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SOIL INSECT PESTS OF WISCONSIN CRANBERRY PRODUCTION

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Introductory comments. With over 1 million different species in the world, insects have successfully colonized a great diversity of habitats. The soil is a particularly ideal niche for insects because the soil provides protection from heat and cold, drying and heavy rains, and natural enemies such as birds. And the roots and underground stems, tubers, corms, bulbs, and rhizomes of various plants provide an abundance of food. When root-feeding insects build up to large numbers, they can cause significant plant damage. Most crops have one or more serious pests that live in the soil. Corn rootworm larvae, an abundant and widespread pest of corn roots, can reasonably be considered the most important agricultural pest in the entire state.

Depending on the crop, soil insects can cause damage directly to the marketable commodity, such as carrots, potatoes, onions, radishes, and ornamental bulbs. Other soil insects do not damage the harvestable crop, but, instead, cause plant stress and correlated loss in yield or quality by feeding on the roots that are necessary for moisture and nutrient uptake; such is the case with the pests living in cranberry soils. In severe situations, prolonged root feeding by large numbers of soil insects can lead to plant death.

Across North America, there are about 10 types of soil insects that are injurious to cranberry. Here in Wisconsin, we are fortunate to have relatively few of these, and the ones we have are often not as severe as in other growing regions. The distribution of the major soil insects can be seen in the following table. Note that the first four insects are all in the white grub family, the next three are in the leaf beetle, flea beetle, and rootworm family, and the next two are weevils; these are all beetles (Coleoptera). The last is a moth (Lepidoptera).

Insect	Wisconsin	East Coast	West Coast
ranberry root grub			
June beetle grubs			
Oriental beetle			
Hoplia grubs			
cranberry rootworm			
striped colaspis			
redheaded (cranberry) flea beetle			
black vine weevil			
strawberry root weevil			
cranberry girdler			

Not present, or not significantly damaging

Present at damaging levels

As can be seen in the table, Wisconsin has three soil insects of primary importance: white grubs (June beetle larvae), cranberry flea beetle, and cranberry girdler. Each of these will be discussed individually below.

General control strategies for managing soil insects. Each of the following strategies has been used to manage various cranberry soil pests. Specific controls will be discussed below for each of the three pests.

Soil insecticides. Currently, there are two insecticides of interest for use against soil pests of cranberry. Diazinon 14% granular insecticide has been available for use for many years. It does not have a national label, but registration has been through the Special Local Needs (SLN) process as reviewed by the Wisconsin Department of Agriculture, Trade, and Consumer Protection. This SLN label was not supported by the registrant in 2004, but will likely be reinstated for the 2005 field season. Diazinon 14G can not be applied by air, and there must be a 10 ft. untreated buffer next to all bed ditches. The target insect is only cranberry girdler. The other product is a new registration, Admire, with the active ingredient of imidacloprid. This insecticide has good activity against certain soil pests on the East Coast, but not for our complex of species. We are not recommending it for use at this time, pending further research trials.

Foliar insecticides. Insecticides applied to the above-ground parts of the plant are not generally recommended to control soil insects. The exceptions are with those soil insects that have an accessible above-ground stage. This is the case with cranberry flea beetle, the adult of which is an important foliage feeder and can be controlled with foliar insecticides. Whereas no insecticides are specifically registered for this pest on cranberry, most broad-spectrum materials will work well.

Biological controls. Commercially-available insect parasitic nematodes have been tried by many growers for controlling cranberry girdler and other soil insects. Such nematodes vary in their effectiveness depending on species of nematode, pest species, and quality of the product as supplied by the producer. Generally, nematodes are much more expensive to use than insecticides, but in some cases, such as for certified organic production, they may be the only option. Currently, effective nematodes are available for cranberry girdler but not June beetle grubs. I know of know efficacy studies against flea beetle larvae.

Flooding. Flooding is a long-established practice for controlling many types of insects in cranberry. It is also a control practice widely used against soil insects in many other crops. The benefits of flooding are restricted to those insects that will be killed in a flood with a short duration, so that plant injury or crop loss does not also occur. Growers are currently using flooding to control cranberry girdler. Flooding does not control June beetle grubs and, as far as I know, there have been no studies conducted on cranberry flea beetle.

Sanding. Sanding has long been known to provide benefit for beds infested with cranberry girdler. It does not control white grubs and there are no data for control of flea beetles. The benefits of sanding also include improved root and runner growth.

Good horticultural practices. Soil insects that destroy roots or damage the conductive capabilities of stems result in the reduction of moisture and nutrient flow to the above-ground portions of the plant. Proper fertilization and irrigation, especially in times of drought, will help maintain plant vigor even in the presence of low to moderate populations of soil insects.

Cranberry girdler. Cranberry girdler is a member of the sod webworm complex, which has several species that damage turfgrass. Cranberry girdler has a peculiar range of host plants. In addition to cranberry and turf, it is also a pest of certain conifers and can cause damage to young trees in seedling plantations.

Biology and damage. Cranberry girdler spends the winter as a fully grown larval caterpillar in the soil, inside of a cocoon composed of silk, soil, and dry plant residues. After the weather warms in the spring the larvae pupate within their cocoons. Adult moth flight usually begins in late May, peaks during the month of June, and tapers off and ends by late July; this is the period when adults mate and females lay eggs. Young larvae are present beginning in late July; in this stage they feed on the fibrous cranberry roots. As they grow they begin to feed on the bark of the horizontal runners, chewing away the woody tissue and leaving a very rough surface to the stems. In some cases the stems may be chewed sufficiently that they are totally severed. Bark removal (girdling) results in restricted nutrient and moisture flow into the uprights. Larvae continue to feed well into September. If population levels are high, plants may appear drought stressed during late summer and fall. Feeding is finished and cocoons are produced by early October. There is only one generation per year. The most noticeable damage occurs in spring after the winter flood has been removed. At this time, the severely injured areas will have dropped their leaves and dead spots will be seen in the field. Inspection of the vines at this time will reveal the feeding injury if girdler is the culprit.

Monitoring and control. Pheromone traps are available for monitoring adult flight. Traps should be placed in the field by May 15. Check and record trap results weekly; yearly records should be kept to evaluate seasonal activity in comparison with long term trends. When patches of dead vines are seen, inspect the runners at and below soil surface for chewing.

Diazinon 14G has been the product historically recommended for controlling cranberry girdler. Registration is based on a state Special Local Need (24(c)) label, which was not renewed by the registrant in 2004. As I write this, WDATCP is evaluating a petition for reinstatement of this label for the 2005 field season. A single application is permitted; appropriate timing is 10-14 days after peak flight, after most eggs have hatched but before larvae get too large to be controlled. Diazinon 14G may not be applied by air and untreated buffers must be used adjacent to in-bed ditches. Check the label for full instructions. Diazinon 14G will likely be phased out by EPA within the next few years; we will be working to evaluate other potential soil insecticides. Foliar insecticides are not available for controlling cranberry girdler.

Biological controls, in the form of insect parasitic nematodes, have been used by the industry. Both lab and field studies show that nematodes can be an effective control tactic. However, difficulties with production, handling, and application of these living organisms has sometimes resulted in less than optimum results. Further, they tend to be quite expensive. When used properly, they should be a viable control option, especially for specialized uses, such as in certified organic production. Timing of application is approximately the same as for Diazinon 14G, roughly 10-14 days past peak adult flight.

Flooding is becoming a more widely accepted option for controlling girdler larvae. In Massachusetts, a flood one week in duration in late September is recommended. Floods of shorter duration and a bit earlier seem to be used here. In order to protect the health of the vines, flooding should only occur when cool cloudy weather is forecast for the duration of the flood. No university research has yet been done to evaluate flooding for control of cranberry girdler.

Sanding has proven to be successful in suppressing cranberry girdler by reducing habitat favorability. The sand layer should be as thick as possible, and a minimum layer of 1" is recommended. The benefits of sanding are temporary, allowing populations to ultimately rebound, and sanding every three years is recommended. In addition to reducing the girdler population, sanding also has benefit in rejuvenating injured vines.

Redheaded flea beetle. Redheaded flea beetle (often called cranberry flea beetle by the cranberry industry) is a general feeder that attacks a multitude of types of wild, cultivated, and weedy plant species. Crop plants attacked include corn, soybeans, alfalfa, potatoes, grapes, flowers, and many more. Flea beetles get their name because they are good jumpers. Redheaded flea beetle causes plant damage in the larval stage by feeding on cranberry runners, stems, and roots, whereas the adult beetle can cause significant damage as a leaf feeder.

