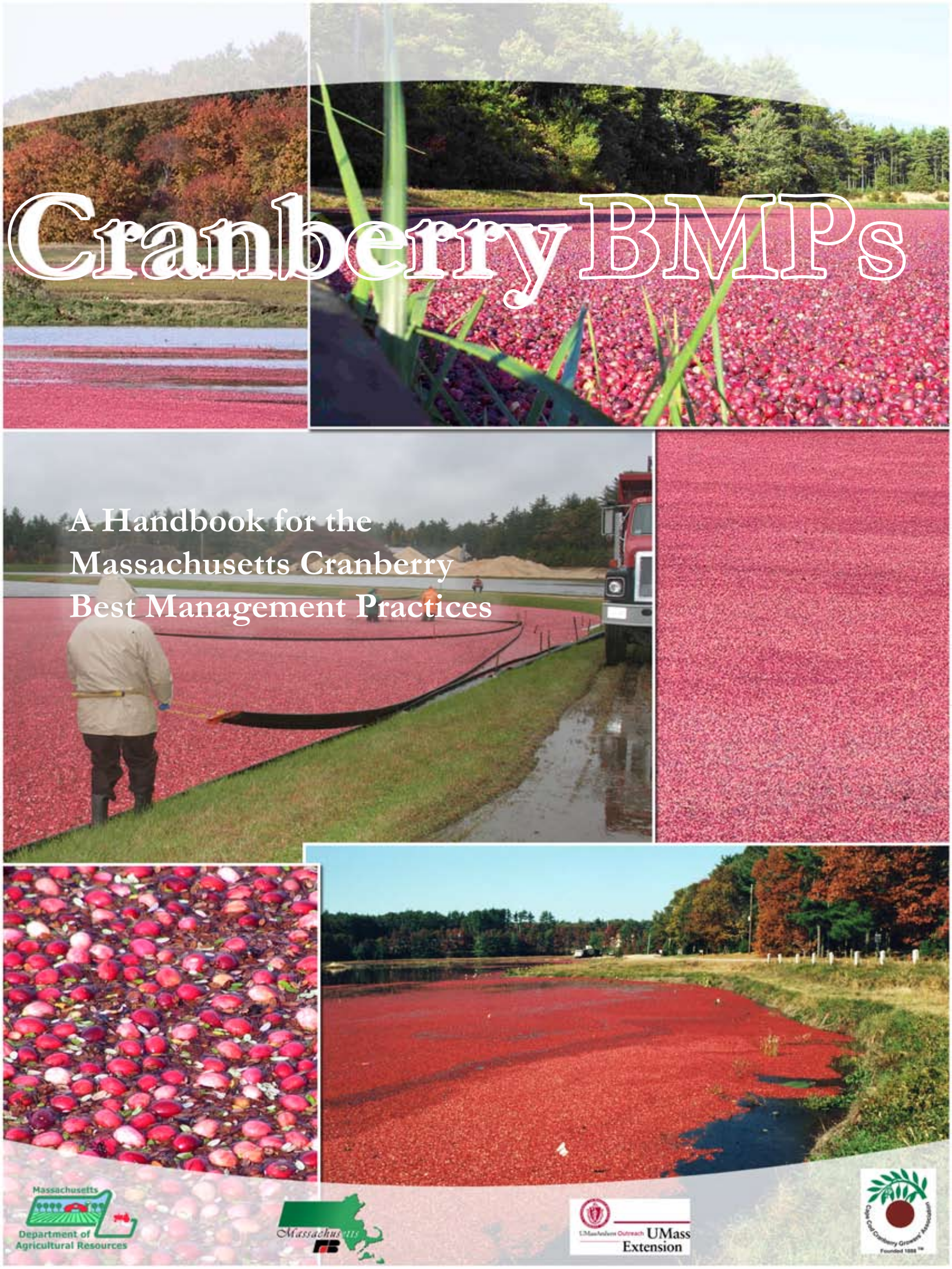

Cranberry BMPs

A Handbook for the Massachusetts Cranberry Best Management Practices

Massachusetts Department of Agricultural Resources

Massachusetts

UMass Extension

Cape Cod Cranberry Growers' Association

Introduction to the Revised Guide

Cranberries are grown on approximately 14,000 acres in Massachusetts and are an important horticultural commodity in the Southeastern region of the state. In addition, more than 60,000 acres of open space are associated with cranberry operations. This open space provides habitat to many plant and animal species as well as providing an aesthetic value. Open space associated with cranberry farms serves to protect and recharge watersheds. Cranberry farming also contributes to the economy and quality of life in Southeastern Massachusetts.

