TOXICITY OF MINOR ELEMENTS

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Cranberry growers are increasingly concerned about mineral nutrition of cranberry vines. Significant yield increases have been associated with fertilizer application. However, once the nutritional requirements of the plant are met, applied mineral elements can continue to accumulate in the soil and plant tissues. Once these levels reach some undetermined point, toxicity to the plant may occur. The levels at which specific nutrients become toxic to cranberry should be equally important to cranberry growers as at what point nutrients become limiting (deficient). Growers will need to keep soil and tissue levels between these two points to maximize yields. Nutrients that are required in small doses may also become toxic in large doses.

Plant nutrition advisors are recommending applications of large amounts of some elements. The long-term impact of these recommendations are unknown. We began a research project to understand the effect of large quantities of minor elements on cranberry growth. Some of the results are reported here. This is not a final report since the research is ongoing.

Approach:

The research was conducted at the University of Wisconsin-Madison, Arlington Research Center. 'Stevens' cuttings were rooted and grown hydroponically in dilute Hoagland's solution per our standard practice. Solution pH was adjusted three times per week. Once the plants were growing well, concentrations of a single minor or micro-element was increased to a series of elevated concentrations. All other nutrients were held constant at normal levels. Plants were watched for visual symptoms. Once symptoms of impaired growth or appearance were observed, plants were harvested, dried and analyzed for mineral content to determine the tissue concentration where symptoms appeared. Following this initial screening, the experiments were repeated in aeroponics (fresh nutrient solutions are intermittently sprayed onto the roots) but at concentrations closer to the concentration that produced symptoms to produce a narrower bracket where damage may be observed.

Plants grew well in the greenhouse environment. We did not have severe insect or disease problems. We were able to observe different symptoms depending on the element we provided in excessive amounts. Visual symptoms are not distinctive and are not reliable indicators of mineral nutrient toxicity. Common symptoms are leaf necrosis and leaf drop.

Boron

In solution culture the Boron concentration in shoots increased linearly with increasing solution concentration. Once the solution concentration exceeded the normal amount supplied in solution (0.125 ppm) shoot tissue concentrations were high enough to be considered excessive (Fig. 1). Root tissue concentration stayed relatively stable to slightly increasing with increasing solution concentration. Tissue dry weights of both shoots and roots did not change with increasing Boron concentration in solution (Fig. 2). This suggests that Boron does not cause significant reductions in growth even at extremely high tissue concentrations. Our data clearly show that Boron accumulates in shoot tissues and not in roots.

We chose 4 ppm boron to go into aeroponics which we thought would give about 225 ppm in the tissue or roughly 3 times the levels currently considered excessive. For the first 6 weeks in aeroponics both the control and +B plants grew well indicated by similar fresh and dry weight measurements (Fig. 3). By about week 4 or 5 we began to notice necrosis of leaves on the +B treatments and by weeks 7 and 8 leaf drop contributed to a decrease in fresh and dry weight. Tissue B concentration was stable in the control plants at about 80 ppm, but climbed in the +B plants to exceed 450 ppm (Fig. 4). Preliminarily, we propose that tissue B in excess of about 300 ppm indicates that symptoms will be imminent.

Copper

Copper concentrations in roots increased almost linearly with increasing solution concentrations (Fig. 5). Surprisingly, copper concentration in the shoots did not change with increasing solution concentrations. After a few weeks in elevated copper solutions cranberry roots were darkly discolored suggesting that copper was accumulating in the roots. Elevated copper concentrations did reduce shoot growth at elevated solution concentrations even though copper concentrations in the shoots were not elevated (Fig. 6). Excessive copper will be difficult to diagnose since we would not expect to find high copper levels in shoots that would normally be sampled for tissue testing, yet excessive copper will reduce plant growth.

We chose 4 ppm copper for aeroponics. For the first four weeks both control and +Cu plants grew well. For weeks five through seven there was a noticeable reduction in both fresh and dry weights of the treated plants (Fig. 7). Tissue Cu concentration declined during the experiment from about 8 ppm to about 5 ppm, suggesting too little Cu in the control solution (Fig. 8). Copper in the tops increased from about 14 ppm to 30 ppm. Cu concentration in the roots was even more pronounced, rising from 300 ppm at the outset to over 1400 ppm by week 7. No proposal is made for toxic Cu leaf tissue levels as the greatest injury appears to occur in the roots and we have no reliable technique for sampling roots in the field at present.

Sulfur

As sulfur concentration in the solutions increased both root and shoot sulfur concentrations increased (Fig. 9). By the time these samples were harvested even the normal solution produced very high tissue sulfur levels. All of the elevated sulfur solutions produced excessive tissue sulfur levels. Excessive tissue sulfur levels reduced the dry weight-of shoots, but not of roots (Fig. 10). Excessive tissue sulfur should be easy to detect with normal tissue testing.