Biology and damage. Adult flea beetles are up to ¼" in length, and mostly shiny black in color, but with a dark reddish head. They can be found in cranberry beds from late July through September, during which time they feed on the leaves of cranberry and certain weedy species found in cranberry beds. When feeding on cranberry leaves, the beetles feed primarily on the leaf surface in a skeletonizing fashion. The opposite leaf surface dies and turns brown, somewhat resembling the damage caused by fireworms, except the leaves are not webbed together. There is conflicting information as to the stage of development in which this insect overwinters, however, it is likely the egg stage. Eggs hatch in spring and the small, slender, pale colored larvae feed on roots (and underground stems) of cranberry and other plants during late spring and summer. Eventually they pupate in the soil, and a few weeks later the adult beetles emerge. There is just one generation per year. Larval feeding damage on stems looks similar to that cause by cranberry girdler, but is done earlier in the growing season. Plants often respond by sending up small weak upright stems that arise near the damaged areas. Discolored and thin areas of vines are readily seen in mid to late summer. The problem may be compounded by drought stress.

Monitoring and control. Monitoring is best conducted during routine sweepnet sampling. IPM specialists have developed a working threshold of 10-20 beetles per 25 sweeps. In addition, growers and crop consultants should be aware of the insect and its symptoms during routine crop examination. If feeding by the larvae is suspected, check the runners for visual evidence of feeding.

I have seen no information on the possible efficacy of either flooding or sanding to control this insect. Neither have I seen data on insect parasitic nematodes, however, it is known that some nematodes successfully parasitize other members of the flea beetle family. Admire insecticide is registered for use as a soil insecticide against rootworms (the flea beetle family) in cranberry, but I have seen no data on the effectiveness against redheaded flea beetle. The most frequently used approach to controlling flea beetle is to use foliar insecticide sprays. Although carbaryl (Sevin) is a commonly used product, I expect other materials are similarly effective.

White grubs. The term "white grub" is a bit of a generic name that refers to the larvae of many types of beetles in the scarab family. One group of scarabs consists of the common May and June beetles. These are members of the genus *Phyllophaga*, and include nearly 30 Wisconsin species. Only one of these is known to attack cranberry, *Phyllophaga anxia*.

Biology and damage. June beetles are quite large, robust insects, often over an inch long in the adult stage and nearly twice that size as the larval grubs. Most species require three years to complete their life cycle. Adult beetles fly in May and June and mate and lay eggs during this period. Eggs hatch within a couple weeks and young larvae begin feeding on plant roots; initially they are well under ¼" in length. They continue to feed through this first year of their life cycle until the soil turns cold in fall or early winter, at which time they burrow down below the frost line. The following spring they move back up to feed on roots, and continue in the larval stage throughout this entire year, once again burrowing downward as the soil cools. In the third year, they come back to the surface, feeding until early summer. They then pupate in the soil, and develop into adults in fall. The adults stay in the soil until the following spring, when they emerge and start a new generation.

Larvae cause damage by pruning roots, thereby inhibiting the plant's ability to take up moisture and nutrients. Plants are not anchored to the soil and when the stems are tugged on, the sod feels as though it is lose, just sitting on the soil surface. In heavily infested areas, significant plant death can occur. The greatest amount of damage is usually done in the second and third years of the life cycle.

Monitoring and control. There are no traps or other specialized monitoring methods. Plant dieback can be caused by many factors. Where dieback is evident, dig up the soil inspecting for grubs and damaged roots. The grubs are easily seen and usually within the top 3-4" of soil; some may even be at the soil surface. In any given area of the state, many of the white grubs may be in the same stage in the same year. In such locations, some years may have more noticeable adult flights. In these cases, damage is more likely to show up in the second and third years after the big flights.

Currently there are no good measures to control white grubs in cranberry. They are not controlled by flooding, sanding, or currently available biological controls. There are no effective soil insecticides registered for use on cranberry. In areas where there are moderate white grub populations, good horticultural practices such as proper irrigation and fertilization will reduce plant stress. Admire insecticide is registered for white grub control in cranberry, but the target species are different white grubs found on the East Coast. Admire is not an economically effective control for *Phyllophaga* grubs.

Updates on cranberry plant/soil water relations and on mycorrhizal colonization in Wisconsin cranberry production.

Sarah Stackpoole
Kevin Kosola
UW Madison Horticulture Dept.

In this article I will discuss recent findings from our research on root growth responses to soil water availability in cranberry, and from our work on the prevalence and potential role of ericoid mycorrhizal fungi in Wisconsin cranberry marshes.

We can gain insights into management of cranberries in cultivation by considering the adaptations of cranberries to their native, sphagnum bog environment. Cranberries growing in a sphagnum bog are essentially growing in a sponge, with an abundant supply of acidic water. These plants have runners and roots growing down to, but not beyond, the saturated zone.

We know from recent work in our lab that the balance between root and shoot growth in cranberries is sensitive to soil water availability. High water tables lead to shallow rooting depth, as cranberry roots are unable to grow into flooded soil. In these cases, shoot growth dominates root growth, so the root/shoot ratio is relatively small. If the water table is high and constant, this small, shallow root system is capable of supplying sufficient water to maintain growth and reproduction. Lower soil water availability leads to deeper, more vigorous root growth, and an increase in the root/shoot ratio- plants are "rootier".

Sarah Stackpoole has collected data in 2004 that indicates that this same response is seen in the field. Samples were collected at the high- and low-water table ends of a gradient along approximately ½ mile, where bed elevation was constant, but the water table was approximately 4 inches deeper at the dry end relative to the wet end, leading to consistently lower soil moisture. (Fig. 1). This seemingly small difference in water table height has caused a significant difference in cranberry root/shoot development. The root system in the dry end of the series of beds was generally deeper, and constituted proportionately more of the total plant biomass. These plants were "rootier", consistent with observations in the greenhouse (Fig. 2).

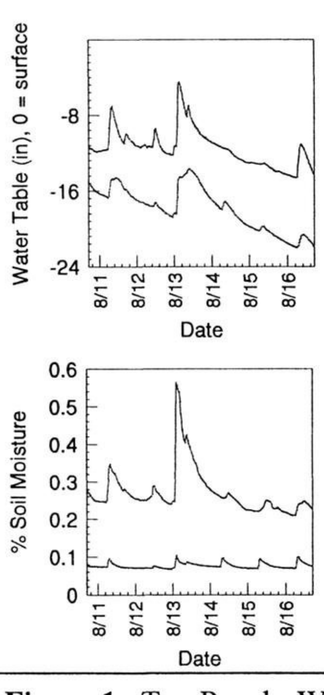

Figure 1. Top Panel: Water table depth from surface (inches). Bottom panel: % soil moisture (g water per gram soil). Dark line is data from wet end of the gradient, light line is data from dry end of the gradient. Data collected in 2004.

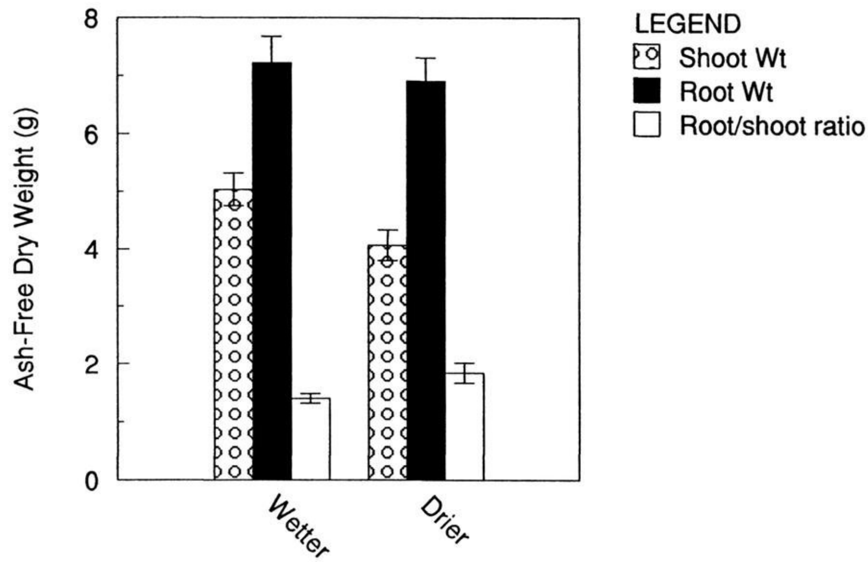

Figure 2. Shoot weight, root weight, and Root Wt/Shoot Wt ratio (root/shoot ratio) for "Stevens" vines growing at the wet and dry end of a water table gradient over approximately ½ mile.

Mycorrhizal colonization is common in Wisconsin cranberry production. In our initial survey of mycorrhizal colonization in 100 different cranberry beds distributed among 7 marshes, we found the average rate of colonization was 42% (% root length with mycorrhizal fungi). Marshes where Bravo is applied yearly to control cottonball had colonization levels similar to those found on the other marshes where fungicides are not typically applied.

