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Influence of Soil-applied Boron on Yield, Fiber Quality and Leaf Boron Contents of Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

Experiments were conducted to investigate the usefulness of boron (B) on cotton cultivar CIM-499 grown on a silt loam (coarse silty, hyperthermic, typic haplocambids) soil. Boron @ 0 (control), 1.0, 1.5 and 2.0 kg ha^{-1} was applied. The experiment was laid out in a randomized complete block design with three replications. Results revealed significant improvement in fruiting efficiency, leaf-B concentration and seed cotton yield with B fertilization. The value cost ratio (VCR) was observed highest (8.97), when B was applied @ 1.5 kg ha^{-1}. However, fiber quality (i.e., fiber length, fiber fineness, and uniformity ratio and fiber strength) was little affected with B fertilizer.

Key Words: Boron fertilizer; Seed cotton yield; Boron concentration; Fruit production; Fiber quality

INTRODUCTION

Cotton growth and yield are strongly affected with boron application (Dong, 1995). Boron (B) deficiency in cotton hamper plant growth by reduced photosynthate translocation through vascular bundles of petioles, causing stunted growth and abnormal reproductive development (Liu *et al.,* 1986; Wang & Zhou, 1992). Cotton (*Gossypium hirsutum* L.) is sensitive to soil B deficiency because of its high B requirement (Shorrocks, 1992). Soil applied B increased cotton yields even when B deficiency was not evident in the plants (Anderson & Boswell, 1968). Boron fertilizer is beneficial to cotton production in sandy and silt loam soils in several parts of USA and Africa (Murphy & Lancaster, 1971; Mathews, 1972; Roberts *et al.,* 2000). Cotton yield is determined by number of bolls produced per unit area and boll weight (Sawan *et al.,* 2002). Fruiting pattern and boll retention influenced by climatic factors (Bhatt, 1977; Reddy *et al.,* 1992; Sawan *et al.,* 2002), management practices (Pettigrew, 2004) and pests (Brooks *et al.*, 1992) determine the number of bolls produced. Bolls on the middle portion of the plant had the greatest survival and fruit shed was less likely (Constable, 1991). Guinn (1985) reported that fruit shedding and boll retention were primarily related to nutrition. Keeping in view the importance of B for cotton and its wide spread deficiency, the present study was aimed at to investigate the effects of boron fertilization on seed cotton yield, fruit production and nutrient concentration under an arid environment.

MATERIALS AND METHODS

Field experiment was conducted on a silt loam soil. The soil of the experimental site was classified as coarse silty, hyperthermic, typic haplocmbidis, according to USDA classification (Makhdum, 2004). The site is situated at longitude 71º, 37.79′ E; Latitude 30º, 16.49′ N. The soil had pH 8.2; ECe 1.18 dS m^{-1}; Organic Matter 0.45%; $CaCO_3$ 6.5% (US Salinity Laboratory Staff, 1954); Total N 0.03%; Available P 7.0 mg kg^{-1}; Extractable K 188 mg kg^{-1} (Ryan *et al.*, 2001); HCl extractable B 0.40 mg kg^{-1} (Ponnamperuma *et al.,* 1981); Sand 29%, Silt 53% and 18% Clay (Moodie *et al.,* 1959). Cotton cultivar CIM-499 was sown during the last week of May 2003 and 2004 at a spacing of 75 cm between rows and 30 cm between plants in the row. The treatments consisted of four levels of B fertilizer i.e., 0, 1.0, 1.5, 2.0 kg B ha^{-1}.

The source of B was borax (11% B). The experiment was laid out according to randomized complete block design (RCBD) with three replications. The net plot size was 210 m^2. Basal dose of N-P_2O_5-K_2O was applied @ 150 - 60 - 50 kg ha^{-1} in the form of urea, triple super phosphate (TSP) and potassium sulphate (K_2SO_4), respectively. The whole quantity of phosphorus, potassium, boron and one-third nitrogen was applied at seedbed preparation and incorporated in the soil before sowing. The remaining nitrogen was top dressed at flowering and peak flowering stages of plant growth. Weedicide *Pendimethalin @ 1.25 L ha^{-1} was applied before sowing to control weeds. *Stomp-330E (BASF Germany) Jaffer Brother in Pakistan.