We chose 750 ppm S for our aeroponics solution. The growth of the tops was similar for the control or +S plants for the first 5 weeks (Fig. 11). At that point the rate of fresh or dry weight increase declined for the +S plants (Fig. 12). Sulfur concentration stayed stable at about 0.3% of dry weight for the control plants, but rose from 0.4 to almost 1% dry weight for the +S plants. Preliminarily, we propose that tissue sulfur concentrations in excess of about 0.65% should be considered toxic.

Conclusions

The results of this research so far indicate that when “soil” levels of micro or minor elements is very high excessive levels can be found in tissues. In some cases these elevated levels are associated with decreased shoot growth. Boron and sulfur excesses will be easy to detect with tissue tests. Copper accumulates in the roots and will be difficult to detect with normal tissue tests.

Tissue values considered to be excessive for Boron is 300 ppm and for sulfur tissue concentrations in excess of 0.65% should be considered excessive. Based on cranberry tissue tests submitted to the UW-Extension Soil and Plant Analysis Lab, we have not seen tissue concentrations even approaching the levels we have found to be excessive in this research. While growers need to be aware of the risks of providing excessive amounts of nutrients, to date we have not seen samples submitted by growers with grossly excessive levels of nutrients.

We are continuing this work and are presently studying Iron, Zinc, Manganese and Magnesium.

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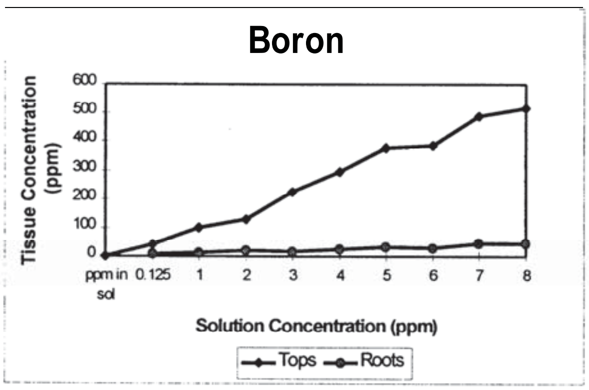
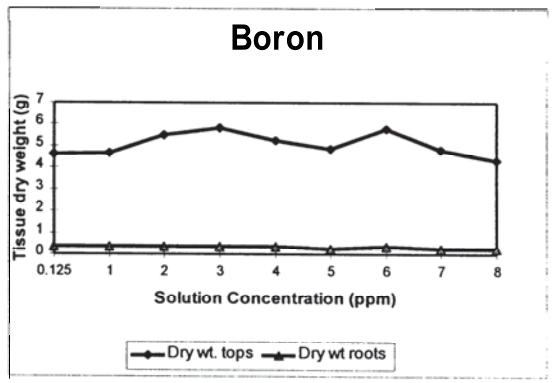
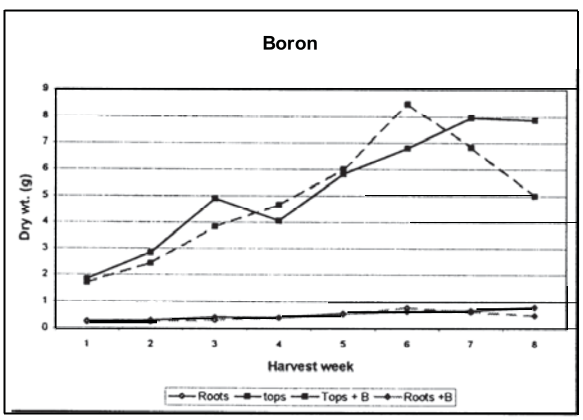
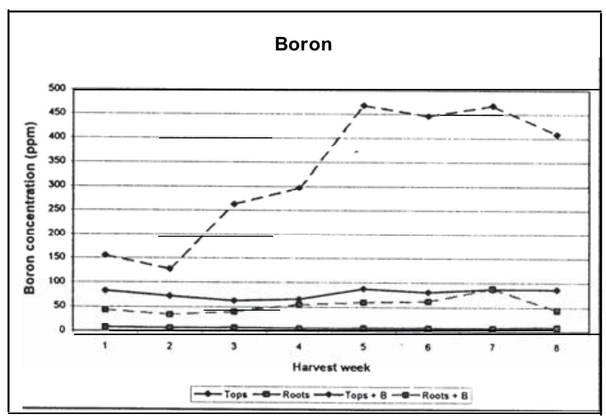
Figures 1 and 2. Effect of elevated Boron in solution culture.



