Research Article

Amelioration of Cotton Leaf Reddening with Boron and Zinc Application through Balanced Nutrient Management Practices

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Abstract | A field experiment was conducted to study the effect of nutrient management on growth, yield characters and leaf reddening in cotton (*Gossypium hirsutum* L.). Cotton variety Haridost was studied under 4 NPK treatments (000 NPK kg ha^{-1}, 120-0-0 kg N ha^{-1}, 120-70-0 kg N ha^{-1}, 120-70-40 kg NPK ha^{-1} and 5 secondary and micronutrient (Control, 50, 3, 4 and 1.5 kg ha^{-1} Mg, Fe, Zn and B, respectively) treatments. NPK @ 120-70-40 kg ha^{-1} resulted maximum plant height, number of green leaves plant^{-1}, number of opened bolls plant^{-1}, seed index, and seed cotton yield ha^{-1}. Red leaves reduced when soil was fertilized with N, P and K @ 120-70-40 kg ha^{-1}; and plots without application of K (120-70-0 kg ha^{-1}) and PK (120-0-0 kg N ha^{-1}) increased number of red leaves. In case of micronutrients, Zn @ 4 kg and B @ 1.5 kg ha^{-1} were highly effective to control reddening of leaves, respectively. Interactive effect of NP @ 120-70 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum reduction of red leaves. Regardless the application of N, P or K and their control, reddening of leaves was linearly affected by Zn and B. It is concluded that there was no direct effect of N, P, K, Mg and Fe on the reddening of cotton leaves but B and Zn application decreased number of red leaves. Plant growth improved markedly when essentially needed NPK was applied @ 120-70-40 NPK in combination with Zn and B @ 4 and 1.5 kg ha^{-1}, respectively.

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Introduction

Cotton plays a key role in socio-economic and political affairs of the world (Kairon et al., 2004). Pakistan is a fourth largest cotton producing country of the world while ranks third in consumption and is a leading yarn exporter (ICAC, 2012) with a production of 12.8 million bales from an area of 2.8 million hectares. However, Pakistan's seed cotton production per unit area owing to biological, physical, socio-economic, environmental and agronomic constraints is quite low. By adopting appropriate agronomic practices cotton yield per unit area can be improved. Management decisions like variety selection, planting date, plant density, and nitrogen management have a profound effect on the development and final outcome of the crop. Innumerable abiotic and biotic factors affect cotton, thus limiting productivity. The reasons for decreasing productivity are due to decreasing soil fertility, imbalanced use of fertilizer and occurrences

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of physiological disorders like leaf reddening. Among these, imbalanced use of major and micro nutrients is the major problem (Hebbar et al., 2007).

Physiological disorders appear as a consequence of nutritional / hormonal imbalances in environmental conditions. A proper understanding of these disorders will be useful while taking up appropriate control measures (Perumal et al., 2006). Some of the commonly occurring physiological disorders in cotton include leaf reddening, parawilt / new wilt, leaf drying/ burn, bud and boll drying, bad boll opening, crazy top, crinkle leaf, bud and boll shedding (a natural phenomenon, may be considered as physiological disorder if the shedding is unusually prolonged and intense due to disturbances in source-sink relationship). Leaf reddening in cotton is disorder which may be an outcome of interaction of location, variety, environmental condition and nitrogen supply (Perumal et al., 2006). Leaf reddening may occur at any growth stage of the crop. However, it is quite often confused with the reddening of leaves caused by sucking pest damage at early growth stages. Keeping in view the economic significance of cotton and the damage caused by reddening of cotton, a field experiment was carried out to examine the effect of nutrient management on cotton growth, yield and leaf reddening.

