Integrated
Cranberry Crop
Management
for Wisconsin

Cranberry

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Contents:

WHAT REALLY LIMITS YIELD?

In order to improve yield of cranberry beds it is important to understand what is currently limiting yields. This summer in a series of articles I will attempt to describe for you research from the scientific literature for cranberries that relates to this topic. There is a substantial body of material regarding yield in cranberries that has been published over a number of years. I will attempt to bring all of this together so that by September you will hopefully understand what is truly limiting to cranberry yields and possible approaches to increase yields and profits.

The first thing to do in situations like this is to define terms. What is yield? This question would be answered slightly differently by people from different backgrounds. An ecophysiologist would define yield as total biomass produced per unit ground area per year. A horticulturist might define yield as total fruit production per year. A grower might define yield as total fruit harvested from a bed, or fruit delivered to a handler. A handler might define yield as fruit processed and sold. For our purposes we'll define yield as either total biomass or as total fruit produced in one year.

Yield capacity can be thought of being similar to an old-fashioned barrel with wooden staves (Fig. 1). The volume of water that the barrel can hold is determined by the length of the shortest stave. If we make one of the long staves longer we do nothing to increase the capacity. Only when we identify and "lengthen" the short stave can we increase yield.

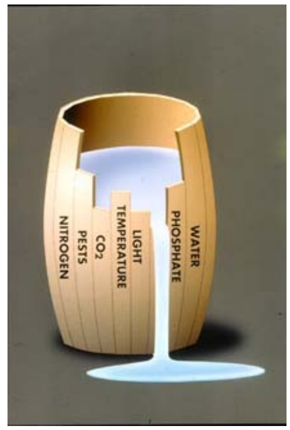


Fig 1. A rain barrel as a representation of yield potential.

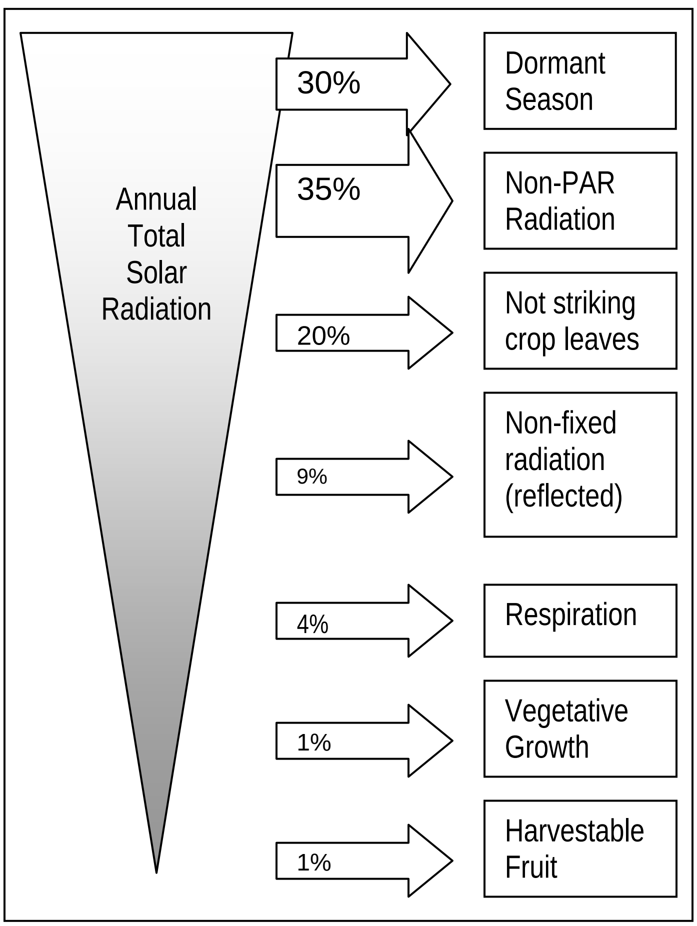
Ecologists track energy flow and nutrient flow through ecosystems. Farms are ecosystems. Energy arrives in the form of sunlight and stays as plant tissue or organic material. Energy and mineral nutrients are removed as the crop is harvested and as leaf litter, etc. Following the flow of energy through the system is very important when we want to determine what is limiting yields.

