i.e control, boron 0.1%, $ZnSO_4$ 0.5%, $MnSO_4$ 1.0%, $MgSO_4$ 1.0%, $MgSO_4$ 1.0% + $ZnSO_4$ 0.5%, $FeSO_4$ 0.5%, $FeSO_4$ 0.5% + $ZnSO_4$ 0.5% and urea 2% at flowering and DAP 2% at boll development stage arranged in complete randomized block design with three replications. The *Bt* hybrid MRC 6304 was selected for the studies because of its popularity among cotton growers and reports of relatively more occurrence of square drying and failure to yield its potential productivity at Farmer's fields. Sowing was performed in first fortnight of May by dibbling 2-3 seeds/hill which were later thinned to one seedling per hill. The recommended fertilizer dose (i.e 75 kg N, 30 kg P_2O_5 and 50 kg K_2O/ha) was applied as per package of practices. Foliar sprays of all the nutrients were applied at two growth stages i.e. flowering and boll development. The rain received during the crop season was 475.5, 432.8 and 587.5 mm spread over 31, 36 and 41 days for year 2009, 2010 and 2011, respectively. Data on growth, yield and quality parameters were recorded from 5 randomly selected plants in each treatment plot measuring 36.45 m^2 (having 78 plants in 6 rows with 67.5 × 75 cm geometry). Seed cotton yield (kg/ha) was calculated from whole plot. All other recommended production and protection practices were uniformly applied. The pooled analysis was made from 3 years' data as per the standard procedure proposed by Cheema and Singh (1991). Economics were also calculated on the basis of prevailing market price of inputs and seed cotton.

Results and Discussion

The pooled data on various growth parameters indicated significant differences for plant height and biomass accumulation (Table 1). Plant height was significantly reduced under control (110.3 cm) whereas application of $MgSO_4$ exhibited the maximum plant height (126.4 cm). However, the values among the treatments were found to be non-significant (Table 1). Biomass accumulation was highest with application of urea at flowering and DAP at boll development stage (110.4 q/ha) while least biomass was recorded under control (89.1 q/ha) closely followed by boron (90.2 q/ha). Pooled data indicated non-significant effects of foliar application on monopods per plant. Sankaranarayanan *et al.* (2010) has also reported that 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.

The data in the Table 1 indicated significant effect of foliar treatments on number of bolls, boll weight and seed cotton yield (SCY). The pooled data revealed highest SCY (3421.4 kg/ha) with application of $MgSO_4$ + $ZnSO_4$ though at par with $MgSO_4$ but significantly better than all other treatments. Eweida *et al*. (1979) reported significantly increased SCY with the foliar application of magnesium and zinc separately and also with combination of sulphate of zinc and magnesium. Application of zinc and magnesium sulphate significantly increased SCY per plant as compared with the untreated control (Soomro *et al*. 2000**,** Zakaria *et al*. 2008). Foliar sprays of $MgSO_4$ 0.5% at 60, 75 and 90 days after planting raised the SCY by more than 18% in comparison to control (Sankaranarayanan *et al*. 2010). Significantly improved number of sympods per plant (22.8) was recorded with application of $MgSO_4$ + $ZnSO_4$ than control (17.6) and $ZnSO_4$ (20.4)

Table 1. Growth and yield parameters of *Bt* cotton under different foliar treatments (pooled mean of 3 years).

Treatments	Plant height (cm)	Monopods/ plant	Sympods/ plant	Bolls/ plant	Weight/ boll (g)	Seed cotton yield (kg/ha)	GOT (%)	Biomass (q/ha)	Halo length (mm)
Control	110.3	1.34	17.6	38.4	4.22	2377.9	33.6	89.1	28.8
Boron 0.1 %	120.9	1.32	21.2	45.0	4.27	2529.8	33.7	90.2	28.4
$ZnSO_4$ 0.5 "	120.8	1.43	20.4	50.5	4.49	3059.9	34.2	100.7	28.8
$MnSO_4$ 1.0 "	123.5	1.40	21.7	45.1	4.60	2779.7	33.8	101.8	28.5
$MgSO_4$ 1.0 "	126.4	1.47	22.1	51.6	4.67	3297.6	33.7	105.9	27.9
$MgSO_4$ 1.0% + $ZnSO_4$ 0.5 "	119.6	1.36	22.8	50.1	4.72	3421.4	34.0	107.6	27.6
$FeSO_4$ 0.5 "	120.4	1.35	22.2	46.6	4.57	2678.5	33.8	109.6	28.9
$FeSO_4$ 0.5% + $ZnSO_4$ 0.5 "	120.9	1.55	22.1	46.6	4.71	2984.8	34.4	103.1	28.7
Urea 2% at flowering and DAP 2% at boll development stage	118.0	1.44	20.8	45.6	4.52	2754.5	33.9	110.4	27.8
LSD (0.05)	7.6	NS	2.2	4.6	0.28	332.8	NS	12.8	0.86

Table 2. Effects of foliar treatments on the ancillary parameters of *Bt* cotton hybrid (pooled mean of 3 years).

