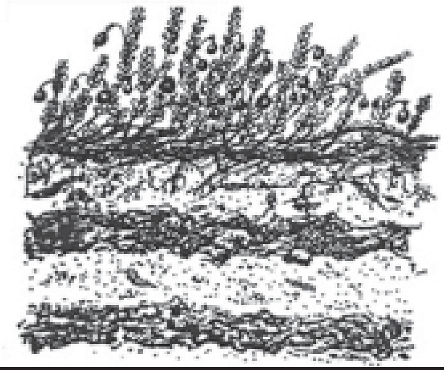

BEST MANAGEMENT PRACTICES GUIDE FOR MASSACHUSETTS CRANBERRY PRODUCTION

Irrigation Management

The **water requirement** of cranberries during the growing season can vary from 0.4 to over 1.5 inches per week. Because of this variability, it is essential to adjust water management practices based on soil moisture monitoring to avoid deficit or excess conditions. In periods of low rainfall and high demand, cranberries must be supplied with additional water through irrigation. During periods of high rainfall, adequate drainage must be supplied to avoid damaging anaerobic conditions in the root zone. In general, cranberries are irrigated by manipulation of the water table or through the use of low-gallonage sprinkler systems or some combination of the two.

Glossary:

Sub-irrigation **-** Manipulation of the water table by controlling depth of water in the ditches in order to supply water needs in the root zone. Water level is maintained so that the soil is moist but not saturated at the bed surface. Sub-irrigation supplements overhead irrigation and depends on the process of capillary rise.

Capillary rise **-** The physical process by which water will rise from the water table through the soil towards the surface. The process is driven by the moisture gradient in the soil (wettest at the water table, driest at the surface). The smaller the soil pores, the higher the water can rise by this process. Fine textured and organic soils have smaller pores than coarse sands. Therefore, water can rise to the surface from a deeper water table in fine textured soils.

Tensiometer **-** A device that measures soil tension, an indirect measurement of the amount of moisture in the soil. Readings are shown in cbars. Tensiometers are used to schedule irrigation.

cbars **-** Centibars, a unit of measurement for soil tension. One cbar is equal to 10 mbars. This is often expressed as a negative number.

Water level float **-** A device placed in a cranberry bed to monitor the depth to the water table. It is used for sub-irrigation monitoring and irrigation scheduling.

Water table **-** The depth beneath the soil surface where the soil is saturated with water.

Recommended Practices

Irrigation and drainage recommendations:

♦ **Monitor soil moisture and depth to water table for irrigation scheduling.**

Maintain the water level in the ditches at a level that is adequate to supply water to the root zone while still allowing adequate drainage from the center of the bed (generally about 14-16 inches below the bed surface, although this will vary based on bed width, soil texture and grade).

Monitor water level in the center of the bed using:

1) <u>Water level float</u> **-** A simple way to monitor the water level in the center of the bed is with a water level float. The water level float consists of a fiberglass rod attached to a float that rides on the water table in a fabric wrapped pipe. The rod may be painted to indicate various depths to the water table. If the bed is substantially out of grade, you may want to place a tensiometer at the high point and a water level float at the low point of the bed. By comparing the water level in the center of the bed as indicated by the water level float to the water level in the ditches, you can assess whether water is moving across the bed at a fast enough rate to meet the water demands of the vines. If the water level in the center of the bed is adequate while the ditch level has dropped too low, you can pump up the ditches without running the overhead irrigation

system (presuming your irrigation system is set up to allow this). If the water level in the center of the bed is too low, you can run the overhead irrigation system. By observing the water level float through several irrigation cycles, you can determine the length of time required for an adequate irrigation. For further information, see the "Construction, Installation, and Use of Water Level Floats" Fact Sheet available at the UMass Cranberry Station.

2) Tensiometer - A tensiometer in the center of the bed can serve the same purpose as the water level float. An advantage of the tensiometer is that it can measure the midday drop in moisture in the root zone that occurs when the water table is near the limit of capillary rise and cannot keep up with plant water demands. The disadvantages of a tensiometer include the fact that they are sensitive to freezing damage and require you to walk out on the bed to take a reading.

