Integrated
Cranberry Crop
Management
for Wisconsin

Cranberry

Crop Management Newsletter

Volume XIX
Number 9
Sept. 5, 2006

Contents:

Climate and cranberry yield 1
Boron toxicity 3
Anthocyanin development 5

CLIMATE AND CRANBERRY YIELD

In previous articles we discussed various factors that can affect yield in cranberry. These were all considered on a very localized basis. Experiments were conducted on a few uprights to a few square feet of bed surface. While this information is valuable because it increases our understanding of how cranberry vines respond to manipulation or to local conditions, it does not give us the global sense of what affects cranberry yields. Skilled managers can affect local conditions, but none of us can affect the overall climate and there is little that can be done to mitigate climatic conditions. But if we at least have some understanding of climatic effects we can reduce our worry quotient.

Research involving climate is more experiential than experimental. Typically yield data covering a number of years is compared to climatic data and correlations are drawn between the two. Researchers in Massachusetts in the 1940s did this sort of work and drew conclusions from the data they had. As statistical techniques have improved more detailed work could be done. Finally, comparisons can be made among growing regions with vastly different climates. In this article we'll explore the effects of weather on yield.

H.J. Franklin in Massachusetts correlated the hours of sunshine received in various months to the size of the crop the current and following year. He showed that above average sunshine during May, August, September, and November was correlated with above average crops during the following year.

Franklin also examined the relationship of temperature and yield. Temperature had little effect on Massachusetts cranberry yields. They did find a weak correlation between a cold March and above-average yields, presumably because cool temperatures in March kept the vines dormant thus avoiding early spring frosts. Excessive heat in May, June, and August was associated with poor yields as this lead to 'blast' of the vines.

Morzuch created a regression model using 79 years of yield and climate data to predict yield based on technological advances and climate. He found that 91% of the variability in yield was explained by technological advances and only 2% was related to climate.

Degaetano and Shulman working with New Jersey data did find statistical correlations between climatic data and cranberry yield. In their research, "Temperature and sunshine appear to have the greatest effect on cranberry growth and production. Precipitation, snow cover, estimates of potential evapotranspiration, and available soil moisture are apparently of little importance. Increased berry production is associated with warm temperatures during mid-May to late June and mid-October to mid-November of the year prior to harvest. Cold temperatures during early February to late March and sunny conditions from early May to mid-June also favor above-normal yields. Excessive heat from mid-June to early August and between the accumulation of 392 and 504°C GDD correspond to below normal production."

During May and June of the year prior to harvest temperatures >65°F and minimum temperatures >50°F were associated with above-normal yields. Between mid-October to mid-November maximum temperatures >65°F and minimums >50°F also corresponded to above normal yields. Lower yields were correlated to years when maximum daily temperatures did not reach 65°F or the low temperatures were below 25°F during this same autumn period.

The relationship between warm temperatures at specific times during the season and yield is not surprising. Consider the phenology of the crop during these times. In the spring uprights are growing. Warm sunny weather would promote vigorous growth that would be more likely to result in a fruit bud. Warm temperatures in the mid-fall would provide optimum conditions for continued bud development. Well developed buds going into the winter would be more likely to produce strong flowers that would set fruit the following year. By the same token, during the harvest year hot weather during bloom and fruit set would interfere with pollen germination and growth of the germ tube through the style and into the ovary.

Similar results were found by a national group of physiologists who were looking at the rate of fruit growth in three cultivars across five growing regions. We were trying to explain why the rate of growth of a given cultivar was so variable across different growing regions. For example, for Stevens Wisconsin and Massachusetts had the highest growth rate while Washington and Oregon had the slowest. Yet at harvest fruit size is similar across states. How could this be? The difference is that the Pacific Northwest has a much longer growing season with more moderate cool temperatures overall. When we tried to explain why this would be we discovered that solar radiation (light) accounted for little of the variability if fruit growth. Growing degree days and number of days were also poor predictors. Instead, the number of moderate temperature days (between 61 and 86°F) was the key and accounted for 80% of the variation in fruit growth rate. The most rapid growth occurred when temperatures were in this range. High temperatures were limiting in New Jersey while cool temperatures were limiting in Oregon and Washington.

Why is temperature so important? Likely because most of what occurs in biological systems varies with temperature. We know that the optimum temperature for photosynthesis in cranberries is in the mid-70s. Temperatures above or below that result in less photosynthesis leading to reduced growth. Respiration is also temperature dependent. Respiration uses the products of photosynthesis and as temperature increases 10°C the rate of respiration doubles. Moderate temperatures maximize photosynthesis while maintaining moderate respiration.

Temperature also affects nutrient uptake. In a study of the rate of uptake of applied nitrogen fertilizer we found a much higher rate of uptake in Wisconsin and New Jersey compared to Massachusetts and Oregon. A follow up study in aeroponics demonstrated that N uptake by cranberries is strongly temperature dependent and that growers should wait until soil temperatures are at least 55°F before applying N fertilizer.