To preserve the positive benefits of cranberry farming in Massachusetts, it is necessary that cranberry growers be equipped to produce cranberries profitably and sustainably. In such a system, the quality of life of the farmer and the community, the profitability of farming, and the preservation of the quality of natural resources and the environment are all taken into consideration. Such a system requires that farming with expert knowledge in some part replaces the indiscriminate use of agrochemical and non-renewable resources.

The University of Massachusetts Cranberry Station has the mission of providing research and education programs to add to the expert knowledge base for cranberry growers. In 1996, a basic guide for growing cranberries within modern environmental and social constraints was produced by the Cranberry Station. Concurrently, the Cape Cod Cranberry Growers Association (CCCGA), working with the Conservation Districts and the USDA Natural Resources Conservation Service, began working on standards for cranberry farming that could be used in the formulation of Farm Plans. In addition, Ocean Spray Cranberries, Inc. was beginning the process of providing Best Management Practices Guidelines to its growers. These groups combined their efforts to produce a unified project that was funded by the Massachusetts Department of Food and Agriculture (DFA) Agro-Environmental Technology Program. The first edition of the Best Management Practices (BMP) Guide for Massachusetts Cranberry Production, containing 10 practices, was the result of this process.

In 1999, these same stakeholders came together to revise and expand the BMP Guide, again with financial support from the MA DFA Agro-Environmental Technology Program and the CCCGA. Key features of the revised and expanded BMP Guide include expanded information regarding water use and protection and the handling and use of pesticides. This information will be critical to help growers and officials comply with requirements of State and Federal laws and regulations, especially the requirements of the Clean Water Act. The expanded guide totaled 24 practices.

In 2010, Massachusetts Farm Bureau and the MA Department of Food and Agricultural Resources (formerly DFA) engaged UMass Extension and the Cranberry Station to revise and expand the BMP Guide. This guide is different as it will be primarily available as an on-line resource. This will greatly facilitate the periodic revision of individual practices as necessary and allows for the addition of more practices over time. The intent is to provide information that will help growers to farm profitably and in harmony with their neighbors and the surrounding environment. Interested parties may also wish to reference Cranberry Chart Book - Management Guide for Massachusetts, published by the UMass Cranberry Station (http://scholarworks.umass.edu/cranchart/).

The current Guide has contains 29 practices. Each section of the Guide begins with a description of the part of cranberry production addressed in that BMP. This information is for the benefit of newer growers and to serve as a point of introduction for others (Conservation Commissions, regulators, environmental groups) who might reference these materials. Following the introductory section is a series of Recommended Practices designed to maximize productivity while preserving the environment. Of course, not all growers will be able to implement every Recommended Practice due

to financial and site constraints, but having such a list in-hand should prove valuable as cranberry farmers strive to maintain profitable and environmentally compatible operations.

ACKNOWLEDGMENTS

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Compiled by Hilary Sandler, UMass Cranberry Station, UMass Extension.

University of Massachusetts contributors included: Anne Averill, Frank Caruso, Carolyn DeMoranville, Peter Jeranyama, and Hilary Sandler. The Environmental Committee of the Cape Cod Cranberry Growers' Association (CCCGA) reviewed several of the BMPs. Special thanks to Larry Boutiette, Jen Friedrich, Dawn Gates, Keith Mann, Gerry Palano, and Brian Wick for thoughtful comments. The Farm Bureau representative was Doug Gillespie and the MA Department of Food and Agricultural Resources representative was Gerard Kennedy.