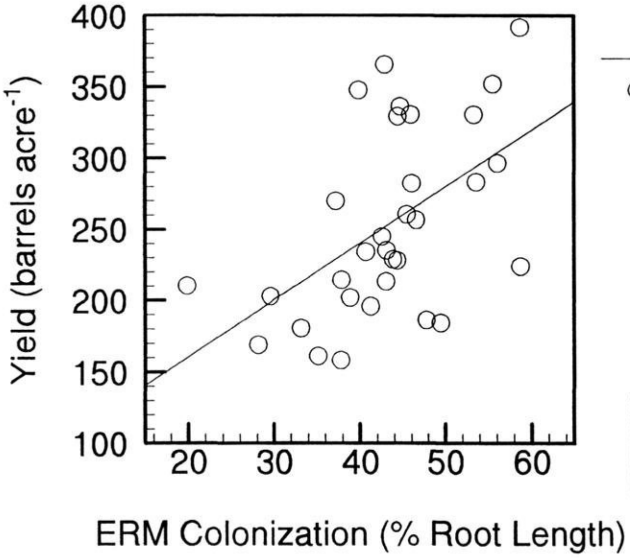

Figure 3. Mycorrhizal colonization (% root length) vs. yield (bbl/acre).

We found a positive relationship between colonization and yield on one of the 3 marshes where we have sufficient data for this analysis (Fig. 3). We sampled 35 beds in this marsh, including both old and renovated beds with a peat substrate and old and new beds with a sand substrate. Colonization was generally quite high on this marsh, even on very new plantings.

Does this positive relationship imply that we should be trying to obtain high colonization rates in order to improve yields? Probably not, given that we only found this relationship in one marsh. A possible cause for the positive relationship between mycorrhizal colonization and yield is the common response of both traits to nitrogen availability. At very low nitrogen levels, both yield and mycorrhizal colonization show a common response to increased applications of N, but only up to a point. Above optimal N levels, both colonization and yield are likely to decline with increasing N fertilization.

Do mycorrhizal fungi serve a beneficial role in cranberry production? In their native sphagnum bog habitat, mycorrhizal fungi act to break down organic nitrogen, giving mycorrhizal cranberry plants access to this otherwise unavailable source of soil nitrogen. We are currently investigating the role of dissolved organic nitrogen in the nitrogen budgets of cranberry beds.

Evaluating Changes in Practices

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To remain productive and profitable in the cranberry industry, a grower needs to implement changes in practices from time to time. Indeed, growing cranberries is a life-long learning process. A lot of learning is acquired by "trial and error," or put another way, by experimentation. How can one determine whether or not a change in practice is making a difference? Well-designed and carefully executed field experiments are a good way to evaluate crop management practices. The following are some tips for doing field research. These guidelines are focused on pest control research, but the principles can be applied more broadly.

Tips for Field Research

1. Choose a site where the pest is a problem. You need to have good pest pressure to see a difference among the different treatments.

2. A good experiment has variables (e.g., different pesticide treatments) and a control (i.e., place where you leave everything as is so that you can compare your treatments to it).

3. Keep it simple. The fewer treatments you have, the more likely you are to carry through with all steps of the project and get meaningful results.

4. Ideally you have repetitions of your treatments within a single bed so that you can take the average. And even more ideally, you repeat the whole experiment in another bed and over multiple years. If results are consistent from experiment to experiment, the more likely that the trend you are seeing is real.

5. Be aware of the tendency to bias an experiment and fight it every step of the way! Think uniformity when you set up plots; don't put one treatment at the bed edge and another in the middle of the bed. When taking data, it might help to have someone unfamiliar with the experiment do ratings. To avoid "rater bias," try to have one person do all the rating, or at least have one person do all rating for one set of repetitions.

6. Taking data. Obviously, the kind of data you take depends on the pest and what sort of damage it does to the crop. For some pests you can take data just once per year and get a pretty good idea of how a pesticide worked. For other pests, you might want to rate multiple times to see how sprays at different times of the year are working.

7. Statistical analysis is used to determine how "real" differences among treatments are. But if you are not trained in statistics, just be aware that the less variability there is among repetitions of a treatment, the more secure you can be in calling differences "real" and not just due to chance.

8. You must take complete notes at every step (experiment set up, observations during the season, and at harvest) and store them in a safe place where you can find them.

9. Cost vs. benefit analysis. Remember, it's not yield but profitability that you want to improve.

Casoron
Dichlobenil (DBN)

Jac Eussen
Crompton Corporation
Crop Protection

Mode of Action

Dichlobenil (DBN) inhibits the formation of cellulose in the plant cell walls. Cells loose their elasticity. They do not elongate but swell in all directions and then burst. At higher doses cell walls are not formed anymore. Dichobenil therefore will only affect growing plant tissue not already established tissue.

DBN-soil characteristics

- The Casoron granule disintegrate when in contact with water, and DBN is released
- DBN is volatile, thus should be watered in after application
- The Casoron granule protect DBN to a certain extend from evaporation
- Volatility is temperature dependent and it is not recommended to apply Casoron above 65/70 F
- In soil DBN will partition between: soil water – soil air – soil particles
- Uptake of DBN by plants from soil occurs through the soil water
- DBN has the property to co-distill with water. Thus as water evaporates from soil DBN will go along with it. 1.4 gram of DBN can disappear in this way with 100 ml of soil water
- DBN also will disappear from soil through soil air
- The partition coefficient of DBN between water and air is 4000. This means that DBN will be forced into the water as long as it is in the soil air space. The solubility of DBN in water however is limited to a maximum of 18 ppm
- Adsorption to the soil strongly dependent on the soil OM content. K=1.0(OM) + 0.5; Maximal adsorption occurs at 10% OM; DBN will desorb from the soil according to the same equation. Adsorption is independent from clay content and CACO3
- Although in organic soils a greater part of DBN will be adsorbed to soil, as a result of its solubility DBN is still regarded as mobile in soil.
- The combined characteristics of DBN will cause DBN not to move much downward as well as laterally in soil. This however will depend on OM. As OM content decreases from 10%, more movement will occur
- Degradation of DBN is a microbial process.
- Half life of DBN is 1.5-12 months
- No effect from light or pH

Consequences for Casoron application.

Peat soils

- Water-in is necessary
- Restricted movement of DBN downward and laterally.
- Co-distillation and evaporation will occur
- Soil will hold a greater part of DBN
- No leaching of DBN.
- 100 lb/a Casoron 4G is adequate for weed control activity and avoiding crop phytotoxicity
- Depending on the weed infestation split applications may be considered