When asked what they farm, many growers would answer that they farm the soil. While there is a certain amount of truth there, I would answer that farmers don't farm the soil, they farm sunlight.

Regardless of what we may do, crops grow primarily in response to sunlight, temperature, water availability, carbon dioxide availability, mineral nutrients and genetics. We'll discuss these in that order.

Without light plants won't grow. Light can be described in both qualitative and quantitative terms. Light quality would include wavelength or color. Plants are only able to use light with wavelengths between 400 and 700 nm. This is roughly coincident to the visible spectrum of light that you and I can see. Plants can't use light energy in the infrared or ultraviolet range. Light also has a quantitative value. Its energy content can be measured in moles of light received.

Figure 2. Estimate of the fate of energy that strikes the earth.



If we consider the total amount of light that is received by a given piece of ground during the course of a year only a small fraction of that light actually results in harvestable yield (Fig. 2). As you can see, much of the light arrives when the vines are dormant. Much is not of the correct wavelength for plants to utilize. Some light is reflected or given off as heat. Some of the products of photosynthesis are broken down in respiration, or are partitioned to vegetative growth or roots. Only about 1% of light that strikes a crop is utilized to produce harvestable yield.

Green plants receive light energy and through the process of photosynthesis convert that light energy into chemical energy that is stored as carbohydrates or sugars. These sugars can be linked together in complex ways to make cellulose, the structural component of plants; lipids, the primary constituent of cell membranes; or proteins, some of which are enzymes that facilitate biochemical reactions within cells. Sugars formed through photosynthesis also give fruit their inherent sweetness.

A primary limitation of photosynthesis is light. As light intensity or quantity increases the rate of photosynthesis also increases (Fig. 3). However, there

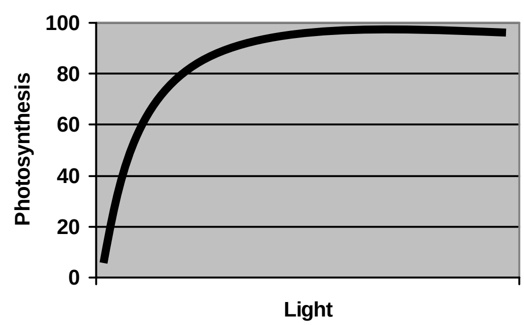


Figure 3. Light response curve for cranberry photosynthesis.

comes a point where photosynthesis no longer increases as light intensity increases. This is called the light saturation point. In cranberries this point is about 700 $\mu mol/m^2/s$. In contrast, full sunlight in Wisconsin is about 2000 $\mu mol/m^2/s$.

Incident light intensity usually does not limit photosynthesis except on very cloudy days and at night.

The limitations to crop yield by light are usually a result of either not having enough leaf canopy to capture all of the light striking cropland or with internal shading within a canopy so that some of the leaves are shaded and unproductive. In the 1940's Roberts and Struckmeyer in Wisconsin examined the effect of upright density on yield of Searles cranberries. They found that as the number of uprights per square foot increased that the number of fruit also increased until they got to a certain point and then berry number declined (Fig 4). For Searles they found the optimum upright

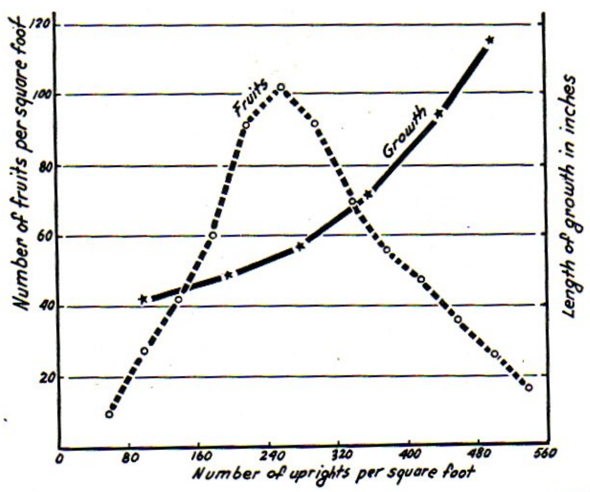


Figure 4. The relationship between upright density, crop yield and upright length in cranberries. From Roberts and Struckmeyer, 1941.

density was about 250 to 300 per square foot. The optimal number for hybrids such as Stevens is probably higher. The reason for the decline as upright density got too high was that uprights were shading one another, causing the uprights to elongate and more of the products of photosynthesis were spent making vines so less was available for making fruit. The importance of light for productivity is also demonstrated in weedy beds. Weeds block sunlight from striking cranberry leaves and by so doing reduce the amount of light available for photosynthesis in the vines. This is the primary form of competition for many of the most pernicious cranberry weed species.