Crop received normal irrigation and standard production practices of the area throughout the season. Crop was kept free of insect-pests through regular pesticide sprays. The average maximum and minimum air temperature 36.3ºC and 25.8ºC; rainfall 123.5 mm; relative humidity 66.4%, were recorded during the growth period of the crop.

Cotton fully expanded young leaf blades, usually 4th

from the terminal (excluding petioles) were sampled before flowering, washed with distilled-demonized water, oven dried (65ºC). The leaves were dry ashed (Gaines & Mitchell, 1979) and analysed by colorimetry using azomethine-H (Bingham, 1982).

Measurements on plant structure and fruit production were made by harvesting plants from one square meter area from each treatment at maturity stage. The seed cotton was hand picked in each plot and total yield calculated on area basis. Number of bolls per plant and boll weight was recorded on 10 randomly selected plants at maturity stage. Fiber quality was determined by methods of Shenek (1998). Data were analyzed statistically (Gomez & Gomez 1984).

RESULTS AND DISCUSSION

Main stem height and number of nodes. Data for plant structure differed significantly due to application of boron fertilizer. With the application of B there was 10.5 and 6.23% increase in main stem height and number of nodes, respectively over control in both the seasons (Table I). Higher number of nodes on main stem is concomitant to greater number of sympodia (fruiting branches), higher foliage and large plant structure (Heitholt, 1994; Zhao & Oosterhuis, 2003). As B fertilizer is directly and indirectly involved in many physiological and biochemical processes during plant growth, such as cell elongation and division, cell wall biosynthesis, membrane function, nitrogen metabolism and photosynthesis (Blevins & Lukaszewski, 1998).

Seed cotton yield and its components. Cotton yield is determined by number of bolls produced per unit area and boll weight (Sawan *et al*., 2002). It is evident that B application enhanced seed cotton yield appreciably in both the years (Table II). On an average, there was 4.27, 9.94 and 13.24%, increase in yield over control by application of 1.0, 1.5 and 2.0 kg ha^{-1}. Increase in yield was the consequence of increased of bolls per plant and boll weight. Mortvedt and Woodreuff (1993) recommended 0.34 - 2.24 kg B ha^{-1} for cotton crop in various states of US. High B fixation in calcareous soils (Batey, 1971) and high B requirement of cotton (Shorrocks, 1992) are also cogent reasons of increase in seed cotton yield. An increase in the yield in the present study is also supported by other researchers (Howard *et al*., 1998; Robert *et al*., 2000).

Fruit shedding (%) and leaf B concentration. Bolls on the middle portion of the plant were reported to have the greatest survival and fruit shedding was less likely (Constable, 1991). Guinn (1985) reported that fruit shedding and boll retention were primarily related to nutrition management. Decrease in fruit shedding percentage and an increase in leaf B concentration were observed by B-fertilizer (Table III). Vasil (1964) reported that B plays a pivotal role in pollen germination and pollen tube growth resulting in successful fruit setting. On an average, 2.0 kg B ha^{-1}, reduced 60% fruit shedding. Zhao and Oosterhuis (2003) reported that number of fruiting sites was reduced from 40 per plant in the B-treated plant to 26 per plant in the B-un-treated plant. Boron deficiency reduced photosynthate translocation from leaf to fruit resulting in fruit shedding. The highest leaf B concentration (66 mg kg^{-1}) was noted in treatment receiving 2 kg B ha^{-1}. Zhao and Oosterhuuis (2003) reported leaf B concentration increased with an increase in soil-applied B. It was also noted that there was decrease in fruit shedding due to boron fertilizer. Results of present study demonstrated the beneficial effects of boron fertilizer in increasing relative fruit fullness due to enhanced translocation of photosynthates from source to sink.

Fiber quality parameters. Application of boron did not exert any significant effect on fiber quality parameters such as fiber length, fiber fineness, uniformity ratio and fiber strength (Table IV). The reason being that genetic and environmental factors exert so much influence on fiber quality that little effect from boron can elucidate un-less availability of nutrients in soil is extremely low (Luckhardt & Ensminger, 1968; Walker & Onken, 1969; Nelson, 1980; Makhdum *et al*., 2000).