Original versions of the BMPs were written, reviewed and edited by an industry and grower advisory group consisting of UMass Cranberry Station staff mentioned above, Tom Bicki, Ocean Spray Cranberries; Bruce Lampinen and Joanne Mason, UMass Cranberry Station; Peter Bonome and Len Reno, NRCS; Betty Brown, Dan Daly, Jack Heywood, Jeff LaFleur, David Nolte, Matthew Pitts, Linda Rinta, Chris Severance, and Steve Ward, CCCGA Environmental Committee and its Chemigation Working Group; and Gary Deziel, The Cranberry Institute. Many of their comments remain in the current edition.

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UMass Extension

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CROP AND PEST MANAGEMENT BMPs

Disease Management

Applying an integrated scheme for the control of plant diseases can be a viable approach for many cranberry growers. Sanitation, proper irrigation schedules, resistant varieties, fungicides, and various cultural techniques can be used as components of a disease management program. Success of any control measure hinges upon the correct identification of the causal agent (the pathogen). Some diseases have distinctive field symptoms, but most disease identification should be confirmed by a diagnostic clinic or plant pathology laboratory. By utilizing more than one control measure, a grower may be able to reduce the chance of significant crop loss from infection by plant pathogens.

Disease management implies more than the application of chemicals at the appropriate time in the season. Knowledge of the life cycle of the pathogen, symptoms, as well as the conditions that predispose the plant to infection, contributes to effective management of cranberry diseases. Implementing cultural practices, such as trash removal, sanding, or improving bog drainage, offers opportunities to broaden the baseline defense against crop loss due to plant disease. Follow the recommended practices to encourage the natural defense mechanisms in the plant, make conditions in the bog less favorable for disease development, and decrease the presence and activity of plant pathogens.

Recommended Practices

Scout for disease problems.

Measure areas of affected vines or mark with flags. Make adjustments in your disease management program before appreciable economic loss occurs. Keep annual records that document the presence or increase of specific diseases for each bog. Incorporate keeping quality forecasts into your fruit rot management program.

Obtain proper diagnosis of new disease problems.

If the disease problem is unfamiliar or atypical of symptoms observed in the past, or if you are not getting expected response to control measures, consult with a plant pathologist. Improper diagnosis can delay the implementation of appropriate control measures and result in considerable economic loss. Refer to the Compendium of Blueberry and Cranberry Diseases for aids in identification and more information.

Adopt cultural disease control practices.

Sand on a regular basis to bury pathogen-infested leaf litter. Use late water floods to reduce the incidence of fruit rot for that season. Plant new bogs with vines taken from healthy bogs.

When leaving a Phytophthora-infested site, wash down picking equipment and boots with a 5% bleach solution. Take all precautions to reduce the movement of soil, water, and plant material from diseased bogs to non-infested bogs in order to limit the spread of pathogens.

Prune lush vines to promote good air circulation, reduce localized humidity, and speed the drying-out process.

Properly dispose of trash piles following harvest to remove sources of fruit rot fungal spores.

Symptoms of fairy ring disease on a cranberry farm

Remove trash from the bog area during or after harvest.

Cranberry leaves, stems, and fruits left behind after harvest are colonized by fruit rot fungi. Trash can serve as a source of primary inoculum for infection of uprights, blossoms, or fruit in subsequent seasons. Do not leave trash in piles around the bog. Move trash to the furthest reasonable distance from the production site. Avoid stockpiling trash upwind from the bog wherever possible.

For dry-harvested bogs, use a post-harvest flood in the fall. Any remaining trash should be removed from the winter flood before it is released.

Remove trash from a water-harvested bog during harvest or as soon after as possible.

Proper use of water is an important component to successful disease management.

Run sprinkler systems for at least 4-5 hours in the early morning when irrigation is necessary. Short (1-2 hr), frequent intervals of watering on established bogs promote shallow root growth that is more susceptible to heat and drought stress.

Newly planted bogs may need to be watered daily in short episodes (about 2 hr) until vines are established.