Materials and Methods

A field experiment was conducted at the Soil Fertility Section, Agriculture Research Institute, Tandojam. The soil was silty clay with 7.7 pH, 0.75% organic matter, 0.09% N, 9.0 mg kg^{-1} P, 140 mg kg^{-1} K, 7.8 mg kg^{-1} Mg, 2.0 mg kg^{-1} Zn, 1.7 mg kg^{-1} B, 1.2 mg kg^{-1} Fe. The plot size was 3 x 4m ($12m^2$) with three replicated randomized complete block design (Factorial). Cotton variety Haridost was tested against different levels of macro secondary and micronutrient. Factor-A was Macronutrient fertilizers (N): N_1= control, N_2= 120 kg N ha^{-1}; N_3=120 N+ 70 kg P_2O_5; N_4= 120 N+ 70 kg P_2O_5+ 40 kg K_2O. Factor-B was secondary and micronutrient fertilizers (M): M_1= Control; M_2=Mg 50 kg ha^{-1}; M_3=Fe 3 kg ha^{-1}; M_4=Zn 4 kg ha^{-1}; M_5= B1.5 kg ha^{-1}. The Nitrogen was applied in the form of Urea (46% N), P as DAP (18% N, 46% P_2O_5), K in the form of SOP (50% K_2O), Mg as $MgSO_4$ (20% Mg), Fe in the form of $FeSO_4$ (15% Fe), Zn as $ZnSO_4$ (21% Zn) and B in the form of Borax (14.6% B).

The recorded agronomic observations were plant height (cm), red $leaves^{-1}$ (young and old), green $leaves^{-1}$ (young and old), shaded flowers $plant^{-1}$, opened bolls $plant^{-1}$, closed bolls $splant^{-1}$, rotten bolls $plant^{-1}$, seed index (g), seed cotton yield (kg ha^{-1}).

Cotton Crop Sowing and Cultural Practices

The sowing was done on ridges by dibbling. The distance between rows was maintained as 75cm (2.5”). The fuzzy seed was treated with sulphuric acid (H_2SO_4). The seed rate was applied at the rate of 4 kg $acre^{-1}$. The seed was with more than 70 percentage germination. Thinning was done after 25 days of sowing and the distance was maintained at 30 cm between plant to plant. The weeding and inter-culturing were carried out after 2 irrigations with spade to keep experimental area free from weeds and break the hard surface between the crop rows. The irrigations were applied as per requirement of the crop and source of the irrigation was canal water. The picking was started when more than 50% bolls were observed to open.

Soil Sampling and Analysis

The soil sampling was done from each plot before the crop sowing. After properly labelling all the samples were brought to the departmental laboratory. Samples were air-dried ground and passed through 2 mm sieve and stored in plastic bags. Selected physico-chemical properties were determined by following the recognized procedures. Electrical conductivity was determined through conductivity meter (Hana Model-8733, Germany) (Rowel, 1994), pH by pH meter (Orion (ISE) Model-SA-720 USA) (Rowel, 1994). Bouyoucos Hydrometer method was adopted for the determination of soil texture (Kanwar and Chopra, 1959), Walkley-Black method was used for the determinations of soil organic matter (%) (Jackson, 1958), total nitrogen (%) in soil was measure by Kjeldahl’s method (Jackson, 1958), AB-DTPA method was adopted for available phosphorus with Spectrophotometer (Model Specord-200 PC. Analytik Jen, Germany) (Soltanpour and Schwab, 1997), Potassium was determined with the help of Flame photometer-Jenway UK Model No. PFP-7. AB-DTPA method was used for determination of extractable Fe, Mg and Zn using atomic absorption spectrophotometer (Analytic-Jena-Germany, Model AAS-Vario-6) (Lindsay and Norvell, 1978). Boron in soil was determined by dilute HCl method (Rashid et al., 1997) and subsequent measurement by using azomethine-H (Bingham, 1982).

Table 1: *Agronomic traits of cotton as affected by integrated nutrient management*

