IRRIGATION WATER MANAGEMENT 2021 - 2023

Prepared by Peter Jeranyama

Water management is arguably one of the most critical issues affecting the cranberry industry for four major reasons: (a) crop production, (b) environmental concerns, (c) costs and (d) regulatory scrutiny. The objective of this section is to introduce the concept of crop water stress index (CWSI), and discuss soil moisture monitoring devices such as tensiometers, moisture sensors and water level floats.

An evaporative demand study conducted by Bruce Lampinen showed that for many weeks during the growing season, most cranberry beds were too wet. Wet conditions as a result of inadequate drainage or excessive irrigation in cranberry production potentially result in increased root rot (mostly *Phytophthora cinnamomi*) and fruit rot diseases, poor nutrient uptake, inhibition of root development, reduced fruit retention and reduced productivity. Fruit rot in cranberry is an infection by any of a large number of different fungal pathogens, among them *Allantophomopsis lycopodina* and *A. cystisporea* that causes black rot. These organisms are more prevalent under wet conditions, and a wet canopy may create a microenvironment for fruit rot pathogens to thrive.

Traditionally, cranberry beds received one inch of water per week from either rain, capillary action from the groundwater, irrigation or some combination of these. But conditions can vary from bog to bog so the **one inch (1") rule** does not always result in ideal soil moisture conditions.

Plants maintain hydration and internal temperature through a process called transpiration in which water is moved from the soil, through the roots to shoots, and out through pores (stomata) in the leaves. As this process occurs, moisture is depleted from the soil. The plant can control the rate of transpiration by controlling the opening of the leaf stomata to let the water out. In other crops, crop water stress index (CWSI) is used to measure plant transpiration from canopy temperature and air dryness. However, there is evidence that cranberry has poor control over its stomata and therefore, its transpiration process. Since cranberry has poor control over its transpiration process, leaf measurements alone may not sufficiently define CWSI for cranberry and we have no such index specific to cranberry yet.

Ideally, irrigation scheduling should take into account plant phenology in conjunction with the status of the soil water matrix to quantify water stress with different soil conditions. Summer irrigation also coincides with the application of nitrogen fertilizers, which are highly susceptible to runoff during irrigation events. Surface runoff of nitrogen reduces soil nitrogen available to the cranberry plant.

Measurement of soil water status is based on two technologies: (i) measuring the amount of water in the soil (e.g. 'feel test', water float, or volumetric water sensor) and (ii) measuring the energy status (water potential) of the water (e.g., tensiometer). In general the following bog conditions exist in MA: (i) new renovations and constructions (0-10 years old) with a constructed sub-grade, (ii) renovated beds that have a peat/hardpan natural underlayment, and (iii) older beds that have developed layered soil in the root zone (alternating sand and organic layers with root mass). The layering structure of these older bogs will present challenges to getting uniform contact with monitoring devices.

Soil probing can be used as a check on other monitoring methods and is especially useful in monitoring the depth of penetration of irrigation applications and rainfalls. Sometimes other problems, like compacted soil layers, can be detected from the probing.

Appearance and Feel Method.
Although measuring soil water by appearance and feel is not precise, with experience and judgment, farmers have been able to estimate soil moisture level with a reasonable degree of accuracy. **However, this can be very challenging in sandy soils and is not a recommended method for cranberry.**

Note: A general problem with estimation of soil moisture arises because of the heterogeneity within soils, with single point measurements rarely being representative. Ideally, several devices should be distributed across the management area covered by an irrigation system.

Water Level Floats. In cranberry, water level floats have been used to determine when to irrigate. Note that this technology depends on the presence of a water table in the bed. Water level floats have the advantage that you can see the level of the water table without walking onto the bog. They measure the level of the water table and do not include any plant processes or plant evaporative demand. Instructions for constructing a water level float are available from UMass Cranberry Station website at: http://ag.umass.edu/cranberry/fact-sheets.

Water demand by vines can be assessed by comparing the water level in the center of the bed to the water level in ditches to see if water is moving fast enough across the bed. By observing the water level float through several irrigation cycles, you can determine the number of hours required for an adequate irrigation.

Tensiometers. A tensiometer is a sealed, water-filled tube with a vacuum gauge on the upper end and a porous ceramic tip on the lower end. A tensiometer measures the soil water potential. As the soil around the tensiometer dries out, water is drawn from the tube through the ceramic tip. This creates a vacuum in the tube that can be read on the vacuum gauge. When the soil water is increased, through rainfall or irrigation, water enters the tube through the porous tip, lowering the gauge reading.

Tensiometers provide a valuable measure of the energy status of water in the soil, thus providing a rigorous indication of the water availability to plants, with values that allow comparisons between a set of growing conditions.

A tensiometer reading in the **2 to 5 cbar** range should be expected as long as the water table is between 8 and 18 inches. This range is adequate for cranberries (see Table 1).

NOTE: Tension readings are technically negative, but for simplicity of concept, we have chosen to report them in this book as positive numbers.