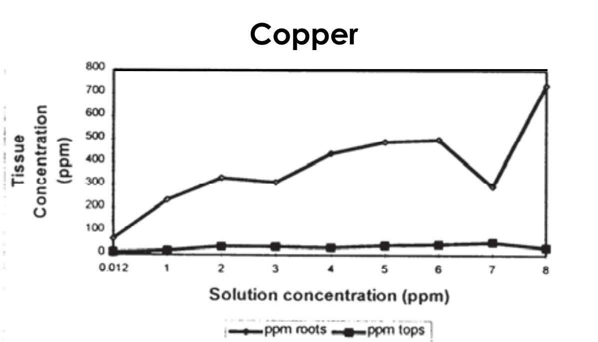


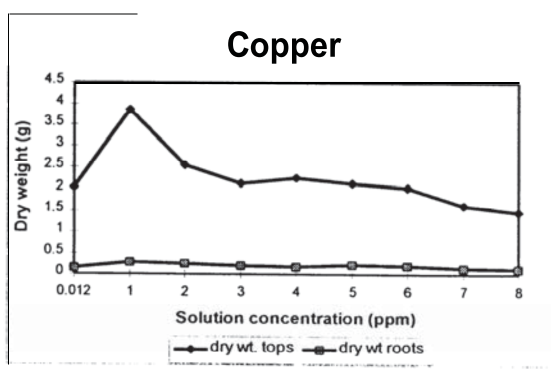
Figures 3 and 4. Effect of elevated Boron in mist culture (aeroponics).



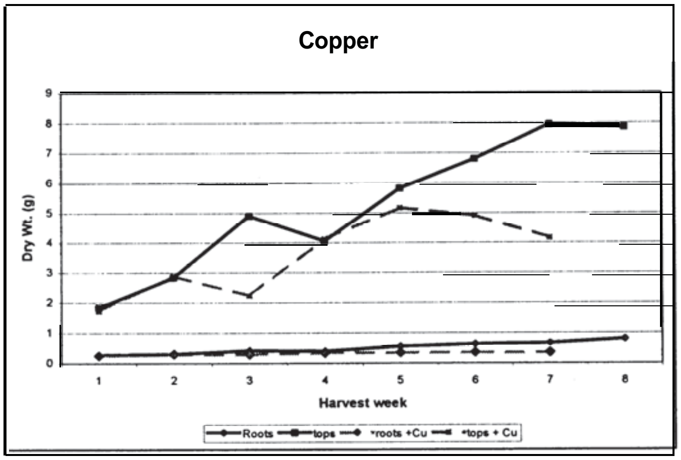


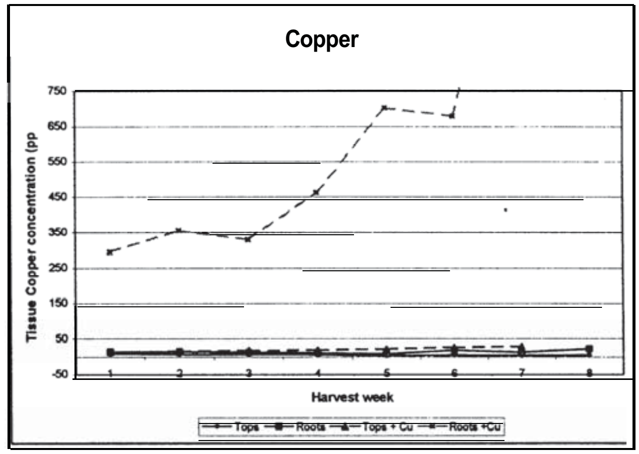
Figures 5 and 6. Effect of elevated Copper in solution culture.



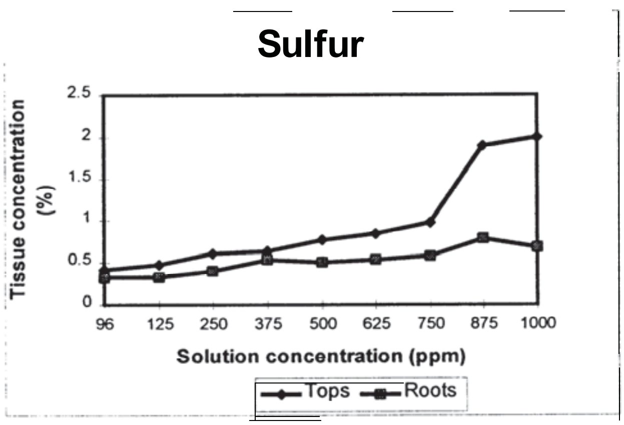


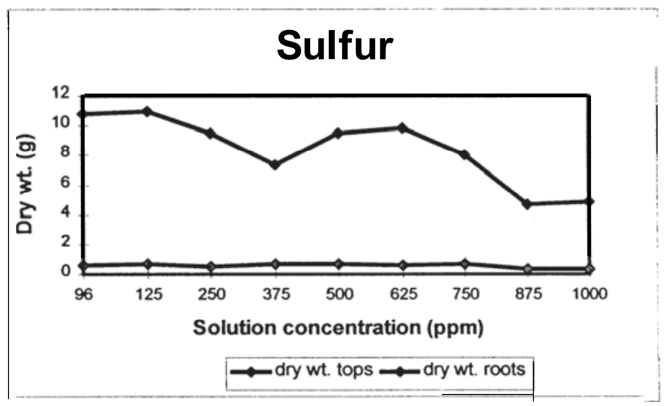
Figures 7 and 8. Effect of elevated Copper in mist culture (aeroponics).





Figures 9 and 10. Effect of elevated Sulfur in solution culture





Figures 11 and 12. Effect of elevated Copper in mist culture (aeroponics).