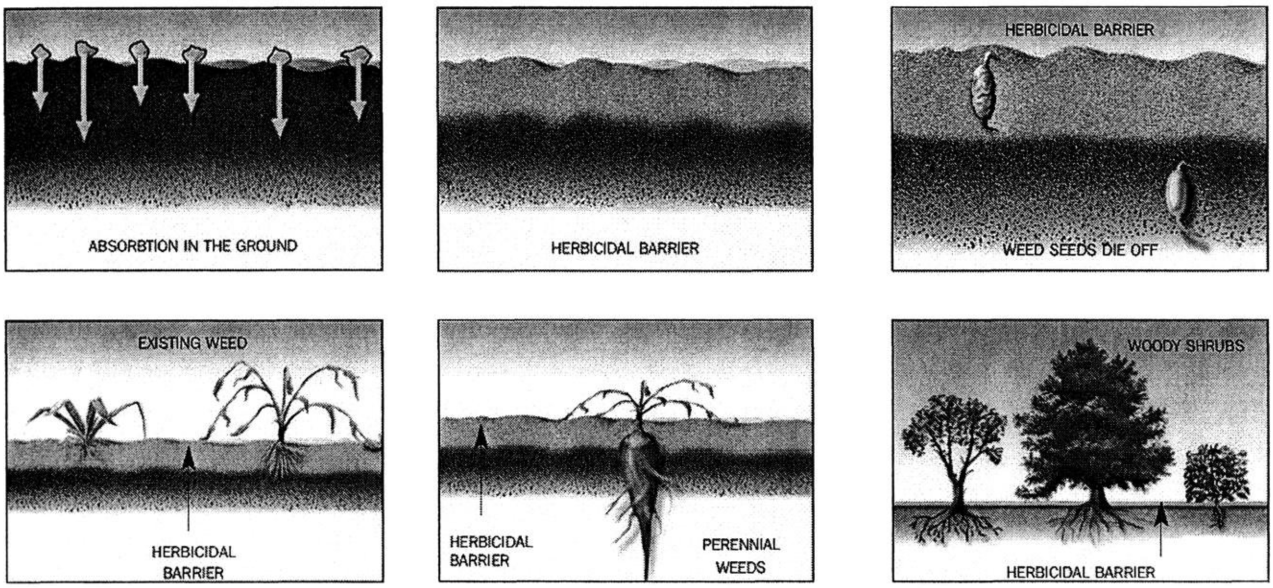
Sand

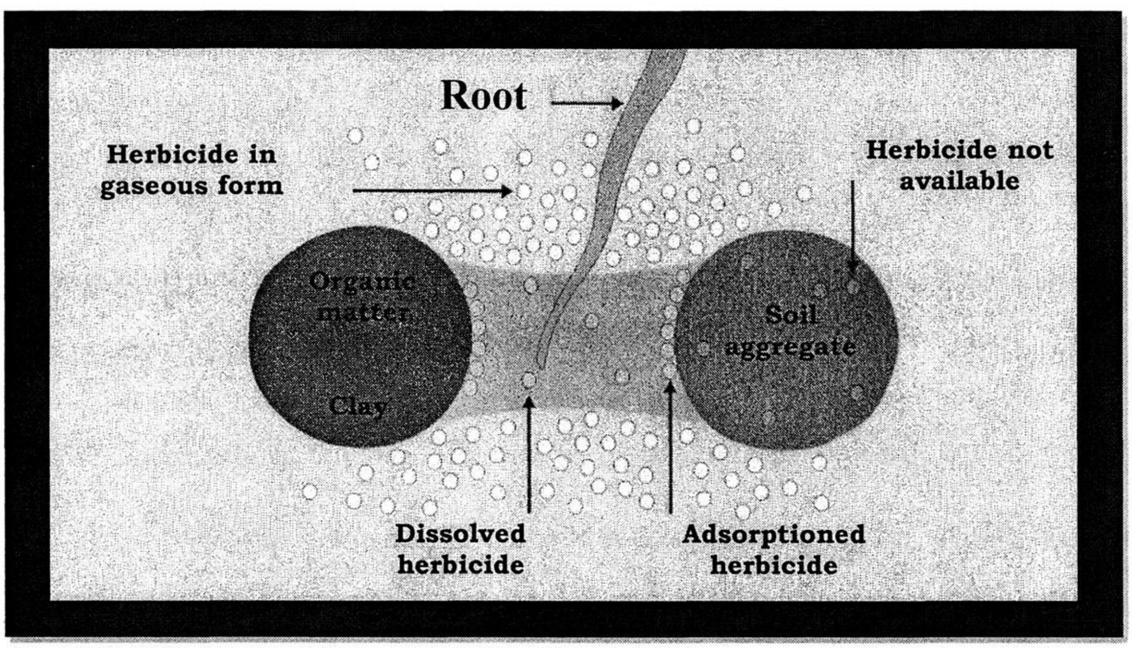
- Water-in is necessary
- Movement downward and laterally will occur
- Co-distillation and evaporation will occur
- Soil will hold DBN depending on OM
- More DBN is available at greater soil depth than in peat soils.

- Casoron rate should be adapted. Lower than 100 lb/a rate for efficacy and phytotoxicity. Maximum
12 one application rate: ca.: 50lb/a
- Split applications should be considered

Sand soil + OM

- In sandy soil with more or less OM, DBN will behave in between peat soil and sand soil. Rates should be adapted accordingly.
- Small amounts of OM will already hold DBN
- OM may develop gradually during the years of cultivation. Behavior than will gradually change from sand soil to peat soil. Casoron application can be adapted.
- Rates will change from the 50 lb/a maximum to the 100 lb/a maximum





Status of the UW Cranberry Improvement Program and the 'HyRed' Release

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The Cranberry Improvement Program has been working extensively on furthering the release of 'HyRed' as well as bringing along new selections and laying groundwork for future cultivars. In 2005 we continued the evaluation of 2000+ second generation progeny in test plots for consistent bud set, yield and fruit quality. New techniques for scale-up of promising selections were utilized to go from 16 sq. ft. discovery plots to 225 sq. ft. performance evaluation plots. These techniques allow us to scale-up a greater number of individuals and 15 were performed in 2005 and another 25 are set for 2006.

Bulk scale-up of one promising selection (for yield, improved color in October and potential insect resistance), from our original first cross, to partial bed size using conventional planting will be undertaken in 2006. The success of this planting will likely allow it serve as a model for future releases where yield is a higher priority (unlike 'HyRed' where fruit color was the primary goal).

Ongoing evaluation of tetraploid cranberry hybrids will continue in 2006 and observations and data collected in 2005 will be used to develop methods to monitor yield and vigor, fruit quality, and most importantly pollination and fruit set. A critical factor we have learned is the influence of competing pollen sources on tetraploid fruit set, which will be controlled for evaluation in 2006.

New hybridizations have/are being performed to lay the groundwork for future selections by testing hypotheses related to specific yield components. These crosses rely on advanced selections as parents. One test cross ready to plant in 2006 will test the hypothesis of maximizing the growing season to maximize yield. To accomplish this, an early flowering selection was crossed to a late maturing, vigorous selection to determine the effects on fruit size in the progeny.

Extensive developmental and regional testing of 'HyRed' fruit color has confirmed (once again) its early fruit color and the universal high color in all regions tested so far. Even at later harvests dates 'HyRed' yields double the TACY values when compared to most other cranberry varieties. There are now almost thirty 'HyRed' sites, mostly in Wisconsin, but also one or two each in New Jersey, Massachusetts, Oregon and British Columbia. A 'HyRed' logo has been developed to allow growers and handlers to specifically identify 'HyRed' cranberries in the marketplace.

Licensing HyRed Cranberry

Brad Ricker, Licensing Manager
Wisconsin Alumni Research Foundation

HyRed, developed at the UW-Madison and patented by WARF, is the first cranberry variety that requires a royalty-bearing license. While licenses and royalties are becoming more common in other areas of agriculture, it has been an interesting challenge to come up with a commercialization plan for HyRed that is fair to all interested parties and that will contribute to the success of HyRed in the marketplace rather than detract from it.

Wisconsin Alumni Research Foundation
WARF has served as the intellectual property organization for UW-Madison for almost 80 years and has been a pioneer in technology transfer worldwide. Today it has over 1800 active cases and generates more than $50 million a year for the University through its licensing and investment activities. These funds support a broad range of research programs at the Madison campus, including start-up expenses for new faculty and numerous competitive grants. Under the current UW-Madison royalty distribution policy 70% of the first $100,000 of income from a license agreement is directed to the research program of faculty inventors. In turn, this WARF funding generates new research results which can lead to new inventions, and the cycle continues.

Opportunity
Licensing and planting HyRed will provide cranberry growers with a new opportunity for generating income. Earlier, higher and more consistent color development in fruit should generate premiums for many cranberry producers. Harvest dates for HyRed could well be a few weeks before other varieties, allowing better utilization of resources for both growers and processors. If color premiums warrant it, harvest could be delayed to take advantage of significantly higher anthocyanin levels compared to other varieties. HyRed appears likely to earn a place in most Wisconsin bogs in the coming years.

Grower's License
In the summer of 2004 WARF began granting commercial licenses to a number of cranberry growers who were already testing HyRed under a Materials Transfer Agreement with the UW. Others will have an opportunity to acquire HyRed plants as the researchers generate cuttings or when Licensed Propagators are authorized to scale up their beds and provide materials for sale. Plant materials can not be transferred by Licensed Growers to other locations or even other Licensed Growers, but may freely propagate HyRed for use on their own marsh while following the license guidelines for maintaining variety integrity.

Twelve licenses have been executed to date, generating about $15,000 through the license fees that are paid after signing the agreement. This fee is creditable towards future royalty obligations, which are $60/acre for Wisconsin growers and $90/acre for others. Another four licenses are under discussion at this time and we expect that licensing will continue at a rate of 5-10 agreements each year until larger quantities of HyRed plants become available in a few years.

Licensed Propagators

Several Licensed Growers have expressed an interest in becoming authorized to sell HyRed vines to others in the future and negotiations are underway to accomplish this. A limited number of qualified growers will be licensed to provide this important service and encouraged to scale up HyRed quickly to fulfill the anticipated demand for vines. A key part of this will be establishing and monitoring specific protocols and quality standards so that anyone purchasing vines in the future will be assured that they are receiving the genuine HyRed variety. WARF will work closely with the inventors and the Licensed Propagators to establish and maintain a fair and productive supply system for the industry which, once established, should generate additional income for WARF and the University.

Looking Forward

HyRed is being protected in Canada as well as the United States and eventually HyRed is likely to spread beyond Wisconsin. However, all of the royalty income will return to Wisconsin where it will support further research. The inventors are working on additional, improved varieties and it is anticipated that Wisconsin cranberry producers will literally see the fruits of these research and licensing efforts for many years to come.

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HOW MUCH PHOSPHORUS FERTILIZER IS REALLY NEEDED?

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Phosphorus is required by plants to grow and reproduce. Phosphorus can also be an environmental contaminant. Phosphorus is frequently the limiting factor in the growth of algae in freshwater lakes and impoundments. Substantial algal growth contributes to the eutrophication of water bodies. Cranberry production is intimately tied to surface water. Cranberry growers may use as much as six acre-feet of water per acre of planted vines during the course of a season. The concentration of phosphorus in water exiting cranberry farms is generally acceptable, around 40 μg/liter. However, given the large quantity of water used in cranberry production the total load of phosphorus leaving a property may be significant.