Macronutrients (Kg ha^{-1})	Plant height (cm)	Number of red leaves plant^{-1}	Number of green leaves plant^{-1}	Number of shedded flowers plant^{-1}	Number of opened bolls plant^{-1}	Number of unopened bolls plant^{-1}	Number of rotten bolls plant^{-1}	Seed index (1000 seed weight, g)	Seed cotton yield (kg ha^{-1})
Control	72.0 d	8.60	42.40 d	4.40	11.60 d	3.90 b	3.90 b	67.30 d	1346.20d
120 kg N ha^{-1}	110.0 c	8.70	71.20 c	4.26	21.40 c	4.80 a	4.46 a	84.70 c	2118.30c
120-70 kg NP ha^{-1}	119.0 b	8.60	77.40 b	4.40	26.60 b	4.90 a	3.40 bc	91.10 b	2734.00b
120-70-40 kg NPK ha^{-1}	127.0 a	8.50	80.30 a	4.40	34.20 a	4.70 a	3.24 c	100.90a	3427.20a
SE	0.6423	0.5658	0.8463	0.2966	0.5417	0.2497	0.2664	0.4486	11.821
LSD 0.05	1.3002	1.1454	1.1733	0.6004	1.0966	0.5054	0.7225	0.9082	23.930
Secondary and Micronutrients									
Control	103.0 c	12.70 a	63.91 b	6.25 a	19.9 d	4.91 a	5.60 a	82.00 c	2301.20c
50 kg ha^{-1} Mg	105.0 b	12.41a	64.33 b	6.21 a	21.25 c	4.90 a	5.52 a	84.70 b	2369.90b
3 kg ha^{-1} Fe	105.1 b	12.20 a	64.60 b	6.25 a	21.33 c	4.90 a	5.25 a	85.10 b	2382.10b
4 kg ha^{-1} Zn	112.0 a	2.41 b	73.50 a	1.25 b	28.0 a	3.90 b	1.25 b	89.30 a	2495.20a
1.5 kg ha^{-1} B	111.0 a	3.9 b	72.90 a	1.6 b	26.60 b	4.25 b	1.50 b	88.90 a	2484.40a
SE	0.7181	0.6326	0.9462	0.3316	0.6057	0.2791	0.2979	0.5016	13.216
LSD 0.05	1.4537	1.2856	1.9155	0.6712	1.226	0.5651	0.8078	1.0154	26.754

Means followed by the same letter within the same parameter are not significantly different ($p > 0.05$) using DMRT

Statistical Analysis

The data collected were analyzed for Analysis of Variance (ANOVA) of individual and interactive effects of the experimental treatments. For treatment mean discrimination Duncan's Multiple Range Test (DMRT) was applied.

Results

Plant Height (cm)

Data in Table 1 shows the application of NPK @ 120-70-40 kg ha^{-1} resulted maximum plant height (128.7 cm); however, the plots without application of K and P (120+70 kg ha^{-1} NP and 120 kg N ha^{-1}) resulted in a reduced cotton plant height of 119 and 110 cm, respectively; while in control plots, the cotton plant height decreased to 72 cm. In case of micronutrients, Zn @ 4 kg and B @ 1.5 kg ha^{-1} resulted in higher plant height of 111.4 and 111 cm; while plant height was equal (105 and 105 cm) in plots supplemented with 3 kg Fe or 50 kg ha^{-1} Mg, respectively against 102.6 cm plant height in control. Interactive effect of NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum plant height (132.7 cm) and lowest (64 cm) in control. The cotton plant growth improved markedly when essentially needed NPK were applied together; while plots without application of either K or P showed a significant impact on plant height in adverse direction. Moreover, application of micronutrients also proved their essential requirements to the cotton plant, and plant response to Zn and B application was more pronounced than Fe and Mg.

Number of Red Leaves Plant^{-1}

Reddening of leaves was examined under the effect of various macro, secondary and micronutrients and the results (Table 1) indicated that on an average number of red leaves was reduced to 8.4 plant^{-1} when soil was fertilized with N, P and K @ 120-70-40 kg ha^{-1}; however, the plots without application of K (120+70 kg ha^{-1} NP) and P (120 kg N ha^{-1}) displayed a little increase in the number of red leaves *i.e.* 8.7 and 8.7 plant^{-1}, respectively as compared to 8.6 plant^{-1} in control. In case of micronutrients, Zn @ 4 kg and B @ 1.5 kg ha^{-1} were highly effective to control reddening of leaves with 2.5 and 3.9 red leaves plant^{-1}, respectively against 12.1, 12.4 and 12.7 red leaves plant^{-1} in plots supplemented with 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of NP @ 120-70 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum reduction of red leaves (2.0 plant^{-1}) and found maximum number (14.0 plant^{-1}) in the interaction of 120 kg N × 50 kg Mg ha^{-1}.