Schedule your irrigation such that you do not extend the period of time that the vines are continuously wet. Infection by fruit rot fungi is favored when the fruit and vines are continuously wet for long periods.

Reduce the movement of water from diseased bogs to non-infested bogs to limit the spread of pathogens.

Use practices that minimize plant stress or lush growth. Avoid promoting conditions that favor pathogen infection.

Avoid excessive nitrogen applications and improve bog drainage. Thick vine growth and poor drainage often prevent rapid drying and favor infection by fruit rot fungi.

Example of lush vine growth

Reduce plant stress from drought and heat. Irrigate vines to provide evaporative cooling. Sprinklers should be run for at least 1 hour and continue irrigating to keep the vines damp until the sheltered temperature falls below 85 F.

When conditions favor oxygen deficiency (e.g., snow cover, clouded ice, sand on ice), withdraw water from beneath the ice to provide air circulation. Winter injury may be minimized by keeping the bog flooded when soil is frozen and/or cold, windy conditions are predicted. Vines under stress (including heat, drought, and those injured by frost) are more susceptible to upright dieback.

Properly apply insecticides, herbicides, and fertilizers throughout the season. Plants weakened by pest pressures, phytotoxicity, or poor nutrition management are more susceptible to disease.

Plant new or renovated bogs with varieties that exhibit disease resistance.

The most commonly used varieties in Massachusetts are listed from the most resistant to least resistant to fruit rot organisms: Stevens, Howes, Franklin, Bergman, Early Black, McFarlin, Ben Lear, and Crowley.

Black Veil, Foxboro Howes, Matthews, Shaw's Success, and Wilcox have shown good fruit rot resistance in experimental field trials. Current availability of these varieties is limited.

Thus far, Crimson Queen, Demoranville, Grygleski, HyRed and Mullica Queen all appear to be susceptible to fruit rot, although it is not possible to rate them from most susceptible to least susceptible at this time.

No variety appears to be resistant to *Phytophthora cinnamomi*, although Stevens and Black Veil appear to be less susceptible to attack by the pathogen than other varieties.

To confirm a variety is true to type, bring uprights and *attached fruit* to the UMass Cranberry Station. Varieties can also be identified by sending samples to the Marucci Center, Rutgers for DNA fingerprinting. There will be a fee for this service.

To confirm a variety is true to type, bring uprights and attached fruit to the UMass Cranberry Station.

Minimize mechanical injury to fruit during dry harvesting.

The incidence of storage rot may be increased when fruit are injured by improperly operating harvesting machines. Injured fruit are more susceptible to infection because the fungi can

enter though the wounds. Exercise caution when dumping berries into empty bins. Take all precautions to minimize fruit bruising.

Fungicides may need to be integrated with cultural controls to obtain adequate disease management.

For most fungal disease problems in cranberries, control is obtained by preventing initial attack by the pathogen. A steady increase or noticeable change in disease problems over a few years may indicate a need to adjust your disease management program.

When multiple fungicide applications are employed as they are for fruit rot management, utilize fungicides with different modes of action against the fungal pathogens to avoid resistance development.

If you use fungicides late in the season, use less persistent fungicides at the lowest effective rate to reduce fungicide residue on fruit.

For each application system, determine and use the optimum amount of water, pressure, injection timing, etc., needed to obtain a good distribution of fungicide.

Based on conditions on your bogs, use the lowest effective rate and number of fungicide applications for fruit rot control.

When the Keeping Quality Forecast, as reported by the UMass Cranberry Station, is favorable and/or a bog has a history of low rot, consider using reduced rates of fungicides that control fruit rot fungi. Fewer applications of mid to high range rates may also be considered.

If a late water flood was used, the number of fungicide applications for fruit rot control can be reduced without compromising fruit rot control.

Cranberries with fruit rot symptoms

Consider using less fungicide per season (lower rates or fewer number of applications) if berries are grown for the processed fruit market rather than the fresh fruit market. You are only protecting against field rot as compared to field and storage rot for fresh fruit. In years of good to excellent keeping quality forecasts, no fungicides should be applied on late water bogs with berries grown for the processed market.