Tensiometer readings are normally expressed as centibars (cbars) of tension. A tensiometer reading of 0-2 cbars in the root zone indicates that the water table is too high and that damaging, anaerobic conditions may be occurring. With a water table present, the reading on the tensiometer should be in the 2 to 5 cbar range as long as the water table is between 8 and 18 inches below the surface. As the water table drops below about 18 inches, the soil can dry substantially at midday as the ability of capillary rise to move water up into the root zone lags behind the plant water demands. Because of this midday drop in tension, it is best to read your tensiometers at midday as well as (or instead of) in the morning. A midday tensiometer reading above 10 cbars in the root zone indicates that the water level is too low to supply water by capillary rise and irrigation should be initiated the following morning. A substantial difference (greater than 3-5 cbars) between morning and midday tensiometer readings is a good indication that capillary rise is not able to keep up with plant water needs at midday.

It may be helpful to put a tensiometer next to a water level float to calibrate the relation between water table level and soil moisture tension in the root zone for your individual soil conditions. Be aware that above 10 cbars, the response time of tensiometers in cranberry soils is slow and that under high evaporative demand conditions, the tensiometer may respond too slowly in this range to be relied upon.

- **Monitor soil moisture in the appropriate area of the bed.**

It is important to monitor soil water conditions to schedule irrigation efficiently. When irrigating primarily by sprinkler, the driest areas will tend to be near the edges of the bed while the wettest areas will tend to be near the center. The reverse will be true if you depend on sub-irrigation. Therefore, you should monitor soil moisture (and or water table level) both near the edges of the bed (approximately 5 to 10 feet in from ditch) as well as in the center of the bed.

A water table depth more than about 18 inches below the surface or a midday tensiometer reading higher than 10 cbars indicates that irrigation is needed. Since morning irrigation is recommended (see below), it is important to do regular tensiometer readings in order to avoid the situation where finding a too-dry midday reading requires immediate irrigation.

When monitoring tensiometers on a daily basis, if a morning reading rises above about 5 cbars, you can initiate an irrigation immediately. As an alternative, you can read the tensiometers at midday and irrigate the following morning when the midday reading is above about 10 cbars. Ideally, if you monitor the tensiometers in the morning and again at midday, you can initiate irrigation (the following morning) when the morning and midday tensions begin to deviate by more than about 3-5 cbars.

- **When using sprinkler irrigation, time applications for maximum efficiency.**

When irrigation is required, the sprinkler system should be run early in the morning rather than in the evening. Vines can get watered with minimal evaporation, and the surface of the vines (and fruit) can dry out in the sun's heat. When the sprinkler system is run in the evening, the vines remain wet for an extended period, thus creating favorable conditions for infection by fruit rot fungi.

- **Use sub-irrigation to maintain an even water supply to the roots.**

Sub-irrigation is accomplished by maintaining a water table beneath the surface of the bed throughout the growing season. Maintaining water in the ditches at a level about 18" below the bed surface is an essential component of this method.

Capillary rise from the water table can meet a substantial portion of cranberry water needs under many conditions. In a typical cranberry bed in Massachusetts, sufficient water can move up to the roots from the water table if the depth is no greater than about 18 inches <u>below the soil surface</u>. However, with water tables lower than 18" below the surface or under high evaporative demand conditions (hot and dry), capillary rise may not be adequate to meet plant demands.

It is essential that you know the characteristics of your individual bed before attempting to irrigate primarily by capillary rise. The height of capillary rise will vary from bed to bed with finer textured soils (fine sand, silts, clays) as well as those with higher organic matter contents tending to have higher capillary rise. Conversely, capillary rise will be less in coarse sand beds.

Since soil conditions and contours of beds vary, you must be certain that water is moving at an adequate rate up from the water table into the root zone as well as horizontally across the bed to meet the water demands of the vines at the center of the bed.

- **Combine sub and sprinkler irrigation to maximize efficiency.**

Water use efficiency can often be maximized by combining sub and sprinkler irrigation. This can best be accomplished by monitoring soil moisture using tensiometers and/ or floats at both the center of the bed and near the edge of the bed (about 5-10 feet from the ditch).