Number of Shedded Flowers Plant^{-1}

Shedding of flowers in cotton is caused by the deficiency of certain nutrient elements in the soil. Data (Table 1) shows the number of shedded flowers in plots given NPK @ 120-70-40 kg, NP @ 120-70 kg and N @ 120 kg ha^{-1} was 4.4, 4.4 and 4.2 plant^{-1}, respectively as compared to 4.4 shedded flowers plant^{-1} in control. This indicates that shedding of flowers in cotton was not associated with the application of macronutrients (NPK) and there was almost same number of shedded flowers in treated plots and control. However, there was significant impact of micronutrients application on shedded flowers plant^{-1}, and Zn application @ 4 kg and B @ 1.5 kg ha^{-1} reduced the number of shedded flowers up to 1.2 and 1.6 plant^{-1}, respectively against 6.2, 6.2 and 6.2 shedded flowers plant^{-1} in plots supplemented with 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of macro and micronutrients indicated that NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in lowest number of shedded flowers (1.0 plant^{-1}); while shedded flowers were in maximum number (7.3 plant^{-1}) in the interaction of 120 kg N × Mg @ 50 kg ha^{-1}.

Number of Opened Bolls Plant^{-1}

Opening of bolls in cotton is mostly influence by the growth and vigor of the plant and plant growth is influenced by the adequacy of soil nutrients required by the plants. The impact of various macro, secondary and micronutrients on the number of opened bolls plant^{-1} of cotton was investigated and the results showed that number of opened bolls in plots applied with NPK @ 120-70-40 kg ha^{-1} was highest, (34.20 plant^{-1}), and the number of opened bolls reduced at K (NP @ 120-70 kg ha^{-1}) and P (N@ 120 kg ha^{-1}) upto 26.6 and 21.4 plant^{-1}, respectively. In case of impact of micronutrients application on opened bolls plant^{-1}, Zn application @ 4 kg and B @ 1.5 kg ha^{-1} resulted higher number of opened bolls, 28.0 and 26.6 plant^{-1}, respectively against 21.3, 21.2 and 19.9 opened bolls plant^{-1} in plots supplemented with 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of macro and micronutrients indicated that NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum opened bolls (39.7 plant^{-1}); while opened bolls were lowest (8.7 plant^{-1}) in the interaction of 120 kg N × 0 micronutrients. Statistically, the impact of macro, secondary and micronutrients on boll opening in cotton was significant ($p > 0.05$) and non-significant ($P>0.05$) for their interaction.

Number of Unopened Bolls Plant^{-1}

Application of N @ 120 kg ha^{-1} without P and K resulted in relatively more unopened bolls (4.9) plant^{-1}, followed by application of NP @ 120-70 kg ha^{-1} (4.7 plant^{-1}) and N @120 kg ha^{-1} (4.6 plant^{-1}) as compared to 3.9 unopened bolls plant^{-1} in control (Table 2). In case of impact of micronutrients Zn application @ 4 kg and B @ 1.5 kg ha^{-1} resulted in lesser unopened bolls, 3.9 and 4.2 plant^{-1}, respectively against 4.90, 4.90 and 4.91 unopened bolls plant^{-1} in plots supplemented with 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of control × Zn @ 4 kg ha^{-1} resulted in lowest unopened bolls (3.3 plant^{-1}); while unopened bolls were maximum (5.7 plant^{-1}) in the interaction of NPK@ 120-70-40 kg × Mg @ 50 kg ha^{-1}. Statistically, the impact of macro, secondary and micronutrients on unopened bolls in cotton was significant (p> 0.05) and non-significant (p > 0.05) for their interaction.