Keep accurate records.

Accurate records of fungicide applications are essential for farm planning and performance evaluation. Fungicide application dates, formulations and rates used, keeping quality forecasts

(preliminary and final), and fruit rot history should be recorded on an annual basis. Maintain records of any clinical diagnosis performed.

For more information:

Caruso, F. L. et al. 2010. Compendium of blueberry, cranberry and lingonberry diseases. American Phytopathological Society Press, St. Paul, MN. (currently in press).

Cranberry Bog Construction and Renovation and Water Management BMPs in this series.

Cranberry chart book - Management guide for Massachusetts. University of Massachusetts Cranberry Station. http://scholarworks.umass.edu/cranchart/.

Sandler, H.A. and C.J. DeMoranville. 2008. Cranberry production: a guide for Massachusetts, CP-08. UMass Extension Publ.

Prepared by Frank Caruso and Hilary Sandler, 2010.

Disease Management Checklist

✓ Obtain proper diagnosis of new disease problems.

✓ Practice good sanitation measures.

✓ When using fungicides, alternate different fungicide classes to avoid resistance by the fruit rot fungal pathogens.

✓ Schedule irrigation to minimize leaf wetness periods.

✓ Use the Keeping Quality Forecast to plan fruit rot management.

✓ Employ cultural practices that maintain good air movement in the vine canopy.

Integrated Pest Management

The Concept of Integrated Pest Management. Integrated Pest Management (IPM) is an ecological approach to pest control based upon sound biological knowledge and principles. Integrated pest management has also been defined as the intelligent selection and use of pest control actions that will ensure favorable economic, ecological and sociological consequences. Cranberry IPM integrates biological, cultural, and chemical control practices to manage pest problems. An integrated approach to pest management is based upon dynamic principles rather than a definitive set of rules for control of a particular pest situation.

IPM combines specific cultural, chemical, and horticultural needs of a particular crop to develop a broad-based approach to controlling the most economically threatening pests. Cultural practices, such as late water floods, sanding, and the use of disease-resistant varieties, can greatly influence the severity of a pest problem. Pesticides are used in IPM programs, tempered by their compatibility with other control measures and their consistency with IPM philosophy. Though most programs experience a decrease in spray applications, participation in IPM does not inherently result in less pesticide use. Pesticide recommendations are based upon monitoring techniques that estimate current pest pressures, and in some cases, dictate an above average number of applications.

IPM is difficult to define, not because it is so complex or abstract, but because it is an approach to pest control. It is a strategy rather than a specific and exact methodology. Its strength is in its adaptability in one form or another to all pest problems. IPM is the balanced use of cultural, biological and chemical measures appropriate· to an individual situation.

The Process of IPM. IPM is a process that relies heavily on judgment, adaptability, and the necessity to incorporate change. The process can be broken down into several basic components: education, monitoring, and decision-making. The first step is to become educated about the concepts of IPM. Education also includes mastering the techniques for monitoring pests, knowing what management options are available, and understanding what makes one site different from another. This can be achieved via workshop attendance, books, newsletters, etc. Once there is an understanding of IPM, the concepts can then be put into practice. Practicing IPM involves collecting information (monitoring) and making site-specific management choices (decision-making).

Overall vigor and nutrient status of cranberry vines play a critical role in the ability of the plant to defend itself against pests. Thus, nutrient management is included as an important component in cranberry IPM along with the traditional spheres of insect, disease, and weed management.

Recommended Practices

Educate yourself about IPM techniques and philosophy.

Subscribe to University of Massachusetts extension newsletters and other industry newsletters as appropriate.

Attend at least one workshop on cranberry production, environmental concerns, IPM practices, etc., offered by the UMass Cranberry Station, Cape Cod Cranberry Growers' Association (CCCGA), or handler-affiliated companies each year.

Refer to the Cranberry Chart Book during the growing season for details on management options. http://scholarworks.umass.edu/cranchart/.

Use guides available through UMass Extension and industry resources. Refer to identification and production guides available from other growing areas as applicable.

