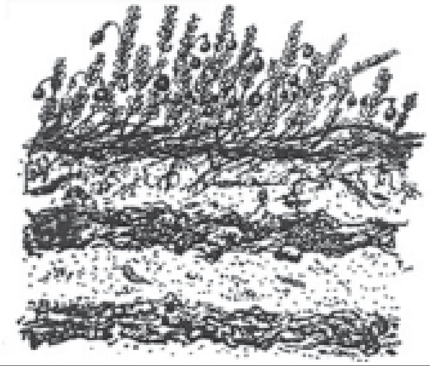

BEST MANAGEMENT PRACTICES GUIDE FOR MASSACHUSETTS CRANBERRY PRODUCTION

Mineral Soil Bog Construction

Regulatory restrictions on development of new cranberry bogs in wetlands have resulted in a limitation on the sites where bogs may be constructed. While renovation of existing wetland cranberry bogs is permitted, new acreage is restricted to non-traditional settings, typically uplands. In either setting, an ample supply of good quality fresh water, adequate drainage of the bogs, and the ability to hold a flood to cover the cranberry vines are essential to successful cranberry production.

In traditional wetland bogs, nutrients and pesticides are retained in the soil of the bog largely due to the high organic matter content of the peat and muck soils. In such settings, the risk of groundwater contamination is minimal. During renovation of these wetland bogs, the organic subsoils remain essentially undisturbed and continue to provide protection for the groundwater beneath the renovated bog.

When bogs are constructed on mineral soils with low organic matter content, there is an increased risk of fertilizer and pesticide leaching as water moves downward through the soil profile. To permit the use of conventional management operations (e.g., maintaining a flood), non-traditional sites must be engineered to provide suitable site hydrology and soil characteristics that mimic traditional wetland settings. Adapting the existing site hydrology to one that supports cranberry production may require manipulation of the water table, soil permeability, soil texture, and soil organic carbon content. Proper site selection and construction are essential if cranberry production in non-traditional settings is to utilize conventional cultural activities, keep production costs minimized, and protect groundwater resources. Following the recommendations below can optimize these objectives.

Recommended Practices

Bog construction in mineral soils - water table modification required

Site selection and evaluation

- Before beginning construction of bog or water containment structure, consult federal, state and local authorities regarding any required permits.

  Consult with a soil scientist or engineer prior to the initiation of construction activity to verify that the projected site is designated as an upland location.

  Do not assume that you are exempt from regulatory approval if you are constructing a bog in uplands.

  Construction of a bog exceeding 4.66 acres requires MA Water Management Act compliance and a permit. This limit may be extended to 9.3 acres if your construction plan has been approved by the local Conservation District. For construction of more than 9.3 acres, a permit is always required. If you divert the ‘reach or flow’ of a water body in the construction of a reservoir, or if installation of flumes or dikes or other water control structures results in the filling of an adjoining wetland, you are subject to Section 404 of the Clean Water Act.

  New plantings constructed within 200 feet of a river are subject to the River Protection Act. New plantings constructed within 100 feet of a wetland are subjected to the Wetlands Protection Act.

- **Careful consideration should be given to the environment around the site, particularly the proximity to public and private drinking water supply wells.**

  If new bogs are established within state specified wellhead protection zones, the bogs are subject to Pesticide Regulation 333CMR 12:00 entitled, "Protection of Groundwater Sources of Public Drinking Water Supplies from Non-Point Source Pesticide Contamination". These zones can be a Zone II area, which is a delineated area of an aquifer that contributes water to a public water supply well or an Interim Wellhead Protection area that is a 0.5 mile radius around a new well, until the Zone II is delineated.

  Some towns have Wellhead Protection by-laws that prohibit the excavation of soil to within 4 feet of the groundwater. Check with your local town hall. Wellhead protection zone information is available at your local town hall or the Cape Cod Cranberry Growers' Association.

  To insure protection of groundwater resources, sites should be selected where there is adequate soil depth to maintain a 12 to 18 inch separation between the bottom of the construction zone and the top of the true natural water table.

- **Evaluate surface soil at the site for texture, organic carbon content, water holding capacity, pH, and permeability.**

  If these characteristics are acceptable, stockpile this soil for later use. Use fine-textured soils with at least 5% organic carbon content to construct confining layers. Sand may be stockpiled for future sanding needs. Cranberry bog soils should be in the acid range - pH 4.0-5.0. Design and construction are site-specific and dependent on local hydrology and soil materials available at the site. It is a good practice to consult with an engineer to obtain site-specific recommendations for constructing bogs with materials on your site.

