Influence of Nitrogen and Boron Interaction on Cotton Production

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ABSTRACT

Studies across the cotton (Gossypium hirsutum L.) growing regions of the United States have shown boron and nitrogen to be essential nutrients for profitable cotton production. Four levels of nitrogen (N) (0, 34, 67, and 101 kg/ha for 1996 and 0, 67, 101, and 135 kg/ha for 1997) and four levels of boron (B) (0, 0.56, 1.12, and 2.24 kg/ha) were used on DPL-50 in a split-plot design with B subplot treatments randomly assigned within N whole plot treatments. The treatments were replicated four times. Nitrogen as sodium nitrate and ammonium nitrate for 1996 and 1997, respectively, were side-dressed and boron was foliarly applied as solubor. Yield parameters were measured for each treatment. There was no N X B interaction so data were averaged over N and B rates, respectively. In both years, increased N rate up to 101 kg/ha N increased lint yield ($P < 0.01$). The increase in lint yield for 1996 was 96, 369 and 455 kg/ha for 34, 67, and 101 kg/ha N over the untreated control, respectively. In 1997, however, the only significant yield increase was observed for the 101 kg/ha N rate. For both years, the maximum yield was achieved with 101 kg/ha N and 0.56 kg/ha B rates. Adding foliar boron at 2.24 kg/ha, however, decreased lint yield over the untreated control. Leaf blade tissue level increased with increasing B rates compared with the initial B level. Additional research is needed to fully understand the benefit of B in N utilization.

Introduction

In multiple studies across the cotton growing regions of the United States, boron (B) has been shown to be an essential nutrient for successful cotton production (Wear, 1963; Miley *et al.*, 1969). Boron has increased nitrogen (N) and carbohydrate metabolism and sugar translocation in cotton (Gascho, 1994). Research conducted with other plant species have shown that tissues obtained from B deficient plants contain more non-protein N than plants supplied with adequate B (Scripture and McHarque, 1943). Boron is important in all stages of cotton development. Boron recommendation for cotton in the south-eastern U.S.A. does not exceed a total of 1.12 kg/ha B. The most common recommendation is 0.56 kg of elemental B/ha added to mixed fertilizer or preplant herbicide, or mixed with insecticides in two applications of 0.28 kg/ha B each spray.

Low levels of B have been associated with aborted bolls and lack of flowering. The addition of B in deficient situations has caused increases in flowering and boll production (Wear, 1963). On sandy soils the addition of 1.12 kg/ha B produced signs of toxicity in cotton, and on clay soils over 8 kg/ha B reduced cotton plant weight and yield (Plummer and Wolf, 1920). In 1996 and 1997, experiments were conducted at the Atlantic Coastal Plain region of Virginia to determine: 1) if nitrogen-fertilized cotton produced additional yield increases with added B; 2) if plant boron content was maintained throughout the growing season through foliar B sprays; and 3) if the rate of N fertilization affected B response.

Materials and Methods

Field experiments were conducted at the Atlantic Coastal Plain region of Virginia during the 1996 and 1997 growing season. Four levels of nitrogen (N) (0, 34, 67, and 101 kg/ha (1996) and 0, 67, 101, and 135 kg/ha (1997) and four levels of boron (B) (0, 0.56, 1.12, and 2.24 kg/ha) were used on DPL-50 in a split-plot design with four replications. B subplot treatments were randomly assigned within N whole plot treatments. Each of the 34, 67, 101 and 135 kg N/ha rates were split into three applications (a third at planting, pinhead square and two weeks later, respectively). Boron was foliarly applied three times during the growing season for totals of 0, 0.56, 1.12 and 2.24 kg B/ha. Nitrogen as sodium nitrate and ammonium nitrate for 1996 and 1997, respectively, were side-dressed and B was foliarly applied as solubor. Foliar applications began at first flower, then two weeks and four weeks after first flower. Soil sample was taken prior to planting.

Leaf and petiole samples were obtained for N and B analysis one week before first flower and one week after each foliar B application. Samples were obtained by removing 20 leaf and petioles from each plot from uppermost fully expanded main-stem leaves. Samples were washed in distilled water, dried at 60º C for 24 hours, ground and analyzed. Seedcotton yield for each treatment was determined by mechanically harvesting the centre two rows of each plot. Fiber quality was assessed with HVI testing of handpicked samples.

Result and Discussion

Effect on Lint yield

No significant interaction between N and B was found, i.e. the effect of B did not depend on the rate of N fertilization. Nitrogen affected ($p < 0.001$) lint yield with increasing N rate resulting in greater lint yield. For both 1996 and 1997, the highest yield was obtained with the 101 kg/ha N rate (Table 1). This increase in yield (for 101 kg/ha N) was 455 and 129 kg/ha for 1996 and 1997, respectively, over the untreated control. Although not significant, a decline in yield was observed at 135 kg N/ha rate.

