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Response of Yield and Yield Components of Cotton to Different Rates of Boron Fertilizer

Majid Rashidi and Mohammad Gholami

Department of Agricultural Machinery, Takestan Branch,
Islamic Azad University, Takestan, Iran

Abstract: Field experiments were carried out to study the response of yield and yield components of cotton (*Gossypium hirsutum*) to different rates of boron (B) fertilizer. B was applied as foliar at rates 0, 500 and 1000 g ha^{-1}. Statistical results of study indicated that foliar application of B significantly ($P \leq 0.05$) increased boll number, boll weight, seed cotton yield and lint yield. In addition, leaf blade B concentration was affected by B application rate and increased significantly. Results also demonstrated that the highest seed cotton yield was recorded in case of 1000 g ha^{-1} foliar application of B and this foliar application rate resulted in 25% increased seed cotton yield. As a general rule, application of 1000 g ha^{-1} B (two time foliar B application) resulted in the highest yield and yield components of cotton in the arid lands of Iran.

Key words: Cotton · Yield · Yield components · Boron fertilizer · Arid lands · Iran

INTRODUCTION

Boron (B) is an essential element that cotton needs during all stages of growth and fruiting. It has been universally recognized as the most important micronutrient for cotton production and cotton is very sensitive to B deficiency because of its high B requirement [1]. Soil applied B increased cotton yields even when B deficiency was not evident in the plants [2]. It is also essential at all stages of plant growth and critically during fruit development especially with today's fast-fruiting, high-yielding varieties. B fertilizers were beneficial to cotton production in sandy and silt loam soils in several parts of USA and Africa [3-5]. While B is essential for all stages of cotton plant growth, an available supply is most important during flowering and boll development. Relatively small amounts of B are required to support the process of growth and development of seed cotton in the boll. Researches showed that as little as 1.12 kg ha^{-1} of B could increase seed cotton yield by more than 1235 kg ha^{-1}. B increases the nitrogen and carbohydrate metabolism and sugar translocation in cotton [6]. Foliar-applied B supplements and soil-supplied B can correct low B concentrations in cotton [7]. Foliar application of B accelerates the translocation of nitrogen compounds, increases protein synthesis and stimulates fruiting. As small amounts of B are required, foliar application of B may be more efficient than soil application, especially when deficient conditions are suspected [8]. There are many reports on the growth and yield responses of cotton to soil or foliar applications of B. Reports of yield response to soil or foliar applications of B have been contradictory. For example, Heitholt [7] reported no yield response to B utilizing non-buffered spray solutions, whereas Howard *et al.* [8] observed that buffering B spray solutions to pH 4.0 increased yields relative to buffering to pH 6.0. Research in Arkansas, USA, has also shown no yield response to soil or foliar applications of B irrespective of soil N status [9]. Soil applied B increased first harvest lint yields by 9% and four foliar applications, each at 0.11 kg B ha^{-1}, resulted in lint yields comparable to soil application of B at 0.56 kg B ha^{-1} and doubling the B foliar rate did not increase yields, but the B petiole concentration was significantly increased [8]. Lint yield, boll production, flower production and boll retention percentage were not affected by soil or foliar applied treatments. However, foliar B fertilization resulted in leaf blade B concentrations of 154 mg kg^{-1} without detrimental effects [7]. Soil or foliar applied B may not have been beneficial for obtaining high cotton yields. Similarly, there were no positive responses to applied soil-B or foliar-B in the high N soil level in any

Corresponding Author: Dr. Majid Rashidi, Ph.D., Assistant Professor and Faculty Member, Takestan Branch, Islamic Azad University, Takestan, Iran, Tel: +98-9123376127, E-mail: m.rashidi@tiau.ac.ir.

of the five experiments, except for where the low N treatments responded to applied B on a silt loam soil in Arkansas [10]. Oosterhuis and Brown [11] reported no effects on yield, boll number per meter, average boll weight, lint percentages, or petiole or leaf B concentrations of soil and foliar applied B treatments observed over three years. No significant effect of B on lint yield, individual boll weight, or petiole nitrate-N level and no significant N and B interactions were found in a regional study conducted to evaluate the interaction of N and B rates on cotton yields [12].

In Iran, meager researches have been done to study the response of yield and yield components of cotton to different rates of B fertilizer. As B can agronomically and physiologically affect cotton, the main objective of this study was to study the response of yield and yield components of cotton to different application rates of B fertilizer and finding suitable application rate of B fertilizer for cotton production in the arid lands of Iran.