In this article we learned that:

- Climate affects yield of cranberries.
- Warm temperatures in the spring and mid-fall the year before harvest contribute to high yields.
- Hot temperatures during bloom and fruit set contribute to low yields
- Moderate temperatures (between 61 and 86°F) were associated with high fruit growth rates
- Nitrogen uptake is temperature dependent.

Teryl Roper, UW-Madison Extension Horticulturist

Literature Cited:

Degaetano, A.T. and M.D. Shulman. 1987. A statistical evaluation of the relationship between cranberry yield in New Jersey and meteorological factors. Agr. & Forest Meteorology 40:323-342.

DeMoranville, C.J., et al. 1996. Fruit mass development in three cranberry cultivars and five production regions. J. Amer. Soc. Hort. Sci. 121:680-685.

Franklin, H.J. and C.E. Cross. 1948. Weather in relation to cranberry production and condition. Mass Agr. Expt. Stn. Bulletin 450.

Morzuch, B.J., J. Kneip, and D.C. Smith. 1983. An econometric approach to modeling the effects of weather and technology on cranberry yields. Mass Agr. Expt. Stn. Research Bulletin 683.

Roper, T.R. et al. 2004. Rate of ammonium uptake by cranberry (Vaccinium macrocarpon Ait.) vines in the field is affected by temperature. HortScience 39:588-590.

Those who control the access to the minds of children will set the agenda for the future of the nation and the future of the western world.

James Dobson

BORON TOXICITY

Cranberry growers are understandably concerned about mineral nutrition of cranberry vines. Significant yield increases have been associated with improved 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.

Some plant nutrition advisors are recommending applications of large amounts of some elements. The long-term impact of these recommendations is questionable. Several years ago we undertook a research project to understand the effect of large quantities of minor elements on cranberry growth. Some of the results are reported here.

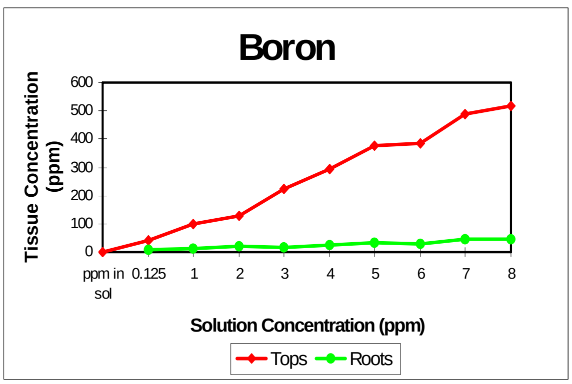
Approach:

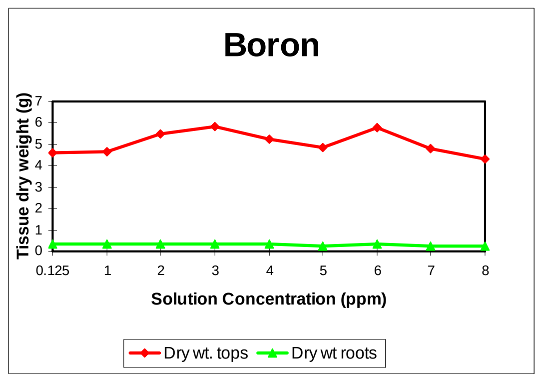
The research was conducted at the University of Wisconsin-Madison, Arlington Research Center. 'Stevens' cuttings were rooted and grown hydroponically in dilute complete nutrient solution per our standard practice. Solution pH was adjusted three times per week (pH tends to drop over time as nutrients are taken up from the solution). Once the plants were growing well, concentrations of Boron 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 experiment was 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 symptoms of excess B in plant tissues.

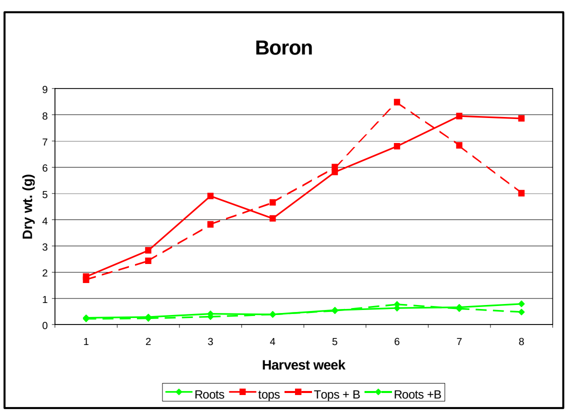
In solution culture the Boron concentration in shoots increased linearly with increasing solution concentration. Once the solution concentration exceeded the normal amount supplied in solution (0.125 ppm) shoot tissue concentrations were high enough to be considered excessive [>60 ppm] (Fig. 1). Root 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 culture (Fig. 2). Our data clearly show that Boron accumulates in shoot tissues and not in roots.