Plants respond to temperature. When it is very cold out during the winter plants go dormant to protect themselves against the inhospitable conditions. Of course frost is a serious risk to most fruit crops and especially to cranberries since they are grown in low wet areas. Photosynthesis is also sensitive to temperatures. The optimal temperature for most crop plants is about 70-75°F. When temperatures are either above or below these the rate of photosynthesis declines. Cranberries are not particularly sensitive to temperatures between about 70 and 90°F (Vanden Heuvel and Davenport 2005). Grower experience also supports reduced yields during years with exceptionally cold or hot weather.

For many crops yield can be seriously limited by water availability. Because cranberries are grown in naturally wet areas and are irrigated water availability is rarely a limitation for yield in cranberries. Water quality may be an issue as water that contains high levels of nitrate may lead to vine overgrowth. Too much water can also be a problem leading to root roots and lack of oxygen in soils.

In the process of photosynthesis light energy is captured and then used to attach one molecule of CO_2 from the air onto a 5 carbon sugar which is immediately split to produce two 3 carbon sugars. When carbon dioxide is in short supply the photosynthetic rate is reduced. A carbon dioxide response curve looks very similar to the light response curve. At low concentrations of carbon dioxide photosynthesis is limited by CO_2. As the CO_2 concentration increases photosynthesis is limited by having enough

5 carbon sugars to act as acceptors of CO_2. As the concentration of CO_2 in the environment has increased rates of photosynthesis of many crop plants have increased.

In order to grow and reproduce plants need water, oxygen, carbon dioxide, and 13 mineral elements in sufficient supply. The plant nutrient guidelines that have been published for some years quantify the amount of these required mineral elements that should be found in plants so that they won't be a limitation to yield. Once these requirements are met adding additional nutrients won't increase yield. Data from the UW Soil and Plant Analysis Lab suggests that Wisconsin Cranberry Growers are doing a great job at providing sufficient nutrients so that these nutrients won't be limiting to growth. Virtually all samples were in the sufficient range for the important major (N, P, K) and minor nutrients (Ca, Mg, S) (Roper 2005, Roper and Combs 1992).

Genetics play a very important role in determining yield of crop plants. Crop yields in field crops have been greatly enhanced by exploiting changes in crop architecture or how much of the products of photosynthesis are partitioned to harvestable yield. Virtually all cranberry cultivars presently being grown are either selections from the wild or one generation from the wild. I believe that there are marvelous increases in yield that are available and that will be discovered as we improve the genetic resources of this crop.

Summary

In this article we learned:

- That yield can't be increased by improving non-limiting factors.
- Light is the energy source for plant life and that only a small fraction of incident sunlight is used by plants to make fruit.
- Temperature can limit plant productivity.
- CO_2 concentration can limit plant productivity, although rarely in nature.
- Plants need 13 mineral elements in addition to water, sunlight and CO_2 to grow and reproduce.

In the next issue we'll explore yield component analysis and what that can tell us about limitations to yield in cranberries.

Teryl Roper
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"MANAGEMENT OF WISCONSIN SOILS" REVISED

The venerable guide to managing Wisconsin's agricultural soils, *Management of Wisconsin Soils* is now in its fifth edition. The latest edition is updated to reflect modern research and understanding of soil management. While the publication is largely aimed at row crops, the information about nutrient uptake and retention of nutrients in soils is applicable to all cropping systems.

The publication can be downloaded or read on-line at: http://cecommerce.uwex.edu Spiral bound softcover printed versions of the bulletin are also available for purchase either on the same website or through your local county office. The price is $15.00 plus shipping. You can order toll-free at 800 WIS-PUBS.