Using this method, sprinkler irrigation is initiated if the soil moisture in the center of the bed reaches critical levels (see previous float and tensiometer sections for details). If the center of the bed has adequate water but the ditch water level drops too low (more than 18" below the bed surface) or the soil moisture near the ditch is too low, the ditch water level can be pumped up. At a research site, the balancing of pumping up the ditch level with sprinkler irrigation allowed the average sprinkler irrigation interval to be extended to every 5-6 days during the 1999 season.

- **Use caution when scheduling irrigation for mineral soil and dry beds.**

For beds where a water table is not maintained below the surface, proper irrigation scheduling is even more critical. Tensiometers placed so that the ceramic cup is in the root zone can be a useful tool. It is essential to locate a tensiometer in the driest part of the bed to avoid water stress related damage in these areas.

Under high evaporative demand conditions, water stress related damage has been observed on mineral cranberry beds in Massachusetts when the midday tension reading in the root zone was less than 10 cbars the day before the damage occurred. Therefore, when a water table is not maintained below the surface, you should monitor midday soil moisture tension and schedule an irrigation (for the following morning) when the midday tension reaches about 8 cbars in the root zone.

When high evaporative demand conditions are predicted (hot, windy weather), you should schedule an irrigation (for the following morning) when the midday tension reaches about 6 cbars in the root zone.

- **Modify management in extreme conditions.**

During periods when temperatures are predicted to be excessive, it is important to have the vines fully watered <u>before the hot conditions arrive</u>.

Based on research done in New Jersey, conditions that require you to pay particular attention to proper irrigation are (1) air (off bog) temperatures of 80°F or more (2) dewpoints of 55°F or less during midday and afternoon hours, (3) clear or scattered sky conditions during the day, (4) wind speeds average greater than 11 mph, and (5) no rainfall has occurred during the last 48 hours.

When the above conditions are present, particularly in newly-planted beds and on mineral soil beds, you should monitor soil moisture in early morning and again in late morning to assure that there is still adequate moisture in the root zone. If moisture is inadequate, sprinklers should be run for 1-2 hours in the late morning or early afternoon to replenish the soil water as well as to cool the vines and berries to prevent injury. However, it should be emphasized that irrigation in the early morning is preferred when possible.

- **Maintain good drainage and water table management.**

Drainage is extremely important to cranberry production. **Regardless of irrigation method used, it is critical to maintain adequate drainage across the bed to prevent waterlogging in the root zone.** Saturation status of the soil can effect root growth and function as well as disease incidence. Suboptimal soil moisture leads to poor uptake of fertilizer nutrients. By providing adequate drainage early in the season, you should be able to improve rooting depth and productivity. As is the case with fertilizer, what you do this season has a large impact on next season's performance. Excessively wet soils increase the likelihood of *Phytophthora* infection while excessively dry soils can promote fairy ring disease.

As described above, a water level float or tensiometer will give you an indication of periods when the water level is too high in the center of the bed. Any time the water level is closer than 8" from the surface, an attempt should be made to lower ditch water level to improve drainage. With the tensiometer, a reading of 0-2 cbars indicates that drainage needs to be improved.

It is important to remember that the level of the water table beneath the surface of the bed is not necessarily flat. After sprinkler irrigation or a rainfall event the water level is higher in the center of the bed. It can take 1-5 days for water to drain from the center of the bed to the ditches depending on soil characteristics and the ditch water level. If you are sprinkler irrigating every 3 days or less, you may always have a higher water table in the middle of the bed than near the ditches.

After a period of sub-irrigation the plants draw down the water table in the center of the bed by using water at a higher rate than it can be replenished by moving across laterally from the ditches to the center of the bed. This situation indicates that sprinkler irrigation is needed to replenish the water in the center of the bed.

- **Conserve water. Manage irrigation so that the objective is achieved with the minimum water necessary.**

Cranberry bog low-gallonage sprinkler systems supply water at the rate of about one-tenth inch per hour; therefore under ideal conditions, five hours of irrigation will apply one-half inch of water. Measure the irrigation rate of each system with catch cans to determine the actual rate for that system.

Apply irrigation based on soil water status and plant needs. Plant needs increase when temperatures are high, skies are clear, or wind is present. Cranberries can use up to 0.20 to 0.25 inches of water per **day** during the hottest, driest, windiest weather, considerably more than the historic benchmark of 1 inch/week. Conversely, during cool damp periods, water demand will be much lower than 1 inch/week. Monitor soil moisture during the season to schedule irrigation (see above).