Table I. Effect of boron fertilization on plant structure

Nutrient Dose (kg ha^{-1})	Main Stem Height (cm)			Number of nodes		
	2003	2004	Mean	2003	2004	Mean
0	107.2c	108.0c	107.6c	34.33c	35.33b	34.83b
1.0	112.0b	112.0b	112.0b	35.00bc	36.00b	35.50b
1.5	118.0a	116.8a	117.4a	36.00ab	37.00a	36.50a
2.0	119.3a	118.5a	118.9a	36.3a	37.67a	37.00a
LSD ($p<0.05$)	2.310	2.098	1.485	1.200	0.7449	0.8895

Means followed by different letters within columns are significantly different

Table II. Effect of boron fertilization on seed cotton yield and its parameters

Boron Dose (kg ha^{-1})	Number of Bolls per plant			Boll Weight (g)			Seed cotton yield (kg ha^{-1})		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
0	25.00c	25.67b	25.33c	2.87d	2.94b	2.90d	2564d	2585d	2575d
1.0	26.33b	26.00b	26.17bc	3.02c	3.05a	3.04c	2676c	2695c	2685c
1.5	26.67b	27.33a	27.00ab	3.06b	3.08a	3.07b	2820b	2841b	2831b
2.0	27.67a	28a	27.83a	3.08a	3.10a	3.09a	2912a	2919a	2916a
LSD ($p<0.05$)	0.745	1.105	0.838	0.019	0.063	0.006	57.30	57.96	51.32

Means followed by different letters within columns are significantly different

Table III. Effect of boron fertilizer on lint (%), fruit shedding (%) and boron concentration (mg kg^{-1}) in leaves at peak flowering stage

Nutrient Dose (kg ha^{-1})	Lint (%)			Fruit shedding (%)			Boron Conc. (mg kg^{-1})		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
0	36.07	36.04	36.06	66.00a	66.70a	66.35a	46.50d	47.67d	47.08d
10	36.27	36.12	36.19	65.00a	64.67b	64.83a	53.20c	55.00c	54.10c
1.5	36.23	36.09	36.16	62.00b	61.00c	61.50b	62.13b	64.00b	63.07b
20	36.20	36.14	36.17	61.00b	60.00c	60.50b	65.23a	67.00a	66.12a
LSD (p<0.05)	ns	ns	ns	2.825	1.546	2.028	1.911	2.514	1.988

Means followed by different letters within columns are significantly different
ns = Non-significant

Table IV. Effect of boron fertilizer on fiber characteristics

Nutrient Dose	Fiber length (mm)			Fiber fineness (µg inch^{-1})			Uniformity ratio (% age)			Fiber strength (000 lbs inch^{-2})		
(kg ha^{-1})	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
0	29.12	29.14	29.13	4.63	4.64	4.64	48.45	48.40	48.42	96.42	96.46	96.44
10	29.12	29.12	29.12	4.65	4.64	4.64	48.45	48.45	48.45	96.44	96.46	96.45
1.5	29.14	29.14	29.14	4.64	4.64	4.64	48.45	48.50	48.47	96.47	96.48	96.48
2.0	29.14	29.14	29.14	4.64	4.66	4.65	48.48	48.52	48.50	96.52	96.51	96.52
LSD(p<0.05)	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

ns = Non-significant

Table V. Economic analysis

Boron (kg ha^{-1})	Yield (kg ha^{-1})	Yield Increase over control (kg ha^{-1})	Cost of B Fertilizer (Rs ha^{-1})	Value of Seed Cotton (Rs ha^{-1})	Net Return (Rs ha^{-1})	Value Cost Ratio (VCR)
0	2575	-	-	-	-	-
1.0	2685	110	454.5	2530	2075.5	5.56
1.5	2841	266	681.75	6118	5436.3	8.97
2.0	2419	344	909	7912	7003	8.70

Basis of calculation of seed cotton @ Rs. 23 kg^{-1} Borax @ Rs. 50 kg^{-1}

Economic analysis. Economic analysis (Table V) shows that application of B @ 20 and 15 kg ha^{-1} produced net return was Rs. 7003/- with value cost ratio (VCR) 8.7 and 5436.3 with (VCR) 8.97, respectively with B @ 2.0 and 1.5 kg ha^{-1}. It is obvious from the present results that @ 1.5 kg ha^{-1} may be considered optimum for better cotton production.

CONCLUSION

Boron application enhanced seed cotton yield appreciable by affecting the fruiting process-better seed setting and boll weight. The result of this study show that addition of 2 kg B ha^{-1} increased yield 11.69% over untreated check. However fiber quality parameters were little affected by B. fertilization. The farmer could get benefit of Rs. 9 by investing Rs. 1 by the addition of B. fertilizers.

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