Volumetric Water Content. Volumetric water content measurements are simple, reliable and inexpensive and indicate how much water is present in the soil. They can be used to estimate the amount of stored water in a profile or how much irrigation is required to reach a desired amount of water. Installing these sensors into the soil allows you to collect long-term measurements.

The spaces between soil particles are referred to as pores. Based on our current research, cranberry bed soil appears to be saturated (all soil pores are filled with water), when volumetric water content is 30 to 40%. This volumetric water content corresponds to a tension reading of 1 and 2 cbar (or kPa) on a tensiometer. Irrigation should be stopped before saturation to promote water and solute uptake by the plant.

Field capacity is reached when the soil has drained all its free water and at this stage the soil is ready for irrigation. In our research, field capacity was reached between 5% and 15%, which corresponds to a tension reading of 4.5 and 6.5 cbar (or kPa) on a tensiometer (Jeranyama et al. 2017).

Using a tensiometer, irrigation should be initiated when a tension of 4.5 kPa (field capacity) has been reached and stopped when a tension of 2 kPa (before saturation) has been achieved. Using a volumetric water sensor, irrigation should be started when a water content of 10% is recorded and stopped before 30% moisture content.

Table 1. Critical levels of tension, volumetric water content and water table level for irrigation scheduling on cranberry beds. Use these as a guide for when to irrigate.

	Tensiometer measurements		**Volumetric Water Content**	**Water level float**
	------------cbars-----------		Water content (%)	Water table (inches below surface)
	Morning tension	Midday tension		
Too wet	0 to 2	0 to 2	>30	0 to 6
Adequate	>2 to 5	>2 to 10	15 to 29	>6 to 18
Too dry	>5 to 80	>10 to 80	<12	>18

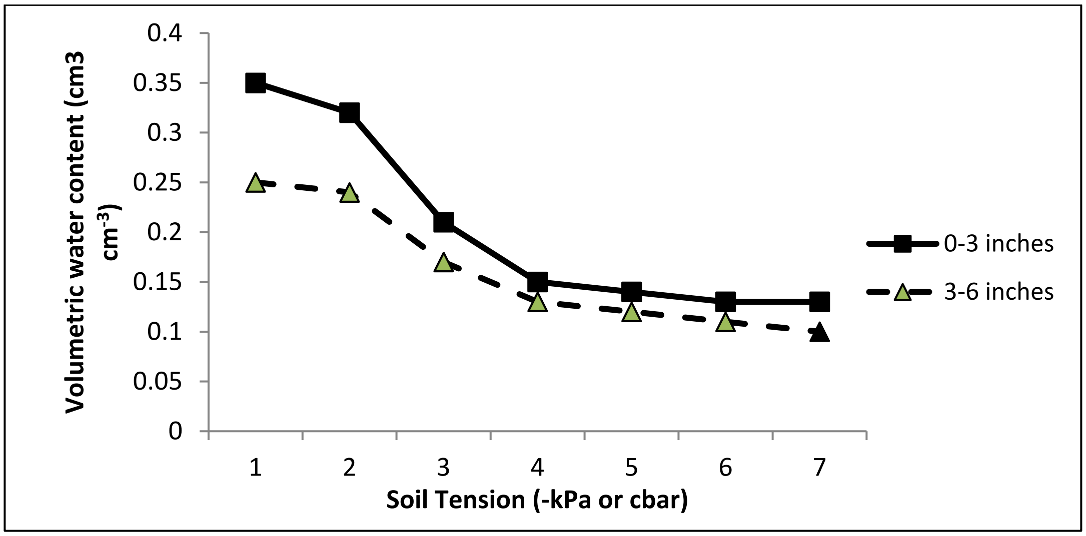

Figure 1. Water retention curve from a cranberry bog at 0-3 inches and 3-6 inches soil depth.

Irrigation in response to the drying of the soil should be initiated at 4.5 kPa where the graph flattens. Further increases in tension are associated with very little changes in water content in the soil as the remaining water is being tightly held by soil particles and is not readily available for plant uptake.