- **Before beginning any earth-moving activities, make sure you are in compliance with any applicable federal, state, and local erosion control requirements.**

  For example, if you are stockpiling large quantities of soil, make sure you have adequately contained it with properly secured silt fences and straw bales to prevent offsite erosion and sedimentation. Review the Erosion and Sediment Control BMP.

- **Select a site with adequate supply of fresh water for irrigation and flooding.**

  If possible, site the cranberry bogs so that gravity flow of water is used for drainage and application or removal of a flood. Energy costs will be reduced if water does not have to be moved by mechanical means. In general, older bogs may require as much as 10 acre-feet of water per season to meet all production, harvesting, and flooding needs. With the implementation of appropriate BMPs, water needs on new acreage may be reduced substantially. Make sure that you have adequate water storage capacity to meet your needs.

CONSTRUCTING THE BOG

- **Water table modification during bog construction can be achieved by utilizing a 'perched' water table above the natural water table. This practice is recommended for proper construction of a bog in mineral soils.**

  The construction of a slowly permeable subsoil layer creates a localized or 'perched' water table at some distance above the true water table. Such a construction design is shown in Figure 1. This type of construction calls for a larger initial investment and more detailed engineering and construction specifications than using the natural water table but the costs are offset as a result of lower long-term production costs, more efficient and better controlled water use, and significantly less leaching. Separation from the actual water table allows the use of an organic confining layer of reduced thickness compared to that needed with a natural water table bog.

  Water table manipulation can also be achieved by utilizing the natural water table ***<u>BUT this method is not recommended</u>*****.** While bog construction that utilizes the natural water table can be less costly initially, long-term production costs will probably be higher. Building bogs by utilizing the natural water table requires the placement of a thick (12 to 18 inch) organic confining layer beneath the bog to restrict the movement of pesticides and nutrients outside of the production area. Obtaining such material is costly. Further, the organic layer alone may not hold flood water without the placement of a fine-textured mineral sub-layer. Use of the natural water table is likely to lead to problems after the bog is in production. These problems include: 1) difficult water management due to seasonal fluctuations in the water table; 2) increased irrigation needs and possible inability to flood for harvest, especially in dry years; 3) high costs for pumping water; 4) higher nutrient requirements; and 5) risk of leaching. In addition, while bogs lined with layers constructed entirely of organic material may provide adequate filtration, they may not create an effective seal that would restrict water movement through the bog into adjacent aquifers.

♦ Construction of a perched water table bog requires two confining layers.

Water confining layer (impermeable layer):
A continuous, confining layer of sufficient density and thickness to restrict water permeability should be constructed below the root zone of the cranberry bog. It should extend beneath the drainage ditches and into the interior of the dikes (Figure 1). Conduct engineering tests to determine how thick this layer should be to achieve an impermeable barrier (this will depend on the exact character of the material used). This layer is necessary to flood for winter protection and harvest, to hold soil moisture reserves in the summer, and to minimize leaching. Depending on your site, one of the following will apply:

1. Fine-textured subsoil (loam, clay loam, silty clay loam, clay) - compact this native soil.

2. Coarse-textured subsoils (poorly sorted gravel, sand, loamy sand, sandy loam) - not suitable as a confining layer. You MUST add fine-textured materials to these and then compact the soil. The thickness required depends on nature of material and degree of compaction possible.

3. In some areas, relatively impermeable sub-soil such as dense basal glacial till, glacio-fluvial clays, and ironstone ("bog ore") hardpans occur naturally and can be utilized as a confining layer.

Consult civil engineers, USDA Natural Resource Conservation Service, or other experts about the specifications needed to construct a confining layer with the materials at your site.

It is essential that the confining layer is uniform and continuous throughout the bog and under ditches and dikes; otherwise, water leakage will occur and potential for leaching will increase.

Installation of unleveled confining layers can lead to collection of water and non-uniform drainage in the bog.

If your site has no suitable confining material, you must amend the soil. Amending poor soil materials can be very costly; try to site bogs where suitable materials exist on-site. If necessary, clays such as sodium bentonite (natural material mined in Wyoming) or other materials used as landfill liners may be adapted for use in bog construction. The University of California provides a bulletin on how to use bentonite in water control structures (see 'For Further Information'). Such options are very expensive - if no suitable materials are available on site, consider another site for the bog.

Organic confining layer:
This layer should be 12 or more inches thick with at least 5% organic carbon (8.5% organic matter) and is needed to confine fertilizers and pesticides within the bog. The organic layer is located between the slowly permeable confining layer and the cranberry root zone (Figure 1). The best choices for this layer are peat or muck (20% organic carbon) that should be screened to remove large wood fragments and twigs before use. The next best choice is to amend low-organic soil with organic materials containing humus (peat, muck, organic ditch dredgings, renovation sediments, yard compost, composed wood waste). Do not use undecomposed organics such as leaf litter and sawdust (they do not have effective cation exchange capacity). ***A reminder***: before using waste organics of any kind - analyze for heavy metals and check to see if you need any permits to use yard waste compost. Activated carbon may be used for the organic confining layer, but this option is expensive unless you can find a source of inexpensive waste activated carbon. If you use activated carbon, approximately 8 tons/acre will be needed to construct the organic confining layer.