Applications of more than one-half inch in a single irrigation can lead to waterlogging and puddling. The amount needed on a specific bog will be related to soil texture, permeability, and drainage characteristics. Surface dryness does not always indicate the need for irrigation.

Sprinkler system design and performance:

- **Optimize irrigation system performance.**

An irrigation system will only perform well if it is engineered correctly and is properly operated and maintained.

Clean and inspect the irrigation pump annually. Inspect packing, seals, and foot valve of the pump and repair if necessary. Use a filter basket on the intake pipe of your system to prevent foreign objects from damaging the pump impeller and to limit clogging of sprinkler nozzles.

Check mains, lateral lines, and riser gaskets for leaks annually. Lateral lines should extend out to the ditches and cleanout plugs should be installed to allow for flushing of sediment and other debris that accumulates in the lines. Flush out lines in the spring before installation of risers and sprinklers to minimize plugging of lines and sprinklers during the season. Use riser strainers or filters to prevent clogging of nozzles. Sprinklers at the ends of lines are prone to clogging, so installation of a ballcock shutoff valve or in-line strainer will facilitate easier or less frequent clean-out. Avoid scratching the interior of straight bore nozzles when removing a foreign object lodged in the orifice. Use a coated wire or “plastic” wire to remove materials from an obstructed nozzle. Nozzles containing plastic stream straighteners or vanes should not be cleaned out with wire because vanes are easily damaged. Remove the vaned nozzle from the sprinkler and remove the obstruction with needle nose pliers or tweezers. Protect mains and laterals from dents and limit the number of 90º elbows in the system. Dents and elbows can significantly increase friction losses that can result in significant pressure drop across the system.

Perform routine and periodic maintenance to sprinkler heads. Refer to Rain Bird Maintenance Manual for proper maintenance procedures. Replace broken or damaged sprinkler heads or head components and worn nozzles. Check for nozzle wear by inserting a drill bit of the appropriate size in the nozzle orifice. A slight increase in the orifice size can have a significant impact on the water delivery rate. A 1/64" expansion will increase water use by about 1 gallon per minute.

Sprinklers should rotate at least one revolution per minute if they are to be effective for frost protection. Replace washer stack, bearing washer, and tension springs when sprinklers turn at less than one revolution per minute. Replace conventional plastic washer stacks with Teflon washer stacks to increase rotation speed of sprinkler heads. Brass arm spoon driven sprinklers should rotate at between 1 and 2 revolutions per minute. Use of brass sprinklers with an aluminum arm is another way to increase rotation speed. Excessive rotation can cause premature wear of the sprinkler components. Aluminum arm sprinklers are more fragile than brass arm sprinklers, so exercise caution when removing and storing them.

Sharpen the leading edge of the impact arm when the knife edge becomes rounded to improve water droplet breakup. Spoon driven impact sprinklers are water lubricated so never lubricate a sprinkler with oil or use pipe dope or sealer to seal threads. Make sure risers are straight and are secured with a stake to limit wobble.

A wobbling riser is usually indicative of a worn or leaking gasket or broken coupling. Inspect riser couplings annually and replace worn or broken parts. Leaning risers can have a significant negative impact on uniform application of water. Straightening and staking risers can dramatically improve uniformity of application.

Minimize galvanic corrosion by limiting the connection of dissimilar metallic materials (i.e. brass to aluminum, aluminum to steel). Paint the spoon and counter weight arm of sprinklers with white paint to improve visibility during night and early morning operation. Be careful not to apply paint to the spring, washer assembly and stem of the sprinkler - it will increase resistance and slow rotation speed. Alternatively you can add reflective tape to the counter weight side of the arm.

System operating pressure should fall within the range of 45 to 60 psi with pressure requirements increasing as system spacing increases. Nozzle pressure at the last sprinkler head should be no less than 40 psi, and pressure losses across the entire system should be limited to <15% of pressure at the first sprinkler off the main water line. Some pressure loss is expected across a system due to friction and head effects but a large pressure drop across a system suggests leaks in the main or laterals. The nozzle pressure of a sprinkler is measured with a pitot tube while the sprinkler is in operation. Operating the system at the low pressure range will result in large water droplets and a distribution of most of the water around the outer edge of the pattern, while operating the system above the pressure range will result in misting and drift. Pressure above 60 psi can cause the sprinkler arm to strike the back of the sprinkler body, causing the sprinkler to stand still or turn backwards.