For both years, where N was not applied the application of B did not affect lint yield. The highest yield increase was obtained with the application of 0.56 kg/ha B and 101 kg/ha N (Table 1). This increase in lint yield was 139 and 126 kg/ha for 1996 and 1997, respectively. However, regardless of N treatment, the application of B beyond 1.12 kg/ha did not increase lint yield. In fact a decrease in lint yield for both years was observed for 2.24 kg/ha B.

Effect of applied B on tissue B concentration

Applied B increased leaf tissue B concentration for both 1996 and 1997 experimental years (Table 2). However, a decline in 1997 in tissue B concentration was observed with increasing rate of applied N (N X B interaction $p < 0.01$). Similar results were reported by Miley *et al.*, 1969, who found a decrease in both leaf and petiole B concentration when 80 kg/ha N was applied compared with no N. This is also in agreement with a recent report by Oosterhuis (unpublished data) that showed higher B concentrations in plots that received 101 kg/ha N compared with those that received 135 kg/ha.

Dry weight data were not collected for the analysis of total plant biomass, but N fertilization notably increased plant size, (as visually observed). A dilution in plant B may have resulted from plant size increase as indicated by a decline in B tissue concentration with increasing N rate levels (N X B interaction $p < 0.01$). The lack of even a higher dilution effect could be due to the larger plants intercepting more of the spray compared to the smaller plants at the lower N level.

Effect of applied N on tissue N concentration

Percent N levels in the tissue increased with N application (treatment effect $p < 0.001$). Initial tissue levels, obtained one week prior to first flower, was 3.3 percent, which is within the acceptable range (3.5-4.5) for cotton (data not presented). For the July 21 sampling obtained one week after the third application of N (one week before first flower) the N tissue level was above the acceptable range (4.9%). However, N in the leaf tissue declined rapidly with each subsequent sampling after July 21, indicating a rapid use of N by the developing boll load.

Conclusion

Although the N rate giving the highest yield varied from year to year, generally N fertilization increased lint yield. An important question addressed by this study was to determine if foliar applied boron would attenuate high plant N levels that cause excessive vegetative growth at the expense of flower production. In this study, N fertilization produced larger plants and high leaf N levels, but also increased yield. Excessive vegetative growth at the expense of flower production was not observed. Our findings support the current recommendation for B which is 0.56 kg/ha for high yielding cotton. A third year of field research is underway to determine if the observed results occur over years.

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Table 1. Cotton lint yield as affected by nitrogen and boron fertilization for 1996 and 1997.

Foliar B kg/ha	Soil N applied, kg/ha				
1996					
	0	34	67	101	Average
0	1022	1106	1407	1426	1227 [b]
0.56	1011	1169	1447	1565	1298 [a]
1.12	1040	1199	1415	1560	1304 [a]
2.24	1002	985	1282	1316	1146 [c]
Average	1019 [d*]	1115 [c]	1388 [b]	1474 [a]	
1997					
	0	67	101	135	Average
0	1231	1358	1344	1250	1297 [a]
0.56	1216	1401	1470	1377	1366 [a]
1.12	1151	1157	1224	1277	1202 [b]
2.24	1145	1101	1197	1111	1139 [b]
Average	1180 [b]	1254 [ab]	1309 [a]	1254 [ab]	

Nitrogen effect ($P < 0.0001$). Boron effect ($P < 0.001$).
[*]Values followed by the same letter within row do not differ significantly at the 5% probability level.

Table 2. Averaged leaf blade boron levels (ppm) for 1996-97 and pre-application boron level in soil was 25 ppm.

Foliar B kg/ha	Soil N applied , kg/ha				
1996					
	0	34	67	101	Average
0	41.6	35.7	40.6	43.2	40.4 [c]
0.56	45.0	50.4	42.2	48.0	45.7 [c]
1.12	66.6	69.8	68.5	64.6	66.0 [b]
2.34	96.6	90.0	90.3	79.4	89.7 [a]
Average	62.4 [a*]	61.8 [a]	58.8 [a]	58.2 [a]	
1997					
	0	67	101	135	Average
0	40.8	37.6	37.0	36.1	37.9 [d]
0.56	61.3	57.8	53.8	54.1	56.8 [c]
1.12	74.3	68.9	69.7	59.3	68.1 [b]
2.24	94.1	110.5	91.1	79.7	93.8 [a]
Average	67.6 [ab]	68.7 [a]	62.9 [b]	57.3 [c]	

Nitrogen effect ($p < 0.0001$). Boron effect ($p < 0.001$). N X B interaction ($p< 0.01$).
[*]Values followed by the same letter within row do not differ significantly at the 5% probability level.