Cranberries are grown in suitable locations in central and northern Wisconsin. Typical sites have either organic soils comprised of decomposed peat or coarse sand mineral soils. The soils and water in these areas are frequently slightly acidic and high in iron and aluminum. When phosphorus fertilizer is applied, phosphate ions form insoluble bonds with the iron and aluminum ions thus becoming unavailable for immediate plant uptake. Over time the phosphate may be released slowly and become available for plant uptake.

Contrary to long held wisdom, cranberry tissue tests typically are in the sufficient range for phosphorus (Figure 1). Cranberry growers usually apply complete fertilizers to provide a constant supply of phosphorus for plant uptake. 6-24-24 has been a favorite because of its low N value that allows easy application. However with an N:P ratio of 1:4 phosphorus is overapplied with each application.

Previous work in Massachusetts had shown that there was no yield response to application of phosphorus in excess of 20 pounds of actual phosphorus or 45 pounds P_2O_5/acre/year (DeMoranville & Davenport 1997). This was the lowest fertilizer rate in their study. We wanted to examine lower rates to see if that was the critical value or if even less phosphorus could be applied while still maintaining yields.

Plots were established at two cranberry marshes, one on peat soils and the other on sand based soils. Plots were 3 x 5 meters in size. Fertilizer was applied in a split application at three stages of development; roughneck, bloom and fruit set. Phosphorus was applied as either triple super phosphate (TSP) or as a slow release product (Polyon). Phosphorus ranged from 0 to 30 pounds of actual phosphorus per acre per year. Nitrogen and Potassium were supplied at equal rates to all plots. Tissue samples were collected in September each year and analyzed for total minerals, except nitrogen. Just prior to commercial harvest a single square foot sample was harvested from each plot. Fruit were counted and weighed.

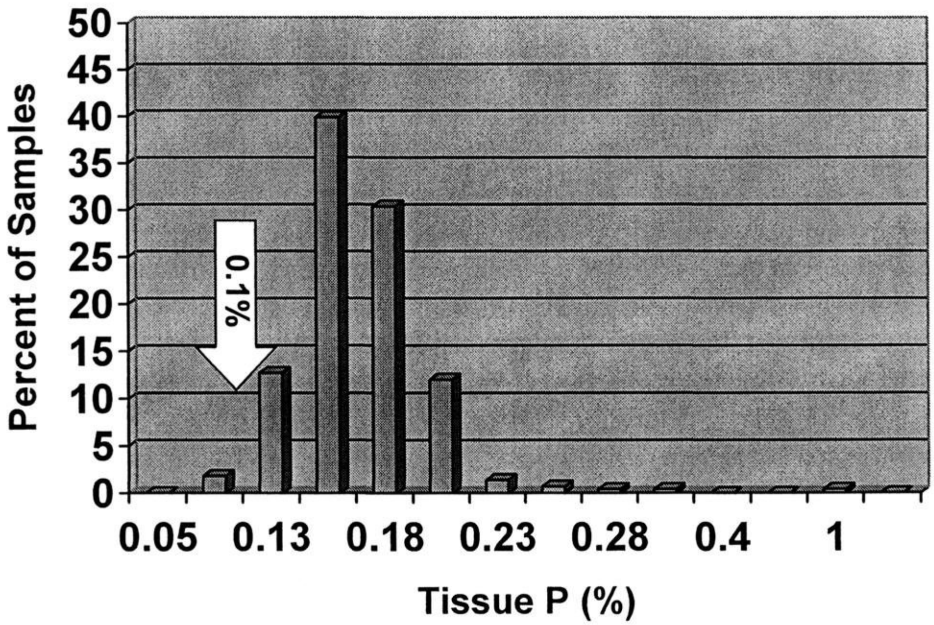
There were no treatment effects of the rate of phosphorus fertilizer applied on total yield or fruit weight in any year at either marsh (Tables 1-3). Yield and fruit count varied significantly by year across most treatments. That is not surprising as high yields one year are frequently associated with lower yields the following year. Weather is also a significant variable. These data underscore the biennial bearing nature of individual cranberry uprights. The sand based bed had higher yields than the peat based bed, but the peat based bed had a severe infestation of dewberries and this would have served to limit yield rather than some intrinsic difference between sand and peat.

There were significant treatment effects for tissue phosphorus concentrations (Table 4). In the sand bed there was a trend towards higher tissue P with higher rates of fertilizer applied. In the peat bed the same trend was evident, but less so than on sand. This supports the notion that peat soils are able to retain and exchange phosphate ions better than sand. However, what is most significant is that after four years of receiving no phosphorus fertilizer the tissue phosphorus concentration in the control plots were still in the adequate range. However, by the fourth year the control plots were barely in the sufficient range. This suggests that growers can apply minimal phosphorus fertilizer and still maintain adequate tissue P.

The previous research showed that yields were not affected at P rates in excess of 20 pounds of actual phosphorus per acre. That was the lowest rate in that study. Our study shows that the actual P requirement to maintain tissue sufficiency of phosphate may be much lower. In this research 5 pounds of actual phosphorus per acre provided the same tissue concentration as 20 or 30 pounds. While the control plots had lower tissue phosphorus concentrations these were not significantly different than treatments receiving phosphate fertilizer.

The results reported here strongly suggest that Wisconsin cranberry growers are applying more phosphorus than is required to maintain tissue phosphorus in the sufficient range. In practice growers can reduce applications of P containing fertilizers while still maintaining adequate tissue P and ensuring that phosphorus is not limiting crop yields. By limiting P application, growers will reduce the prospect of environmental regulations on their ability to use phosphorus containing fertilizers.

Figure 1. Distribution of 281cranberry tissue samples taken between 2002 and 2004 and analyzed by the UWEX Soil and Plant Analysis Lab. The critical value for tissue P is shown.



[18]Table 1. Yield in sand based cranberry beds treated with different rates of phosphorus fertilizer for three years in Wisconsin. n=8.

Treatment	Yield (g/ft^2)			
Rate (lb P/a)	**2001**	**2002**	**2003**	**2004**
Control	116.7	274.5	215.9	128.7
5 TSP	116.7	248.9	230.1	140.0
10 TSP	112.2	273.3	268.6	117.6
15 TSP	118.9	276.5	221.9	126.2
20 TSP	126.9	242.7	269.4	157.4
30 TSP	130.3	261.6	216.6	131.3
10 Polyon	117.6	266.9	238.6	106.0
15 Polyon	122.2	243.8	238.7	145.9
20 Polyon	117.7	226.5	207.2	96.4
30 Polyon	101.8	261.4	227.7	116.0
Significance	ns	ns	ns	ns

Table 2. Fruit number in sand based cranberry beds treated with different rates of phosphorus fertilizer for three years in Wisconsin. n=8.

Treatment	Fruit Number			
Rate (lb P/a)	**2001**	**2002**	**2003**	**2004**
Control	87	188	143	109.3
5 TSP	85	167	146	114.7
10 TSP	82	187	173	100.8
15 TSP	85	182	144	101.0
20 TSP	91	167	181	127.8
30 TSP	94	183	139	112.8
10 Polyon	74	181	158	88.3
15 Polyon	87	169	152	125.0
20 Polyon	86	149	134	83.5
30 Polyon	75	168	146	104.5
Significance	ns	ns	ns	ns

Table 3. Yield and fruit number in peat based cranberry beds treated with different rates of phosphorus fertilizer for three years in Wisconsin. n=8.

Treatment	Yield (g/ft^2)			Fruit Number		
Rate (lb P/a)	2001	2002	2003	2001	2002	2003
Control	46.9	170.4	74.3	43	111	53
5 TSP	52.8	122.2	63.2	48	86	48
10 TSP	54.0	159.2	84.4	49	106	60
15 TSP	57.2	131.9	68.0	54	87	47
20 TSP	60.6	123.0	63.2	56	81	47
30 TSP	68.1	172.3	57.2	62	123	41
10 Polyon	53.2	131.0	51.6	48	89	38
15 Polyon	68.4	162.1	68.6	62	107	48
20 Polyon	52.6	139.5	49.5	50	92	35
30 Polyon	53.7	168.2	46.2	52	111	36
Significance	ns	ns	ns	ns	ns	ns

Table 4. Tissue phosphorus concentration of cranberry vines at two Wisconsin marshes over 3 years. N=4.