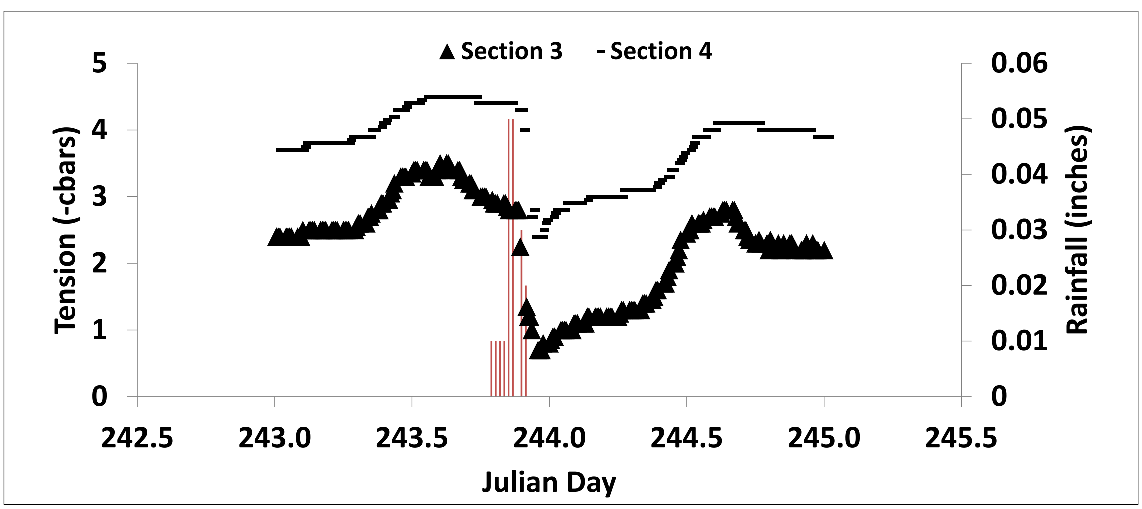

Figure 2. Precipitation (rainfall; vertical gray lines) effect on soil tension; Section 3 is the tension reading in one field and Section 4 is the reading from an adjacent field.

Figure 2 shows that Section 4 is drier than Section 3 as indicated by the higher tension readings at any given time. Precipitation of 0.1 inches dramatically dropped tension readings by <-1.5 cbars on both fields. Section 3's tension was dropped to water saturation levels on Julian day 244 (September 1, 2014), but tension readings rose again as the field gradually dried up. Worth noting is that a slight precipitation caused the tension readings to remain less than -4.5 cbars (trigger point to set irrigation) and even three days after the precipitation, the tension did not rise to previous levels (especially in section 3). This provides solid evidence that irrigating every other day in summer may be too high a frequency, as the field will remain considerably too wet, providing a good environment for disease development.

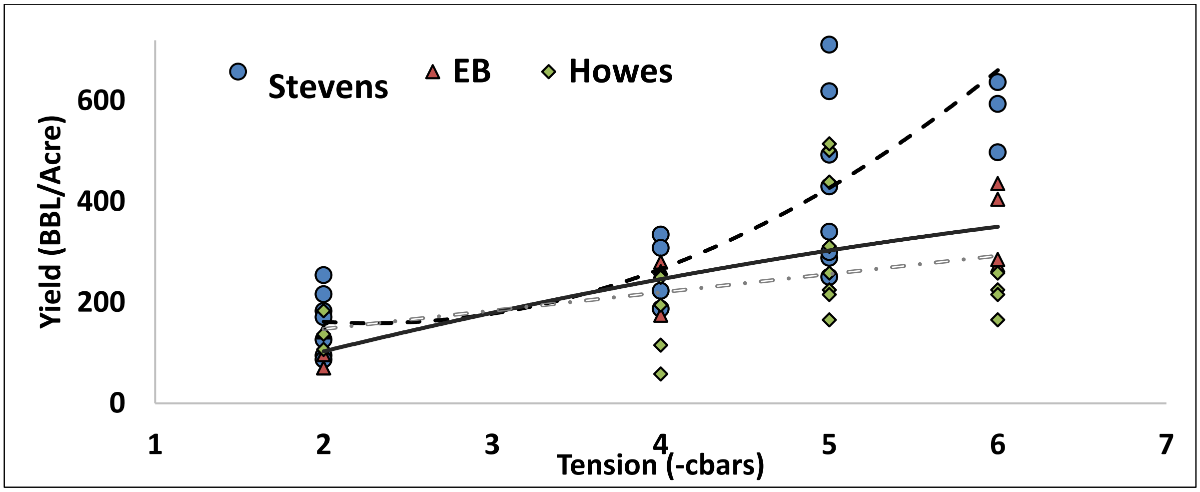

Figure 3. Effect of average soil tension in July and August on cranberry yield.

Soil tension readings in July (flowering period) and August (fruit formation) affects cranberry yield as shown in Figure 3. As the cranberry bed is kept relatively dry in these critical months, the yield is greater than in wetter areas. Soil tension reading accounted for >80% yield variability in Early Black and almost 70% in Stevens. The maximum yields were obtained at a tension greater than -6 cbars. The trend for Howes was less clear and more work is needed to validate this data. Our data corroborates findings of researchers in Quebec that optimum yield is obtained if cranberry beds are kept at about -6 cbars, with the optimal soil tension range for cranberry soils being between -3.5 and -8.0 cbars (Bonin, 2009), limited at the upper matric potential level by, presumably, aeration constraints and at the lower by low unsaturated hydraulic conductivity (Bonin, 2009). A decrease in yield in the low soil tension areas is likely due to a decrease in photosynthesis and production of buds (Caron et al., 2016), as well as the reduced oxygen reaching the root zone due to saturated soils (Bland et al., 1996).

References

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