Number of Rotten Bolls Plant^{-1}

Rottening of bolls in cotton affects the quality and quantity of the crop adversely. The effect of application of various macro, secondary and micronutrients on the number of rotten bolls plant^{-1} of cotton was evaluated and the results are given in Table 2. The analysis of variance suggested significant (P>0.05) effect of macro as well as micro nutrients on the number of rotten bolls plant^{-1}. The number of rotten bolls plant^{-1} was lowest (3.2) in plots given NPK @ 120-70-40 kg and where no application of P (120-70 kg NP) and K (120 kg ha^{-1} N) resulted in increased number of rotten bolls *i.e.* 3.4 and 4.4, respectively. Similarly, Zn application @ 4 kg and B @ 1.5 kg ha^{-1} reduced the number of rotten bolls up to 1.2 and 1.5 plant^{-1}, respectively against 5.2, 5.5 and 5.6 rotten bolls plant^{-1} in plots supplemented with 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of macro, secondary and micronutrients indicated that NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} and NP @ 120-70 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted equally in lowest number of rotten bolls (1.0 plant^{-1}); while rotten bolls were in maximum number (6.7 plant^{-1}) in the interaction of 120 kg N × 0 micronutrients.

Seed Index (1000 Seed Weight (g))

Seed index was determined in plots supplied with various macro, secondary and micronutrients and the results (Table 2) indicated that seed index in plots given NPK @ 120-70-40 kg was highest (100.9 g), while seed index reduced to 91.1 and 84.70 g on without application of K (NP @ 120-70 kg ha^{-1}) and PK (N @ 120 kg ha^{-1}), respectively as compared to 67.3 g seed index in control. This showed that no application of any of the N, P and K will affect seed index adversely. There was also a significant impact of micronutrients application on seed index, and Zn application @ 4 kg and B @ 1.5 kg ha^{-1} resulted higher seed index of 89.3 and 88.9 g, respectively against 85.1, 84.7 and 82.0 g seed index in plots given 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} and NPK @ 120-70-40 kg ha^{-1} × B @ 1.5 kg ha^{-1} resulted equally in seed index (104.3 g) and minimum (61.7 g) in control.

Seed Cotton Yield (kg ha^{-1})

The impact of macro, secondary and micronutrients application on seed cotton yield was investigated and the results (Table 2) indicated that seed cotton yield in plots given NPK @ 120-70-40 kg was maximum (3427.20 kg ha^{-1}), while seed cotton yield was decreased to 2734.00 and 2118.30 kg ha^{-1} on without application of K (NP @ 120-70 kg ha^{-1}) and PK (N @ 120 kg ha^{-1}), respectively as compared to 1346.16 kg seed cotton yield ha^{-1} in control. While where there is no application of any of the N, P and K resulted in adverse impact on seed cotton yield. Impact of micronutrients application on seed cotton yield ha^{-1} was also significant and Zn application @ 4 kg and B @ 1.5 kg ha^{-1} resulted higher seed cotton yield of 2495.20 and 2484.4 kg ha^{-1}, respectively against 2382.10, 2369.00 and 2301.20 kg ha^{-1} seed cotton yield ha^{-1} in plots given 3 kg Fe, 50 kg Mg ha^{-1} and control, respectively. Interactive effect of NPK @ 120-70-40 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum seed cotton yield (3547.30 kg ha^{-1}) and minimum (1233.30 kg ha^{-1}) in controls.

Table 2: *Some physico-chemical properties of experimental field before sowing of cotton crop*

Soil depth (0-15 cm)										
Texture	pH	ECe dS m^{-1}	OM (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Mg (mg kg^{-1})	Zn(ppm)	B (ppm)	Fe (ppm)
Silty Clay	7.7	2.7	0.75	0.09	9.0	140	7.8	2.0	1.7	1.2
15-30 cm										
-do-	7.8	2.5	0.68	0.071	8.6	120	6.5	2.1	1.8	1.4
30-45 cm										
-do-	7.7	2.04	0.54	0.04	7.8	112	6.1	2.0	1.6	1.5

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Seed cotton yield was significantly (p>0.05) affected by application of macro and micronutrients, while their interactive effect was non-significant (p>0.05).