Treatment	Sand bed			Peat Bed	
Rate (lb P/a)	2001	2003	2004	2001	2003
Control	0.127 f	0.126 f	0.105 d	0.150 cde	0.140 e
5 TSP	0.143 cdef	0.131 ef	0.127 bc	0.159 abcde	0.146 de
10 TSP	0.144 cdef	0.138 def	0.126 bc	0.164 abcd	0.153 cde
15 TSP	0.145 bcdef	0.157 bcd	0.130 bc	0.155 bcde	0.159 abcde
20 TSP	0.147 bcdef	0.142 cdef	0.131 bc	0.167 abc	0.158 abcde
30 TSP	0.170 ab	0.143 cdef	0.142 b	0.158 abcde	0.156 abcde
10 Polyon	0.153 bcde	0.135 def	0.126 bc	0.162 abcd	0.155 bcde
15 Polyon	0.139 def	0.128 f	0.121 cd	0.163 abcd	0.159 abcde
20 Polyon	0.166 abc	0.147 bcdef	0.131 bc	0.156 abcde	0.163 abcd
30 Polyon	0.191 a	0.158 bcd	0.175 a	0.176 a	0.175 ab

References.

DeMoranville, C.J. and J.R. Davenport. 1997. Phosphorus forms, rates, and timing in Massachusetts cranberry production. Acta Hort. 446:381-388.

Tissue Test Summary

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Tissue testing is a powerful tool for ascertaining the need to change a fertilizer program. Tissue testing provides a snapshot of a period in time of all of the environmental, cultural, and genetic factors that affect the nutrient content of plant tissues. Cranberry growers are encouraged to take annual tissue samples in late August through early September. The results will guide your fertilizer program for the coming year.

Each year a number of cranberry tissue samples are sent to the University of Wisconsin-Extension Soil and Plant Analysis Laboratory in Madison. This winter I was able to obtain a download of their data for the past three years. The data were provided in a spreadsheet where each row denoted a separate sample. No marsh or bed identification was provided. The samples comprised 281 samples taken over the past three years. This is a large enough sample size that I believe conclusions can be made about the industry based on these samples.

In order to summarize the data in a meaningful way I arranged the data into histograms. This is a means of showing the distribution of results in a graphical way. In each case the left hand axis shows the percentage of samples with a given range of concentrations. The bottom axis shows the concentration of the element of interest in the tissue. The critical value is indicated with an arrow. Samples falling below the critical value will benefit from an addition of that element. Samples at or above the critical value will not benefit from additional applications of that element. However, enough fertilizer must be applied to maintain tissues at concentrations above the critical value.

Nitrogen. Only a handful of samples tested below the critical value of 0.9% and a few samples showed tissue N in excess of 1.1% (Fig. 1). Vines testing in that area would likely show excessive vegetative growth.

Phosphorus. Only five samples tested below the critical value (0.1%) for phosphorus and very few were above the normal concentration (0.2%). This suggests that most Wisconsin growers are doing an excellent job of providing phosphorus to meet plant needs (Fig. 2).

Potassium. Every sample submitted had sufficient tissue potassium (Fig. 3). However, quite a few samples exceeded 0.75% suggesting some growers are applying more than is necessary for optimum plant growth.

Calcium. All samples exceeded the critical value of 0.3% and many samples were in excess of the normal concentration 0.8% (Fig. 4). Calcium is present in many fertilizer materials and the water applied to many properties. It would be unusual to make specific applications of calcium to a bed.

Magnesium. All samples exceeded the critical value of 0.15% and many samples were in excess of the normal concentration (0.25%). Clearly most vines won't benefit from additional magnesium fertilizer (Fig. 4).

Sulfur. All samples exceeded the critical value of 0.08% (Fig. 6). It is surprising that excess sulfur was not found in these tissue samples since sulfur is present in fertilizers such as ammonium sulfate and potassium sulfate. Sulfur is also used to reduce soil pH thus ample sulfur is applied to beds.

Boron. Boron is a micronutrient and thus is required in very small amounts. All of the samples in this survey were in excess of the critical value (15 ppm) and many samples were in excess of the normal range of 60 ppm (Fig. 7). There is no published scientific evidence that loading vines with Boron will increase fruit yield of cranberries.
Zinc. This is the one element that the survey showed was low in vines (Fig. 8). In every case the tissue tests were below the critical value of 15 ppm. Zinc is easiest applied as zinc sulfate and can be blended into other fertilizers. The critical value for zinc is 15 ppm.
Copper. Most samples tested in the normal range (4-10 ppm) for copper (Fig. 9). This is an element that growers will want to pay attention to and not let become deficient.

Most of the tissue samples also had accompanying soil samples. This allowed us to examine correlation between tissue concentration and soil test levels. These soil test values are based on chemical soil testing where the soil is extracted with a dilute strong acid. The extractant is then analyzed for P and K. Chemical soil testing is designed to estimate the amount of P and K that would be available to plants through the course of one season. Figure 10 shows the relationship between soil test P and tissue P. It is clear that there is no relationship. Soil test values are not useful in predicting what tissue P concentrations will be. The R^2 value shows that less than 1% of the variation in tissue P is accounted for by soil test P. The same situation is true for potassium (Fig. 11). There is no relationship between soil test K and tissue K concentration. The R^2 value indicates that less than ½% of the variation in tissue K is a result of variation in soil test K.

The take-home message from this project is that most cranberry growers are doing an acceptable job of managing vine nutrition and soil fertility. The goal of any fertilizer program should be to ensure that the vines are in the sufficient range for the required mineral elements. Except for maintenance doses, adding fertilizer when tissue levels are in the sufficient range is wasteful and expensive.

Figure 1. Distribution of Nitrogen in 180 cranberry tissue samples. The critical value is 0.9% as indicated by the arrow.

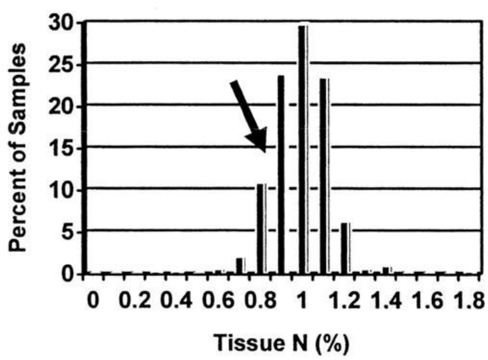


Figure 2. Distribution of phosphorus in 180 cranberry tissue samples. The critical value is 0.1% as indicated by the arrow.

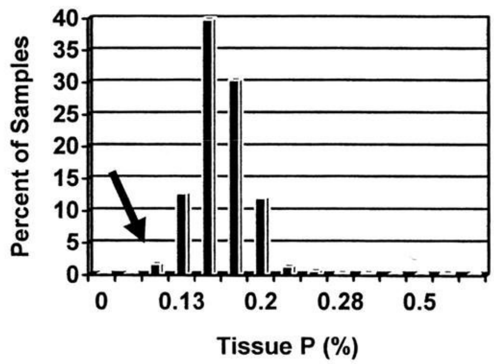


Figure 3. Distribution of Potassium in 180 cranberry tissue samples. The critical value is 0.4% as indicated by the arrow.

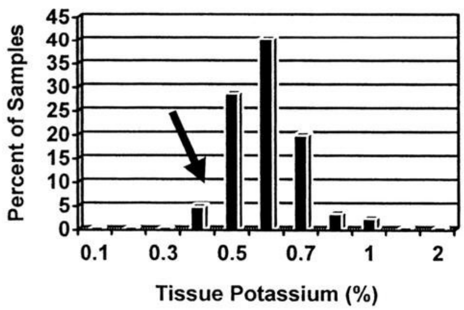


Figure 4. Distribution of Calcium in 180 cranberry tissue samples. The critical value is 0.3% as indicated by the arrow.

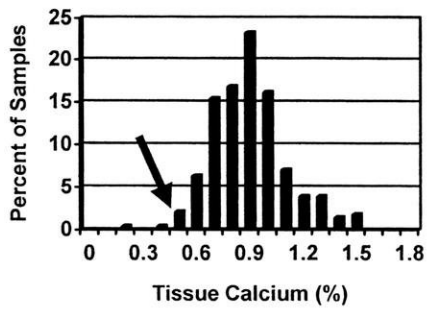


Figure 5. Distribution of Magnesium in 180 cranberry tissue samples. The critical value is 0.15% as indicated by the arrow.

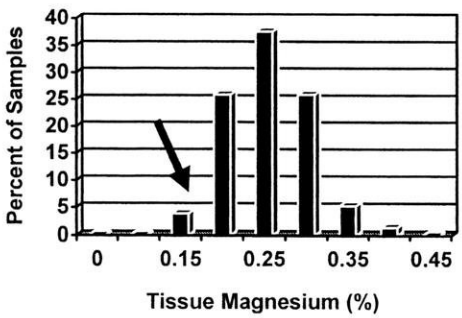


Figure 6. Distribution of Sulfur in 180 cranberry tissue samples. The critical value is 0.08% as indicated by the arrow.