MATERIALS AND METHODS

Research Site: This study was conducted at the Research Site of Tehran Province Agricultural and Natural Resources Research Center, Varamin, Iran on a clay loam soil identified as low in B (0.4 mg kg^{-1}) for two successive growing seasons (2009 and 2010). The research site is located at latitude of 35° 19′ N, longitude of 51° 39′ E and altitude of 1000 m in arid climate (150 mm rainfall annually) in the center of Iran.

Weather Parameters: The mean temperature and monthly rainfall of the research site from sowing (May) to harvest (November) during study years (2009 and 2010) are indicated in Fig. 1.

Soil Sampling and Analysis: The soil of the experimental site is classified as an Aridisol (fine, mixed, active, thermic, typic haplocambids). A composite soil sample (from 36 points) was collected from 0-30 cm depth 30 days prior to planting during the study years and was analyzed in the laboratory for pH, EC, OC, TNV, P, K, Fe, Zn, Cu, Mn, B and particle size distribution. Details of soil physical and chemical properties of the research site during the years of study (2009 and 2010) are given in Table 1.

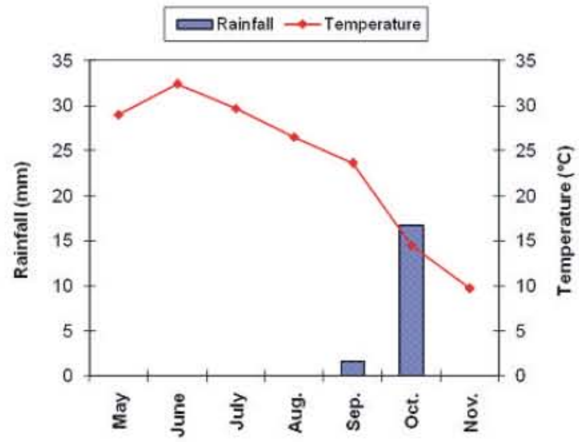

Fig. 1: Mean monthly rainfall and temperature from sowing to harvest (mean of 2009 and 2010)

Field Methods: The experiments were laid out in a randomized complete block design (RCBD) with three replications. Different treatments were three levels of B application, i.e. 0, 500 and 1000 g ha^{-1} B as boric acid foliar application (without, one time and two time foliar B application). Boric acid foliar was applied with concentration of 0.5% (500 L ha^{-1}). Foliar B applications began at the first flower stage and were repeated two weeks after. The control treatment only received water spray. The treatments were carried out on the same plots in the 2009 and 2010 growing seasons. The size of each plot was 12.0 m long and 6.0 m wide. A buffer zone of 3.0 m spacing was provided between plots. In both growing seasons, one of the most commercial varieties of cotton cv. Varamin was planted manually on May 5, 2009 and May 7, 2010. Plots consisted of 6 rows of cotton planted with row spacing 0.8 m. Plots were over seeded and then thinned by keeping plant to plant distance 20 cm, or a population of 62,500 plants ha^{-1}, at approximately the first or second true leaf stage. Management was consistent with typical agronomic practices used for upland production in the region. For all treatments, irrigation scheduling was based on the basis of soil water content monitoring. Also, pest and weed control operations were performed based on common local practices and commendations. All other essential operations were kept identical for all the treatments.

Table 1: Soil physical and chemical properties of the experimental site during study years 2009 and 2010 (0-30 cm depth)

Date	pH	EC (dS m^{-1})	OC (%)	TNV (%)	P (ppm)	K (ppm)	Fe (ppm)	Zn(ppm)	Cu (ppm)	Mn (ppm)	B(ppm)	Soil texture
2009	7.3	3.4	0.72	17	10.6	200	4.4	0.90	1.4	12.3	0.4	Clay loam
2010	7.6	3.0	0.81	17	9.50	224	5.2	0.42	0.5	11.5	0.5	Clay loam

Observation and Data Collection: Leaf samples were obtained by removing 20 leaves from the uppermost fully expanded main stem leaves from each plot. After all bolls matured, all seed cotton at 10 meter lengths of the four center rows was hand harvested at approximately 70% open boll for yield analyses. Yield was determined by hand harvesting the four center rows from each plot twice and weighing the seed cotton. Twenty plants in each plot were randomly selected in mid-September of each year for measurement of number of open bolls. Boll weight was obtained from 20 hand-harvested boll samples collected from 0.5 m of the two outer rows. Lint yields were calculated by multiplying the lint percentage by seed cotton weights.

Statistical Analysis: All data were subjected to the Analysis of Variance (ANOVA) following Gomez and Gomez [13] using SAS statistical computer software. Moreover, means of the different treatments were separated by Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$.