Discussion

Present study showed that NPK application @ 120-70-40 kg ha^{-1} resulted maximum plant height, slightly reduced red leaves $plant^{-1}$, maximum green leaves $plant^{-1}$, shedded flowers $plant^{-1}$, maximum open bolls $plant^{-1}$, equal unopened bolls $plant^{-1}$, minimum rotten bolls $plant^{-1}$, highest total bolls $plant^{-1}$, highest seed cotton yield $plant^{-1}$, maximum seed index and highest seed cotton yield ha^{-1}. Without application of K and P (120+70 kg ha^{-1} NP and 120 kg N ha^{-1}) resulted in adverse effects on all the above characters. Red leaves reduced when soil was fertilized with N, P and K @ 120-70-40 kg ha^{-1}. There was no impact of macronutrients (NPK) application on the shedding of flowers in cotton as divulged from the results of the present study; while the effect of micronutrients, particularly, Zn and B showed an obvious impact on red leaves and shedded flowers $plant^{-1}$ declined with the addition of NPK, Zn and B in the fertilization program for cotton. The results of experiment further showed that number of red leaves per plant decreased with application of B and Zn. The results of our experiment are in agreement with the findings of Masram et al. (2015), reported that application of macro and micronutrients decreased the incidence of cotton leaf redding in Bt and non-Bt cotton at boll development stage nitrogen and potassium were helpful for controlling the reddening in Bt and non-Bt cotton.

Results further revealed that leaf N, P and K accumulation were highest in plants receiving NPK @ 120-70-40 kg ha^{-1}. The effect of micronutrients indicated that the leaf Mg, Zn, B and Fe contents were relatively higher in plots treated with Mg @ 50, Zn @ 4, B @ 1.5 and Fe @ 3 kg ha^{-1}, respectively. This indicates balanced application of macro, secondary and micronutrients are of prime importance that will obviously ensure the higher crop productivity. Application of N, P K is essential for optimum seed cotton yield and while omitting any of these elements will result an adverse effect on this character. These results are further supported by Perane et al. (2011), they found that maximum leaf reddening in cotton was recorded where no fertilizers were applied. The maximum reduction in leaf reddening was observed in application of 10 t ha^{-1} FYM + 125% RDF (125:63:63 kg NPK ha^{-1}) + two sprays of micronutrients (1.25%). Hosmath et al. (2012) reported that balancing the application NPK and other micronutrients including Zn and B in genotype Neeraja recorded significantly lower number of red leaves than others. Abid et al. (2007) witnessed significant increase in seed cotton yield and its fruiting efficiency with boron fertilization. Boron deficiency in cotton plant hinder plant growth by reduced photosynthetic translocation through vascular bundles of petioles, causing inhibited reproductive growth and development.

In case of micronutrients, Zn @ 4 kg and B @ 1.5 kg ha^{-1} were highly effective to control reddening of leaves $plant^{-1}$. Interactive effect of NP @ 120-70 kg ha^{-1} × Zn @ 4 kg ha^{-1} resulted in maximum reduction of red leaves and maximum red leaves were found in the interaction of 120 kg N × 50 kg Mg ha^{-1}. The results clearly suggested that the leaf reddening problem in cotton will be more severe in soils deficient of Zn and B. Reddening of leaves is a physiological disorder in cotton induced by different abiotic stresses. The lipid peroxide content indicative of membrane fragmentation was decreased. Soil fertility, N, P and K fertility altered leaf reddening in cotton.

Conclusion

The results of study revealed that cotton plant growth and yield traits improved significantly when macro, secondary and micronutrients (Zn and B) were applied together. Plant growth improved markedly when N, P, K were applied in combination with Zn and B. There was no direct effect of N, P, K, Mg and Fe on the reddening of leaves in cotton. However, leaf reddening was significantly decreased by Zn and B application.

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Conflict of Interests

The authors declare no conflict of interest.

Authors' Contribution

Allah Wadhayo Gandahi conceived the study idea, designed and supervised the experiment, helped in data analysis and wrote-up of manuscript. Khalillulah Panhwar conducted experiment and did laboratory analysis of soil and plant samples. Miss Rabail Gandahi helped in editing of manuscript and collection of review material. Muhammad Saleem Sarki contributed in editing of article and critically revised the manuscript. Mahmooda Buriro helped to draft the manuscript.

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