- **Monitor the placement of confining layers during construction. Making a mistake now can be difficult and costly to correct later.**

- **Once the confining layers are in place, the bog surface and irrigation system are installed.**

  Use sand or geofabric-lined perforated drainage pipe above the confining layers to help manage drainage above the ‘perched’ water table.

- **Use tailwater recovery and holding ponds to conserve water.**

  Install tailwater revcovery systems where possible so that water can be recycled within the bog system. Design systems so that gravity is used to move the water onto or off of the bog, requiring pumping for only one direction. For maximum water conservation, the tailwater recovery and associated holding pond should be designed to hold, at minimum, enough water to flood the bog. This will allow for the storage of winter flood water for reuse during other irrigation and flooding events, including the flood-harvest. The existence of the holding pond will also mitigate against heavy instantaneous water withdrawals that might impact sensitive water bodies or aquifers. A benefit of this practice is the ability to store water during periods of high flow so that during low-flow periods, stored water can be used, thus avoiding impacts of instantaneous heavy water withdrawals from shared sources. When designing such a system, it is recommended that a Conservation Farm Plan be in place and that NRCS staff be consulted for assistance in design specifications.

- **Construct ditches to provide adequate drainage and ability for rapid flooding.**

  Perimeter (shore) ditches should be 2-3 feet wide and 2 feet deep to allow good water flow and to act as a barrier to weed incursion from the shore. Lateral ditches should be 1-2 feet wide and 18 inches deep. The number of lateral ditches required will vary; you will need at least a main ditch oriented in the direction of water flow from the water supply to the bog outlet. Other lateral ditches facilitate flooding and draining. To insure proper drainage, install interior drainage ditches or subsurface drainage pipe at approximately 60-foot intervals. Surrounding dikes should be at least a foot above flood water level to minimize erosion. Encourage the growth of the cranberry plants along the ditch edges and plant grass on dikes to minimize erosion. See the Erosion and Sediment Control BMP for further information.

- **Attempt to achieve the ideal of an 85% uniformity coefficient when designing or improving systems.**

  Such a system will use less water, reducing energy costs and leaching potential. A system with narrow spacings (40 by 50 feet), 18-inch risers, and high efficiency nozzles should perform to these specifications. See Irrigation BMP.

- **Make sure that ditch depths are such that routine practices (cleaning, etc.) will not compromise the integrity of the confining layers.**

  Consider adding fine silt layers to the bottoms of ditches to further reduce the risk of water leakage. Compacted glacial till is known to work effectively. Bentonite clay is also effective, but is very expensive.

- **Make sure the bogs are level - this reduces the amount of water needed for flooding.**

  Even on a ‘level’ bog, a crown of several inches facilitates movement of water away from the center. In lieu of a crown, additional drainage should be placed in the center to promote good soil aeration and minimize disease development.

  The smaller the ‘head’ of water above the vines, the less likely water will leak through the confining layer. Lower water level will also reduce costs of moving water.

- **The inability to hold a harvest or winter flood on your bog is a clear indication that ground water resources may be at risk for contamination.**

HORTICULTURAL REQUIREMENTS:

- **Use coarse sand for the uppermost layer of the cranberry bog.**

  The root zone should consist of about 6 inches of coarse sand (70% of the particles should be in the 0.5-2 mm particle size range) to insure adequate drainage and aeration. When selecting a location, on-site availability of such sand is desirable. This sand layer should not be compacted prior to planting.

- **Bog sections should be as level as possible to facilitate drainage and allow flooding with a minimal volume of water. Laser leveling to 6 inches within a diked section is recommended.**

  On a level bog, flooding will be achieved with a lower volume (and height) of water. The height of flood water applied to the bog influences retention of nutrients and pesticides. Mineral soil bogs may be more prone to leaching; limiting flood depth will minimize nutrient and pesticide losses. In all cranberry bogs, nutrients may be forced below the level of the root zone (beyond the reach of the plants). If water must be pumped onto and/or off the bog, lower volume floods will have lower energy costs.

- **If possible, plant cuttings at high density (1.5 tons/acre or more) to insure rapid growth to cover the soil surface.**

  Rapid 'vining in' will lead to less competition from weeds reducing the need for hand weeding and herbicide use during establishment. An additional benefit will be reduced irrigation needs, as loss of water to evaporation from the sand surface will be minimized.