RESULTS AND DISCUSSION

Boll Number: Statistical results of study indicated that different application rates of B (as foliar B) significantly ($P \leq 0.05$) affected boll number (Table 2). Results showed that boll number significantly increased with an increase in B application rate. The highest boll number (18.1) was obtained in case of 1000 g ha^{-1} B treatment (two time foliar B application) and the lowest boll number (14.1) was obtained in case of 0 g ha^{-1} B treatment, i.e. no foliar B application (Table 2). These results are in agreement with those of Oosterhuis and Steger [12] who concluded that foliar B application considerably increased boll number.

Boll Weight: Results of study also showed that different application rates of B significantly influenced boll weight (Table 2). Statistical results showed that boll weight significantly increased by increasing B application rate. The highest boll weight (7.02 g) was recorded in case of two time foliar B application treatment but there was no significant difference between two and one time foliar B application treatments. The lowest boll weight (6.15 g) was recorded in case of no foliar B application treatment (Table 2). These results are also in line with the results reported by Oosterhuis and Steger [12] that foliar B application noticeably increased boll weight.

Seed Cotton Weight of Boll: Statistical results of study indicated that effect of different application rates of B was not significant for seed cotton weight of boll (Table 2). Although effect of different application rates of B was not significant for this trait, the highest seed cotton weight of boll (4.61 g) was obtained in case of one time foliar B application treatment and the lowest seed cotton weight of boll (4.48 g) was obtained in case of no foliar B application treatment (Table 2).

Seed Cotton Yield: Results of study showed that different application rates of B significantly influenced seed cotton yield (Table 2). Results showed that seed cotton yield significantly increased by increasing B application rate. The highest seed cotton yield (4428 kg ha^{-1}) was recorded in case of two time foliar B application treatment but there was no significant difference between two and one time foliar B application treatments. The lowest seed cotton yield (3541kg ha^{-1}) was recorded in case of no foliar B application treatment (Table 2). Yield increase was the consequence of enhanced boll setting and boll weight. With hot-water-soluble B in our experimental fields being 0.40 mg kg^{-1} B, the soils were low in B. It is generally accepted that a soil water-soluble B content of approximately 0.15 to 0.20 ppm approaches the deficiency level [2]. Positive crop responses to B are attributed to a greater B requirement by cotton as compared with most other field [1]. The maximum increase in seed cotton yield with two time foliar B application treatment was about 25% as compare to no foliar B application treatment.

Table 2: Effect of different B foliar application rate on yield and yield components of cotton (mean of 2009 and 2010)

B application rate (g ha^{-1})	Boll number * ($plant^{-1}$)	Boll weight * (g)	Seed cotton weight of boll ^{NS} (g)	Seed cotton yield *(kg ha^{-1})	Lint yield *(kg ha^{-1})	Leaf blade B concentration * (mg kg^{-1})
0	14.1 c	6.15 b	4.48 a	3541 b	1400 c	43.1 c
500	16.8 b	6.49 ab	4.61 a	3991 ab	1562 b	55.0 b
1000	18.1 a	7.02 a	4.52 a	4428 a	1752 a	67.6 a

NS = Non-significant

* = Significant at 0.05 probability level

Means in the same column with different letters differ significantly at 0.05 probability level according to DMRT.

Lint Yield: Statistical results of study indicated that different application rates of B significantly affected lint yield (Table 2). Results showed that lint yield significantly increased with an increase in B application rate. The highest lint yield (1752 kg ha^{-1}) was obtained in case of two time foliar B application treatment and the lowest lint yield (1400 kg ha^{-1}) was recorded in case of no foliar B application treatment (Table 2). The maximum increase in lint yield with two time foliar B application treatment was about 25% as compare to no foliar B application treatment. The similar results were also reported by Anderson and Boswell [2] and Heitholt [7] in field experiments where lint yield increased significantly with an increase in B application rate.

Leaf Blade B Concentration: Results of leaf blade chemical analyses indicated that different application rates of B significantly influenced leaf blade B concentration (Table 2). The highest leaf blade B concentration (67.6 mg kg^{-1}) was obtained in case of two time foliar B application treatment and the lowest leaf blade B concentration (43.1 mg kg^{-1}) was obtained in case of no foliar B application treatment (Table 2). Similar results have been reported by Zhao and Oosterhuis [14]. They reported that leaf blade B concentration considerably increased with an increase in soil-applied B.

CONCLUSION

Use of 1000 g ha^{-1} B (two time foliar B application) was found as the most appropriate and beneficial application rate of B for reaching the highest yield and yield components of cotton in the arid lands of Iran.

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