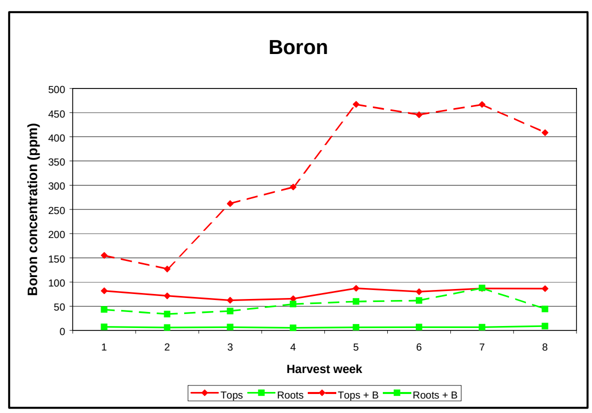
Figures 1 and 2. Effect of elevated Boron in solution culture.





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





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). We propose that tissue B in excess of 300 ppm is excessive and suggests that symptoms will be imminent.

The results of this research strongly suggest that when "soil" levels of boron become excessive that plants will continue to assimilate boron until tissue levels reach a point where toxicity symptoms begin. At this point plant growth slows and certainly productivity would be affected.

We warn growers and advisors to use great caution when deciding how much Boron to apply to bearing cranberry vines. This work clearly shows that toxicity can occur. Further, I know of no evidence that higher yields result from tissue B concentrations in excess of 60 ppm.

Teryl Roper, UW-Madison Extension Horticulturist

You know, I think everybody longs to be loved, and longs to know that he or she is lovable. And, consequently, the greatest thing that we can do is to help somebody know that they're loved and capable of loving.

What do you think it is that drives people to want far more than they could ever use or need? I frankly think it's insecurity. How do we let the world know that the trappings of this life are not the things that are ultimately important for being accepted?

Fred Rogers

ANTHOCYANIN DEVELOPMENT

Since fruit color is so important to the cranberry industry, I thought I would take a little space and describe a little about fruit color development in cranberry. The red color of mature cranberries is caused by the development of anthocyanin pigments in the few outermost cell layers. This is also associated with a dilution of chlorophyll as the berries enlarge. Anthocyanins are fairly complex molecules that require significant amounts of energy to create.

Anthocyanin production is broadly regulated at two levels: environment and genetic. Development of fruit color is associated with bright sunny days and cool nights. Research has clearly shown that the greatest amount of color develops with the coolest weather and that in the immediate pre-harvest period warm temperatures lead to poor fruit color. Hall and Stark working in Nova Scotia with 'Stevens' fruit noted that at low light anthocyanin formation was enhanced by decreasing temperatures. Fruit held at 45°F had 75% more anthocyanin than fruit held at 65°F. The most intense color is also formed where sunlight strikes the fruit directly. Growers have long noted that fruit in the top of the canopy is better colored than fruit deep in the canopy and that the tops of the fruit tend to have better color than the bottoms. The effect of light on fruit color development has been studied extensively for apples (which also must have light directly striking fruit for optimal color development).In apples, light intensity of less than 30% of full sun is ineffective in developing fruit color. Apparently light is critical for two reasons. First, to induce formation of color; and second to provide carbohydrates that are subsequently formed into anthocyanins. Unfortunately, we can do little about the environment on cranberry marshes. We are at the mercy of the weather.

Different cultivars develop more anthocyanin than others and some develop color earlier. These are genetic differences that can be exploited in breeding programs. There seems to be a negative relationship between fruit size and fruit color, with larger berries having less anthocyanin per volume than small berries. There are also qualitative differences with cultivars such as Budd's Blues producing more blue and less red pigment than other cultivars. Most of the newer hybrid cultivars produce better color than older selections from the wild.

In many fruit crops, including cranberry, there is a negative relationship between nitrogen fertilization and fruit color. The exact mechanism is not known, but the speculation is that too much nitrogen forces vegetative growth that takes resources that may otherwise have gone to color production. Alternatively, substantial vegetative growth may provide additional shade that prevents color development.

I know of no research that shows better color follows application of large doses of potassium in the fall. I don't know of a metabolic explanation for such a practice.

In the past several pesticides were used to enhance color development in cranberry. To my knowledge these practices have been abandoned. Good overall management accompanied by cooperative weather is what is needed for good color development today.

Teryl Roper, UW-Extension Horticulturist

Literature Cited:

Hall, I.V. and R. Stark. 1972. Anthocyanin production in cranberry leaves and fruit, related to cool temperatures at a low light intensity. Hort Res. 12:183-186.

WISCONSIN CRANBERRY SCHOOL

The annual Wisconsin Cranberry School will be held at the new Stevens Point Holiday Inn (on Highway 10). The dates are January 16-17, 2007. Please put these dates on your calendar and plan to attend and to bring your full-time workers as well.