SELECT MAX REPLACES SELECT HERBICIDE

Valent has altered the formulation of Select herbicide and renamed the product Select Max. The application rate has changed from 6 to 8 fluid oz per acre to 12 to 16 fluid oz per acre. The pre-harvest interval remains 30 days and the re-entry interval has increased from 12 to 24 hours. The most significant change is that non-ionic surfactant should be substituted for the previously required crop oil concentrate. This provides greater crop safety, especially during warm weather. Valent also reports quicker action with faster uptake of the new product.

Before using Select Max read and study the new label and follow the instructions completely. The new label along with a supplementary fact sheet is in the label database section of the UW Hort Department cranberry website. www.hort.wisc.edu/cran

It is only the ignorant who despise education.

Publius Syrus

COTTONBALL CONTROL IN 2006—ORBIT AND ABOUND

A Section 18 emergency registration for use of Orbit (propiconazole) on cranberry in Wisconsin has been approved by EPA, and a copy of the label is included in this newsletter. You must have a copy of this label to legally use Orbit. A maximum of two applications of Orbit are permitted between March 9 and June 15, 2006. The rate is 4 to 6 fl oz per acre in 20 to 50 gallons for ground application, or in 5 gallons for aerial application. The pre-harvest interval is 45 days, and chemigation is not permitted. In recent years EPA has not permitted sprays of Orbit during bloom, because an alternative fungicide, Abound, is available for use during bloom. Therefore, the purpose of the Orbit Section 18 is to have a product available for the budbreak and early shoot elongation period (see discussion below). I understand that if we have a late spring, shoots are still in the early elongation stages in northern Wisconsin in mid-June. Nevertheless, we have to abide by the June 15 expiration date. EPA has not budged on changing this. There is an excellent chance that either Orbit or a fungicide related to Orbit (or maybe both) will have a regular label in 2007.

Cottonball has two phases: primary infection (=shoot blight, =tip blight) occurs when shoots show about ¼ to 1 inch of new growth; secondary infection (fruit rot, hard rot) occurs during bloom. In theory, if we controlled primary infection, we wouldn't have any secondary infection. In reality, however, a little bit of shoot blight happens even when you spray elongating shoots. However, research has shown that spraying only during bloom is as effective as spraying elongating shoots and again during bloom. Therefore, I recommend spraying only during bloom (Abound), unless cottonball in the previous year was really bad (more than 20% of fruit). In research trials, Abound has been as good as Orbit in controlling secondary infection (although I do realize Abound costs twice as much as Orbit). Since most of you who spray for cottonball do so only during bloom, you will not need to use Orbit.

If you did have a significant cottonball problem in 2005, then budbreak and early shoot elongation sprays probably are warranted. The first application should be made when over half the shoots show more than ¼ inch of new growth, and the second application 7 to 10 days later. Although it's convenient to spray the whole marsh on one day, it's better for disease control to treat different varieties according to their development. The first bloom spray of Abound should go on at about 10 to 20% bloom, with a second application about 7 days later. Remember—the early flowers are more likely to set fruit and therefore are more likely to get the fruit rot phase of cottonball (you can't get cottonball unless a fruit develops!). The fungus follows the same route that pollen takes in getting to the ovary which matures into the berry. ***Therefore, to control cottonball, bloom sprays are critical, and spraying after bloom is a waste of time and money!*** In research trials we have never seen negative effects of Abound on yield, and I have never heard complaints from growers who use it during bloom. Abound is somewhat effective on other fruit rot pathogens, but not as effective as Bravo or mancozeb products.

Patty McManus, UW-Madison Plant Pathologist

Let us be patient, tender, wise, forgiving,
In this strange task of living
Martin Armstrong

CRANBERRY DIGITAL LIBRARY

With funding provided by the University of Wisconsin-Extension we produced a computer CD with a substantial amount of information regarding cranberry production in digital form. In January we mailed a copy of this CD to all known Wisconsin cranberry producers. If you did not receive a copy or if you need an additional copy please contact me and I'll mail you one.

Unfortunately the CD is not searchable by keyword. However, software is available that will index your hard drive or CD's and will allow you to search by keyword. A good example of this software is Google Desktop.

We must also give credit where credit is due. The pesticide database that includes labels and MSDS for materials registered for use on cranberries is the work of Peter Oudemans and personnel in his lab at Rutgers University. He kindly allowed use of this material and we did not properly cite his contributions. We regret this error.

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