Consider upgrading or improving your irrigation system if operating pressure at the heads is less than 40 psi for Rainbird 30 sprinkler heads (or equivalent).

- **Irrigation uniformity may be evaluated by conducting irrigation uniformity catch can tests.**

Irrigation system performance should be evaluated on a regular basis (preferably annually) to insure that it is performing satisfactorily. Irrigation system performance can be measured by conducting a uniformity test. Coefficient of Uniformity (CU) of < 70% indicates that a system needs updating and improvement. USDA Natural Resource Conservation Service recommends that you attempt to achieve the ideal of 85% uniformity when designing or improving cranberry irrigation systems. Use the right combination of lateral spacing, operating pressure, sprinkler model, and nozzle type and size to achieve 90% overlap of wetted diameter.

Irrigation uniformity may be improved by the use of high uniformity nozzles, straightening and staking risers, and installing riser extensions so that sprinkler heads extend above the vines. A riser height of at least 18 inches is optimal. When renovating old bogs or installing new bogs choose the smallest sprinkler spacing possible. Uniformity of application decreases as sprinkler spacing increases.

Based on irrigation uniformity tests on bogs in Massachusetts, properly functioning irrigation systems with the following lateral and sprinkler spacing should achieve CU's in the following ranges. The actual CU will depend on the sprinkler heads used and the running pressure of the system, which will also affect the wetted diameter.

Spacing (ft)	CU(%)
40 x 50	75 - 90
50 x 60	70 - 85
60 x 70	60 - 75

Compare uniformity test results with yield records when evaluating sprinkler system performance.

- **Measure the rate that water is applied by your irrigation system.**

In order for frost protection to be effective, an irrigation system should apply water at a rate of at least 0.1 inches per hour (protection to 24ºF). Most cranberry systems are engineered to provide 0.14 inches per hour to provide a margin for error and protection to approximately 21ºF.

Knowledge of application rate is also necessary to determine how much irrigation water you are applying. Data collected from a irrigation uniformity test can be used to calculate the system's irrigation rate. Modifications can be made by changing operating pressure or nozzle size. Irrigation systems with low CU's are inefficient users of water - they apply more water per unit time than systems with high CU's to insure that at least 0.1 inches per hour of water reach all areas of the bog.

- **If you plan to use your sprinkler system for chemigation, make sure that application will be uniform and safe and that first-to-last head travel times are minimized.**

See the Chemigation BMP for further information on safety, calibration, and techniques for chemigation.

For further information:

Council for Agricultural Science and Technology. 1988. **Effective use of water in irrigated agriculture.** Report No. 113.

Cranberry chart book - management guide for Massachusetts. University of Massachusetts Cranberry Experiment Station. Section on irrigation.

Croft, P. J. 1992. **Meteorological investigation and prediction of scald.** Cranberries Magazine 56(1): 6-7, 18.

DeMoranville, C. J., I. E. Demoranville, and F. C. Caruso. "Influence of weather on cranberry crop production and quality". in Sandler, H. A., ed. **Cranberry Production: A Guide for Massachusetts**. UMass Extension Publication SP-127. December 1997. Second printing February 1998. pp. 14-22.

Florida Irrigation Society. 1991. **Standards and specifications for agricultural solid-set sprinkler and microirrigation systems.** Bulletin.

Lampinen, B. D. 2000. **Construction, Installation, and Use of Water Level Floats.** UMass Cranberry Experiment Station/UMass Extension Publication.

Norton, J. S. 1987. **Low gallonage sprinkler systems and their use.** pp.11-37. *In:* Modern Cranberry Cultivation, University of Massachusetts Extension Special Publication #126.

Rainbird maintenance manual for Impact Sprinklers.

Reno, L. 1994. **Solid-set sprinkler irrigation systems.** Cranberries Magazine 57(11):6-7.

Spear, S. G. "Sprinkler system design, use, and performance". in Sandler, H. A., ed. **Cranberry Production: A Guide for Massachusetts**. UMass Extension Publication SP-127. December 1997. Second printing February 1998. pp. 25-30.

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