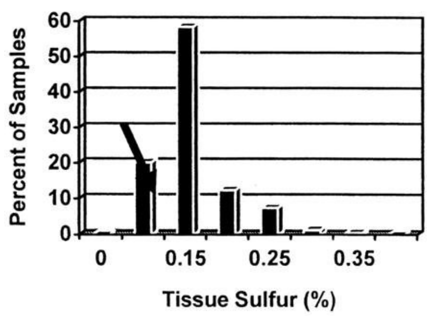


Figure 7. Distribution of Boron in 180 cranberry tissue samples. The critical value is 15 ppm as indicated by the arrow.

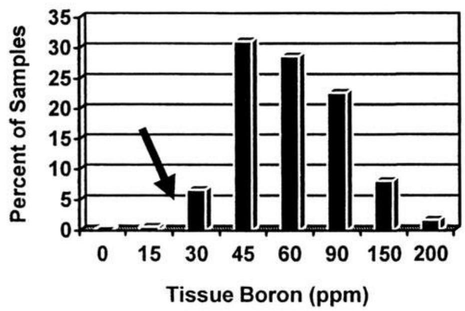


Figure 8. Distribution of Zinc in 180 cranberry tissue samples. The critical value is 15 ppm as indicated by the arrow.

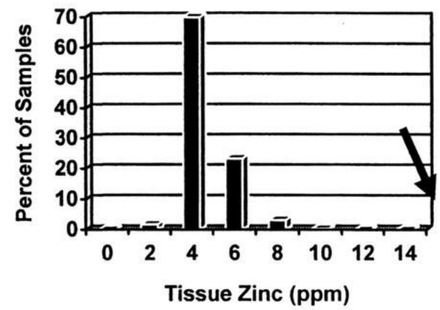


Figure 9. Distribution of Copper in 180 cranberry tissue samples. The critical value is 4 ppm as indicated by the arrow.

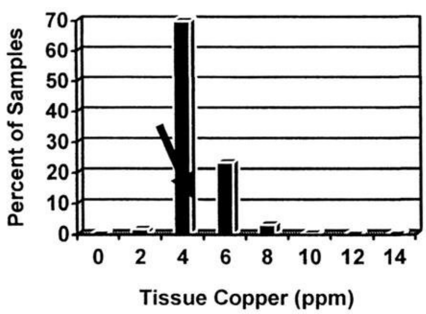


Figure 10. The relationship between Bray soil test data and tissue test data for Phosphorus from 256 Wisconsin cranberry samples. R^2 value = 0.025

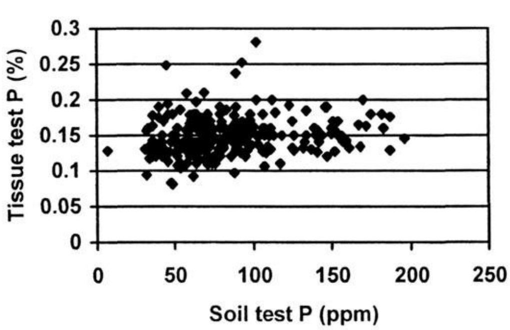
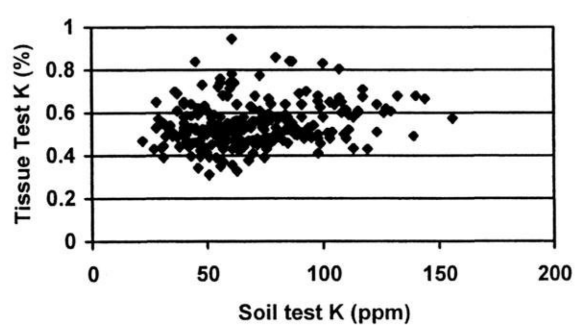


Figure 11. The relationship between Bray soil test data and tissue test data for Potassium from 256 Wisconsin cranberry samples. R^2 value = 0.047



Irrigation Uniformity

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Cranberry production requires a large supply of appropriate quality water. Water is a finite resource and cranberry growers, like all water users, must be wise stewards and not use more than is necessary. Further, increasing energy costs make pumping more water than is necessary a very expensive proposition. Water use can be minimized by having uniform application across each bed. That way some areas are not overwatered in order to provide sufficient water to other parts of the bed.

Sprinkler uniformity is defined as the evenness or similarity in amount of water delivered over or within an area. Ideally, all areas of a bed would receive the same amount of water during the duration of an irrigation event. Sprinkler uniformity is affected by the system design including head and line spacing, the types of sprinkler heads used, and the type of nozzles. Sprinkler uniformity can also change with time as nozzles, heads, and pumps wear, as pipes and joints develop leaks, and if the system is used outside of the design specifications.

Determining sprinkler uniformity and efficiency requires several related measurements. Detailed procedures of how this is to be done are being developed by the Natural Resources Conservation Service in consultation with UW-Extension and WSCGA. These protocols will soon be available through the growers association. This article will serve only to summarize and to present data from a small test that was performed in 2003.

Nozzle wear is a significant source of sprinkler non-uniformity. Nozzles wear as water with grit is pumped through them. Also wires used to unplug nozzles can abrade the opening and thus allow more water to exit that the original design specifies. To check the nozzle opening for wear use the shank of a drill bit of the same size as the nozzle opening. Movement of the drill bit shank should be less than 5-10°. If the bit can move more than this then the nozzle should be replaced. A good management practice would be to replace all nozzles every 2-3 years.

Risers can also contribute to non-uniformity. Risers must be perfectly plumb so that water is sprayed at the same elevation across the bed. Each year as lines are put back into the bed each riser should be checked to ensure that it is plumb and then carefully staked. This is easy to check with a short magnetic bubble level. Riser height can also affect uniformity. Taller risers up to two feet will provide greater uniformity than shorter risers.

The pressure at individual nozzles will change along the length of a line. To check the pressure use a water filled pressure gauge and a pitot tube. With the pump running at operating speed measure the pressure at each nozzle and record the results.

Related to the pressure at the nozzle is the flow at the nozzle. This is easily measured with a hose and a small bucket of known volume. Put the hose over the nozzle and run the hose into the bucket. Measure the amount of time to fill the bucket and record the results.

The critical test used to measure sprinkler uniformity is the catch can test. To do this test containers are placed in a grid with a spacing of 10 x 10 feet. The buckets should have sharp edges and be of uniform size. Coffee cans, ice cream buckets, or 32 oz deli containers work well. The containers should be level in the field. Use stakes to hold them level. Once the buckets are set the sprinklers are turned on and allowed to apply ½ inch of water. The amount of water in each bucket is determined. Uniformity can be calculated from the results.

In 2003 we did a catch can test on a Wisconsin cranberry bed. We worked in an older bed with a two line irrigation system. The lines were about 35 feet from the bed edges and were about 70 feet apart. Heads were 45 feet apart along a line and head placement alternated between lines. The system operated at about 65 psi at a pump engine speed of about 1650 rpm. The nozzle orifice was marked at 11/64 inches. Riser height was 12 inches.

To determine sprinkler uniformity we set up a 15 x 15 foot grid in the bed and placed an empty ice cream bucket at each flagged location. We ran the sprinkler system for 30 to 45 minutes and then measured the amount of water in each bucket. A perfectly uniform system would have identical volumes of water in each bucket. The uniformity coefficient was calculated as:

$$UC = 100\,(1.0 - (\Sigma x) \div (m\,n)$$

Where:

UC = Uniformity coefficient
n = number of cans measured
m = mean value of all observations
x = the deviation of each observation from the mean
Σ x = the sum of the deviations from the mean

Without making any changes to the system we ran the pump for 30 minutes then measured the amount of water in each bucket. The results of this test are shown in Figure 1. The location of the sprinklers is clearly evident in the figure. We had a slight breeze blowing across the beds and that shows in the lack of water in the buckets at position 10. The uniformity coefficient for system was 51%.

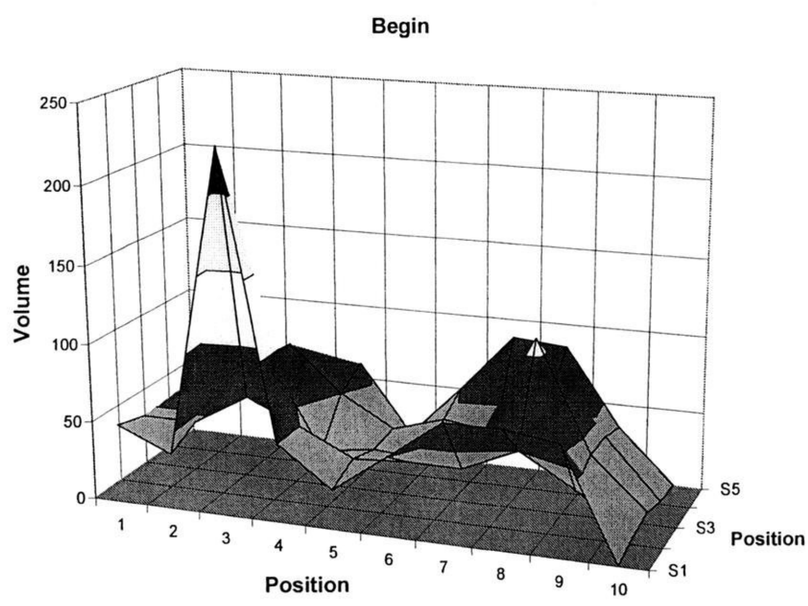

Figure 1. Volume of water per bucket in a 15 x 15 foot grid pattern before any changes were made to the system.