Treatments	Lint yield (kg/ha)	Seed yield (kg/ha)	Seed index (g)	Oil (%)	NUE (kg scy/kg nutrient applied)	Water productivity (g/m^3)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B: C
Control	797.0	1580.9	9.25	22.6	5.08	479.8	22200	87129	64929	2.92
Boron 0.1 %	854.1	1675.8	9.50	22.8	5.41	510.4	22580	92872	70292	3.11
$ZnSO_4$ 0.5 "	1047.3	2012.6	9.37	22.8	6.54	614.8	23905	111512	87607	3.66
$MnSO_4$ 1.0 "	940.2	1839.5	9.37	22.9	5.94	558.4	23204	101464	78259	3.37
$MgSO_4$ 1.0 "	1114.5	2183.2	9.53	22.8	7.05	663.4	24499	120474	95975	3.92
$MgSO_4$ 1.0% + $ZnSO_4$ 0.5 "	1165.0	2256.4	9.08	22.7	7.32	688.9	24809	125569	100760	4.06
$FeSO_4$ 0.5 "	906.9	1771.6	9.04	22.5	5.73	538.9	22952	98547	75595	3.29
$FeSO_4$ 0.5% + $ZnSO_4$ 0.5 "	1028.5	1956.3	8.96	22.7	6.38	600.5	23717	109430	85712	3.61
Urea 2% at flowering and DAP 2% at boll development stage	936.2	1818.3	9.28	23.1	5.89	555.0	23141	101133	77991	3.37
LSD (0.05)	117.6	217.9	NS	NS	0.71	65.9	832	12017	11194	0.36

although it was at par with rest of the treatments. Improved number of bolls per plant and boll weight over the control also contributed for higher SCY. The foliar application of $MgSO_4$ + $ZnSO_4$ increased the boll weight and SCY by 11.8 and 43.8 per cent compared with the control, respectively. The least SCY (2377.9 kg/ha) was observed under control. Yaseen *et al.* (2013) also indicated significant improvement in SCY with foliar application of Zn, B, Mn, Cu, and Fe on cotton grown on calcareous soils with the recommended soil applied NPK fertilizers in Pakistan.

The pooled data indicated that ginning out turn (GOT), oil (%) and seed index were not significantly influenced by foliar application of nutrients, but halo length, lint as well as seed yield was significantly increased over the control (Table 2). Sankaranarayanan *et al.* (2010) also reported significant enhancement for specific fibre quality parameters, such as GOT and uniformity ratio with micronutrient fertilization. Halo length among various treatments ranged from 27.6 - 28.9 mm. Lint yield was also significantly higher (1165 kg/ha) under combined application of $MgSO_4$ + $ZnSO_4$ than all other treatments except for $MgSO_4$. Similarly, seed yield (2256.4 kg/ha) was also significantly enhanced by combination of $MgSO_4$ + $ZnSO_4$. Zakaria *et al.* (2008) found that application of zinc significantly increased SCY and lint yield as compared to control. Highest water productivity (WP) indices were exhibited with application of $MgSO_4$ + $ZnSO_4$ (688.9 g/m^3) followed by $MgSO_4$ (663.4 g/m^3) thereby indicating its superiority over other treatments (Table 2). Least WP was recorded under control (479.8 g/m3). Nutrient use efficiency (NUE) also followed the similar trend with highest and least value with application of $MgSO_4$ + $ZnSO_4$ (7.32) and control (5.08), respectively. Cultivation cost was also highest (₹24809/ ha) with application of $MgSO_4$ + $ZnSO_4$. As a result of better WP and NUE indices and consequently improved SCY, highest net returns (₹100760/ha) and B : C (4.06) was recorded with application of $MgSO_4$ + $ZnSO_4$ though at par with $MgSO_4$ but significantly better than rest of the treatments. Yaseen *et al.* (2013) also reported 20 - 30% more economic benefit over NPK fertilizers alone with foliar application of Zn, B, Mn, Cu and Fe. Application of $MgSO_4$ + $ZnSO_4$ resulted 44.1 and 55.1% higher gross and net returns respectively, over the control (Table 2).

It is inferred that cotton responds to magnesium and zinc and foliar application could be a viable option to break the yield barrier. Pooled data of three year study revealed that two sprays of $MgSO_4$ + $ZnSO_4$ at flowering and boll development can enhance seed cotton yield significantly by improving yield contributing parameters and should be exploited by farmers to enhance cotton productivity.

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