



Mechanisms of Boron Toxicity in Crop Plants

Patrick Brown and Hening Hu
Department of Plant Sciences
University of California, Davis

Boron toxicity is an important constraint to the use of saline irrigation waters in agriculture. Our goal is to determine the mechanism of boron toxicity, to identify the best tissue to utilize for crop monitoring and to define which stage of crop growth and which tissue is most, and least sensitive to excess boron in irrigation waters.

Boron toxicity is a problem threatening significant areas of agricultural production in California and limiting the reuse of drainage waters. Research into the management of B has been plagued by results that are inconsistent, contradictory and difficult to interpret primarily because we do not know why B is toxic to plants and we do not know how to measure crop B and its relationship to the occurrence and impact of B toxicity. Based upon recent findings of the role of B in plants, we hypothesized that root and shoot extension (meristematic) growth would be the most sensitive indicator of boron toxicity. This project aims to identify the mechanism of B toxicity, and to develop the sampling strategies and standards necessary for field research and crop management.

Two experiments have been completed and a third is underway. Experiments one and two were conducted in growth chambers in one gallon pots with potting media:sand mixture. Plants were grown for four weeks at applied boron concentrations ranging from adequate (0.05, 0.25 mM), to concentrations observed in field conditions (0.5, 1.0, 2.5 mM) and extreme concentrations frequently used in experimentation (5.0, 7.5 and 10 mM). Key findings of these experiments highlight the critical difference in crop response to B concentrations found in field conditions from those observed under artificially high B supply.

Under conditions likely to be found in field settings (B in soil solution at 0.25, 0.5, 1.0 and 2.5 mM), we observed that shoot and root growth (total dry weight production) were equally sensitive to the impact of increasing B in the growth media (Fig. 1). Significant negative impacts of B on crop growth were observed at B concentrations of 0.5 mM and higher. At these concentrations, visual symptoms of boron toxicity were restricted to marginal and leaf tip burn on the oldest leaves and slight chlorosis on old leaves at the highest of these B concentrations (2.5 mM).

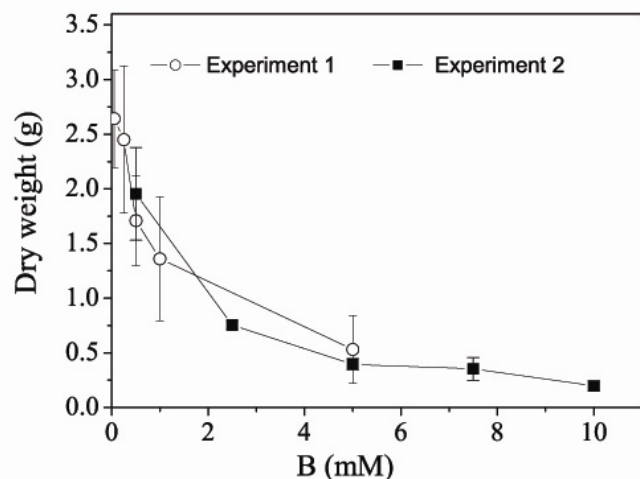


Figure 1. Influence of boron treatments on dry weight of roots of tomato. Plants were grown for 28 days with normal boron supply (0.05 mM) prior to application of treatments. Plants were harvested at day 56. Results of two replicate experiments are presented.

When B was applied at concentrations far greater than occur in agricultural settings (but equivalent to concentrations used in prior experiments) we observe that the symptoms of B toxicity are different from those observed in the field or at concentrations of less than 2.5 mM. When B is applied at these acute levels (5.0, 7.5, 10.0 mM), chlorosis and necrosis occur rapidly (3-7 days) and are distributed throughout the plant. At the extreme B treatment levels, entire leaf collapse and death can occur within 5 days. Very significant (>80%) shoot and root growth inhibition is observed at these B concentrations. These results illustrate that previous experimentation conducted at

unrealistic boron concentrations results in misleading conclusions.

Our original hypothesis stated that meristematic extension growth would exhibit a greater degree of sensitivity to B toxicity than mature tissue. This hypothesis was tested in plants grown at B concentrations that occur in Californian conditions and found to be incorrect. Figure 2 illustrates the extension growth of the two youngest leaves over a 24 day period following application of the B treatments. Whereas clear visual symptoms of B toxicity occurred within 7 days of treatment with B concentrations of 0.5 mM or greater, and overall root and shoot biomass had been reduced by 14 days in all treatments of 0.5 mM or greater, there was no evidence of inhibition of extension growth or young leaf expansion in any plants treated with less than 5 mM boron. Treatment with 5 mM boron did result in a significant inhibition of leaf extension growth by day 10 (fig. 2) but only after very significant effects on whole plant growth and clear symptoms of toxicity had been observed. It is concluded that meristematic and extension growth is not inhibited by boron toxicity and that these tissues are not good indicators of plant boron status.

Additional experiments are now underway to define the stage of crop growth that is most sensitive to boron toxicity. These experiments will help determine when, during a crop growth season, a water source with high boron could most effectively be used for irrigation while still limiting crop damage.

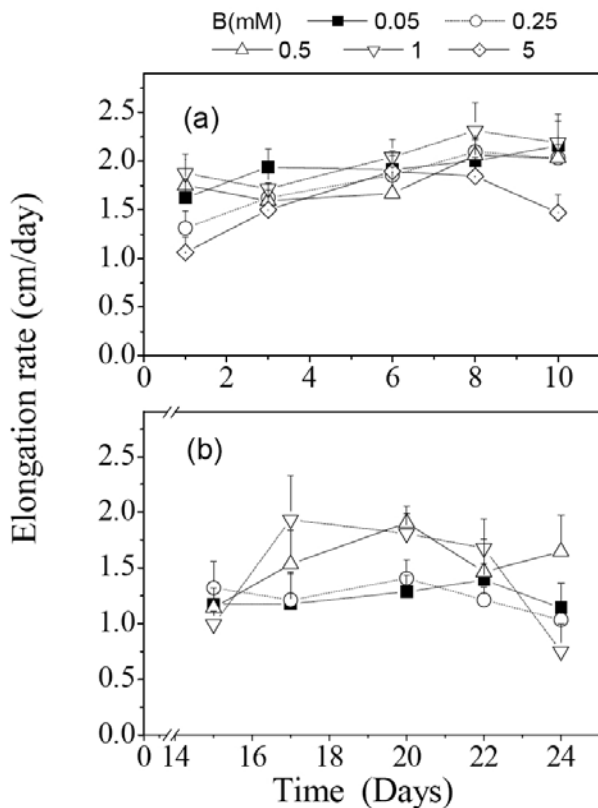


Figure 2. Influence of boron on rate of leaf elongation in youngest expanding leaf tissue. Plants were grown for 28 days at normal B supply (0.05 mM) prior to application of treatments. Leaf elongation was measured from day 0- 10 in the 7th leaf (a) and from day 15-25 in the 8th emergent leaf (b). Plants treated with 5mM did not produce an 8th leaf.

For further information please contact:

Patrick Brown
phbrown@ucdavis.edu
530-304-1390