Nozzle replacement. Our first upgrade to the system was to replace the worn nozzles with new ones of the same size. The old nozzles had worn a little bit and they had been cleaned of debris by inserting a wire through the nozzle and this had scratched the openings. We then ran the sprinkler system for 45 minutes and measured the amount of water in the buckets again. The results of this test are shown in Figure 2. We ran the system 15 minutes longer this time and that increased all values somewhat. However, notice that the surface is much flatter. The uniformity coefficient for the system with new nozzles was 66%; a substantial improvement.

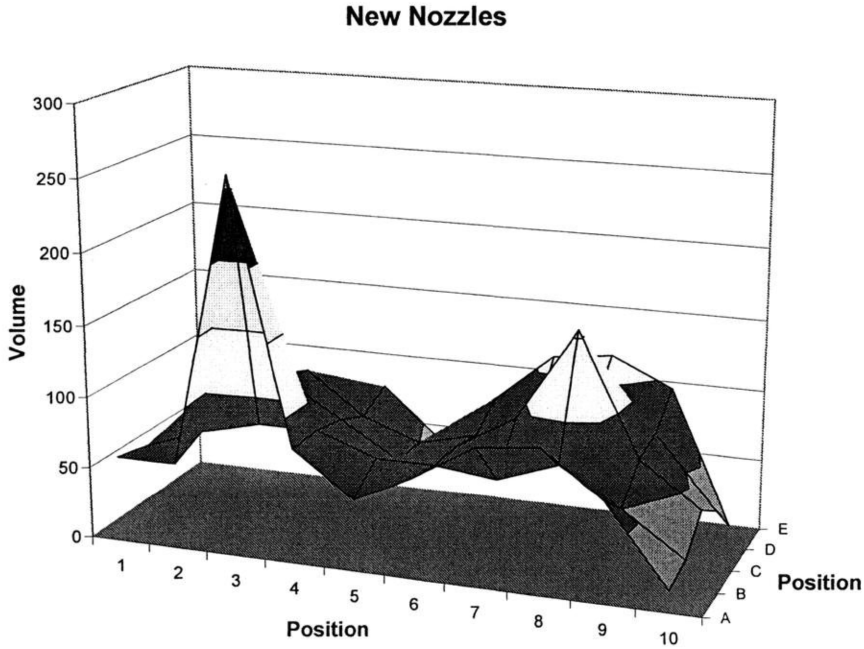

Figure 2. Volume of water per bucket in a 15 x 15 foot grid pattern after nozzles were replaced with new ones of the same size.

Riser Height. Our next upgrade was to increase riser height from 12 to 18 inches. We also staked the risers and made sure they were plumb using a spirit level. The existing risers were not completely plumb so water distribution was not completely even around their coverage area. We ran the sprinklers for another 45 minutes and measured the water caught again. The results are shown in Figure 3. Using taller risers evened out water distribution a little more, but the uniformity coefficient increased only a couple of points to 68%.

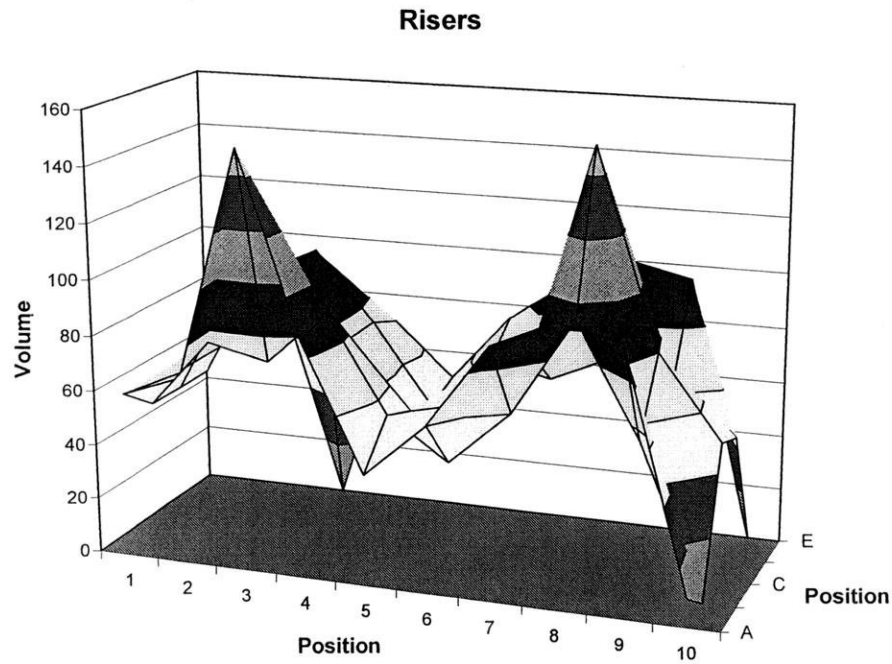

Figure 3. Volume of water per bucket in a 15 x 15 foot grid pattern after nozzles were replaced with new ones of the same size and rise height was increased from 12 to 18 inches.

Three line system. We were then able to obtain funding to replace the irrigation system in this bed with a three-line system using high uniformity sprinklers. We ran our test again with the buckets in the same positions as before. The uniformity coefficient for this configuration was exactly 80%. The results are shown in Figure 4. Clearly the uniformity is higher. The uniformity would have been higher had we run the system longer. Further, some of the buckets were tipped and if they had been perfectly upright our results would have been more accurate.

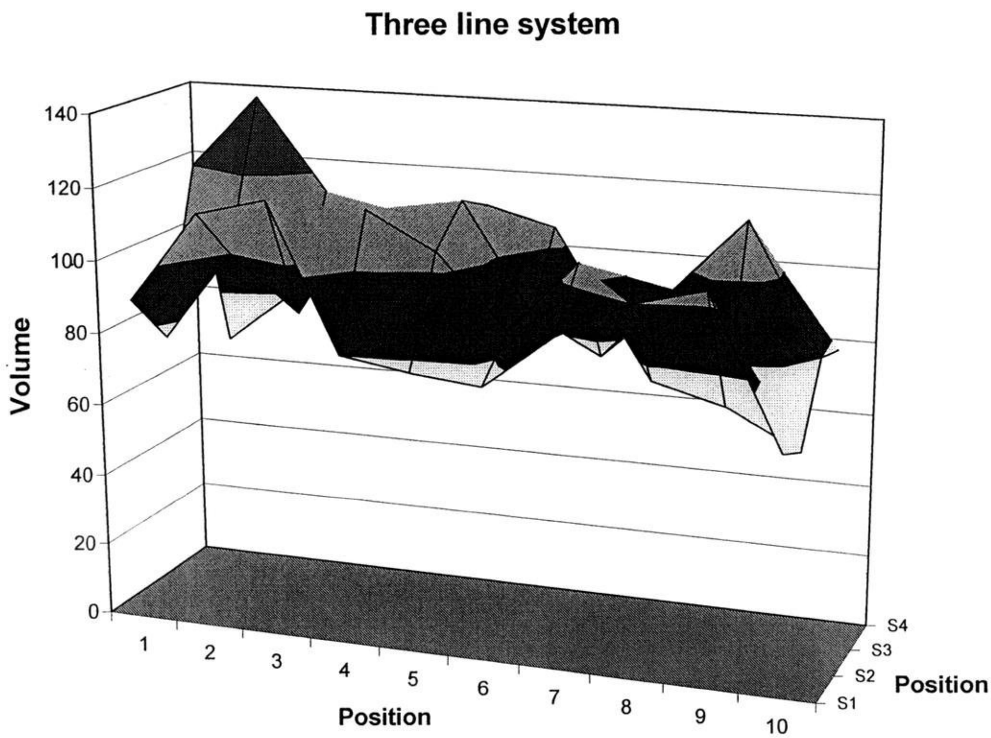

Figure 4. Volume of water per bucket in a 15 x 15 foot grid pattern after the system was upgraded to a 3 line system with high uniformity nozzles.

Conclusions

1. The greatest improvement in sprinkler uniformity at the lowest cost was nozzle replacement.
2. The older two line system had to be upgraded to three lines with closer head spacing to achieve a uniformity of 80%.
3. Increasing riser length gave marginal improvement
4. Substantial water saving can be realized simply by replacing worn nozzles.

We thank Mike Moss and his staff at Elm Lake Cranberry Co. for their assistance in this project. NRCS and WSCGA graciously provided funding to purchase the upgraded equipment.