Mechanism of Boron Toxicity in Crop Plants

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Excess boron (B) in irrigation waters negatively impacts growth of processing tomato; however the impact of the timing of application of B on crop response is poorly understood. Tomato exposed to boron during early and mid-crop development yielded less crop and accumulated less boron than tomato exposed during the later stages of development. In agricultural systems with access to diverse irrigation sources, use of poorest quality irrigation water late in the season is preferable.

In the western San Joaquin Valley, growers have access to irrigation sources that vary in quality from low salt – low boron (B) surface and irrigation district sources, to high salt – high B ground waters. The goal of the present investigation was to determine the relative impact of high B applied at different stages of tomato growth and development. Results suggest that application of high B water at later stages of plant growth and development will have significantly less impact on plant yield than the application of high concentrations of B at earlier growth stages. Total quantity of applied B irrigation and total accumulation of B in above ground parts was higher when B was applied late in the crop development.

Procedures

A tomato B toxicity response study was conducted with processing tomatoes in a greenhouse at Davis, CA.

The experiment had five treatments applied to processing tomatoes grown from transplanted seedlings for 105 days to full maturity. Treatments were:

1. Control: continuous 0.5 ppm B.
2. Continuous high B: two weeks of 8 ppm B, then 3 weeks of 12 ppm B, repeated for three cycles.
3. Early stage high B: two weeks of 8 ppm B, then 3 weeks of 12 ppm B for the initial 5 weeks of growth followed by 0.5 ppm for 10 weeks.
4. Mid stage high B: five weeks of 0.5 ppm B followed by two weeks of 8 ppm B, then 3 weeks of 12 ppm B and five weeks of 0.5 ppm B.
5. Late stage high B: ten weeks of 0.5 ppm B followed by two weeks of 8 ppm B, then 3 weeks of 12 ppm B for the last five weeks of growth.

Key findings

Fruit yield: Late stage high B (treatment 5) had yields equivalent to control B treatments and significantly higher fruit yield than either continuous high B (treatment 2), early (treatment 3) or middle stage high B (treatment 4). Control and continuous high B treatments resulted in yields that were 100 % and 68% greater than high B treatments applied during early and mid growth stages. In addition, there was a greater percentage of large and mature green fruit on the continuous high than on all other B treatments,

Vegetative growth: The application of high B at the late stage of crop growth resulted in significantly higher leaf, stem and root dry weight than continuous high B, mid or early stage high B. However, there was no difference between control and the late stage high B application.

Fruit characteristics: Control and late stage high B had significantly higher percentage of big fruits (>50 grams) than either continuous high B, middle or early stage high B.

Tissue B analysis: In all treatments, B was mainly accumulated in the leaf and stem tissues. Under continuous or mid stage B application, fruits accumulated significantly more total B then other treatments. In all treatments, B accumulated predominantly in leaf tissue, representing 88-90% of the whole plant B. Among the three different high B treatments (early, mid, late), the late stage high B treatment accumulated the highest amount of B both in the leaf and whole plant.

Significance

The growth stage at which high B containing irrigation water is applied, has a significant effect on plant growth, yield and total B contained in above ground tissues. Application of B during early and mid stage crop growth resulted in significantly reduced shoot and fruit growth while late season applications resulted in growth and yields not significantly different from pants grown under low B conditions. Continuous high B application also resulted in significant accumulation in shoot and fruit tissues. High B accumulation in fruits grown with high B treatment will contribute to the removal of B from the field.

Under conditions where two or more sources of irrigation water of differing quality is available, productivity in tomato can be maximized by utilizing the best quality (low B) water for early growth and the poorer quality (high B) water for later growth. Since the demand for water also increases as crops mature, this strategy also allows for consumption of a greater volume poor quality water, thereby reserving higher quality water for use in more sensitive crops or growth stages. Using this strategy, productivity losses can be minimized while the utilization of the poor quality water can be maximized.

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