- **Poor water management is probably the leading cause of sparse vine growth in new bogs.**

  Provide adequate irrigation during stand establishment but do not over water. During the first two to four weeks, as roots are being formed, use frequent but short irrigation periods. Manage irrigation schedules such that puddles are minimized. After the plants are rooted, less frequent but longer (four hours) irrigation periods are preferred to encourage deeper rooting.

  Monitor soil moisture on a regular basis using tensiometer or other types of measuring devices. Refer to the Irrigation BMP for more details.

- **Apply light layers (about 1/2 inch) of sand to the new planting at the end of each of the first two seasons.**

  Light sanding will serve to anchor runners and promote the production of upright stems.

- **Weed control during stand establishment is essential for rapid transition to production.**

  Surface vegetation should be removed from the site, including roots of problem weed species. Soil fumigants may be used to kill weed seeds and roots. ***These materials should be used with caution***, see the Weed Management BMP for further information. Make sure that the soil surface is as weed-free as possible prior to planting. After stand establishment, encroaching weeds may be hand removed, mowed, or clipped prior to seed production and dispersal, or spot-treated with postemergence herbicides. Broadcast, pre-emergence herbicides (except Devrinol) should be avoided during the first year as they may retard stand establishment.

These construction recommendations attempt to create a system that mimics cranberry culture in more traditional settings. This is achieved by allowing for better management and control of water resources, minimizing production costs, and reducing environmental risk. Keep in mind that initial construction costs are higher and engineering requirements are more exacting for proper construction of cranberry bogs in non-traditional settings. A successful cranberry bog is one that produces a high yield in a cost effective manner with minimal environmental impact.

For further information:

Cranberry chart book - Management guide for Massachusetts. University of Massachusetts Cranberry Experiment Station.

Dike standard. 1990. Field Office Technical Guide #356. USDA-SCS. Amherst, MA.

Duffin, R. B. 1976. **Seepage control with bentonite.** Extension Bulletin 2240. Division of Agricultural Sciences, Cooperative Extension, University of California, Davis. 7 pages.

Erosion Control, Bog Renovation, Weed Management and **Irrigation Management** BMPs in this series.

Guide to understanding cranberry bed soil mapping units. 1997. Fact Sheet. USDA, NRCS, West Wareham, MA.

Turenne, J. 1997. **Understanding cranberry soil maps**. Cranberries 61:15-18.

Water Management Act. Information sheet. CCCGA.

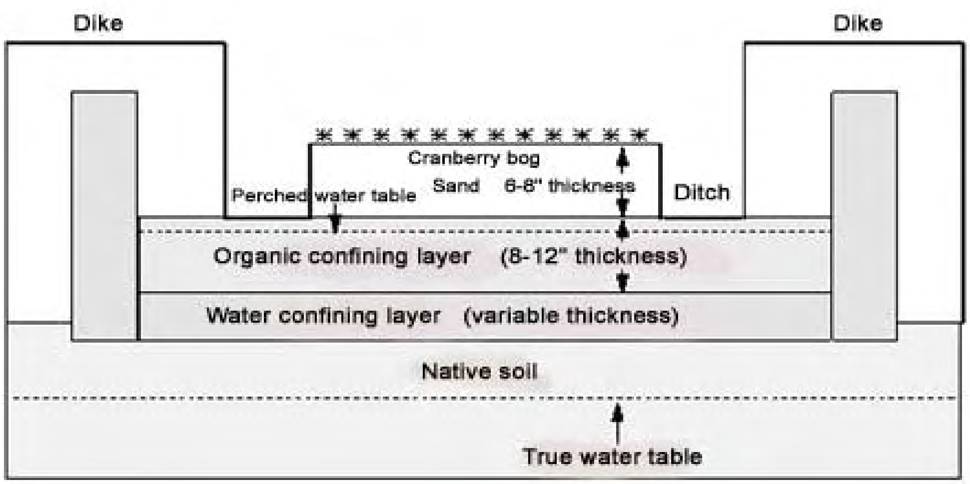

Figure 1. Cross-section showing construction of cranberry bog with location of organic and water confining layers in system using perched water table design.

Prepared by Carolyn DeMoranville (Project Leader) and Hilary Sandler. Source Materials provided by Tom Bicki. Production of this Management Guide was supported by Massachusetts Department of Food and Agriculture as part of the Agro-Environmental Technology Grants Program. Matching funds were provided by University of Massachusetts Extension (USDA Cooperating) and Cape Cod Cranberry Growers Association. UMass Extension offers equal opportunity in programs and employment.
Artwork by Meredith Albright, freelance scientific illustrator, Bellingham, MA. 2000