Include monitoring activities in your yearly production schedule as dictated by pest pressures and/or vine status.

Sweep net for cutworms, cranberry, weevils, gypsy moth, yellow- and black-headed fireworms, spanworms, and southern red mite.

Use pheromone traps for: *Sparganothis* fruitworm, cranberry girdler, and black-headed fireworm.

Pheromone traps used for black-headed fireworm and cranberry girdler

Use crop phenology to time management of cranberry fruitworm and fruit rot.

Monitor fruit for cranberry fruitworm eggs.

Make weed maps.

Conduct soil and tissue tests at recommended intervals and keep the results.

Scout using a sweep net to monitor for insects on a commercial cranberry bog.

Other helpful records may include: Action records (include pesticides and cultural practices); Sweep counts; % out-of-bloom counts; Length of growth / bloom timing; When/how/what used for pest control; Fertilizer records including symptoms and response; Upright length, density, color; Yield; Application dates and rates used, etc.

General maintenance of water control structures are important parts of IPM programs.

Flumes should be checked for water leakage on a regular basis. Tailwater recovery systems should be implemented when possible. High-efficiency nozzles, screens, or half-heads should be used in sensitive areas. Annual calibration of irrigation systems and other application equipment is recommended. Adhere to chemigation/application guidelines. Make appropriate modifications to the irrigation systems to maximize uniformity.

Use collected information for decision-making and implementation of pest management strategies

Use action thresholds when available for scouted pests. Understand how to use pheromone trap data to time insecticide sprays. Plan cranberry fruitworm control strategies/ applications based upon fruit monitoring. Use crop phenology to time fruit rot, nutrient, and cranberry fruitworm management. Use tissue and soil tests to help plan fertilizer and soil amendment program.

Development of an effective IPM program relies heavily upon selection of the most appropriate activities for each individual situation.

Growers should select non-pesticide or reduced pesticide options when appropriate. Growers should also use the appropriate BMPs and the Cranberry Chart Book (give specific management recommendations) as reference sources throughout the season.

For more information:

Averill, A. L. and M. M. Sylvia. 1998. Cranberry Insects of the Northeast. East Wareham, MA: UMass Amherst Cranberry Sta. Ext. Publ. 112 p.

Cranberry chart book-management guide for Massachusetts, University of Massachusetts Cranberry Station. http://scholarworks.umass.edu/cranchart/.

Disease Management, Insect Management, Nutrient Management, Pesticide Application, and Weed Management BMPs in this publication.

Sandler, H.A. and C.J. DeMoranville. 2008. Cranberry production: a guide for Massachusetts, CP-08. UMass Extension Publ.

Sandler, H. A. 2008. Challenges in integrated pest management for Massachusetts cranberry production: A historical perspective to inform the future. Pages 21-55 *in* E. N. Burton, and P. V. Williams, eds. Crop Protection Research Advances: Nova Publications, New York.

Updated by Hilary Sandler, 2010.

Integrated Pest Management Checklist

✓ Consult the most current Cranberry Chart Book for pest management recommendations. http://scholarworks.umass.edu/cranchart/.

✓ Regularly attend educational workshops on pest management and IPM.

✓ Use monitoring techniques, such as sweep netting, to estimate insect thresholds.

✓ Use cultural practices, such as flooding, pruning and/or sanding, to manage insect, disease, and weed pests.

✓ Routinely maintain and inspect application equipment to ensure proper application of pesticides.

✓ Use crop phenology to time disease and insect management strategies.

✓ Use horticultural practices that maximize good soil drainage and good air circulation in the vine canopy.

Insect Management

Minimizing injury to the plants and crop loss by insect pests is one of the greatest challenges in cranberry production. Failure to manage pest insects properly can result in severe crop loss, vine injury, or in extreme cases, the death of large areas of the bog. The most effective insect management strategy uses scouting techniques to monitor insect populations and an integrated approach combining cultural, biological, and chemical control measures that are applied only when the insect population reaches an action threshold. The action threshold is the 'break even' point where injury by a certain pest population is expected to exceed the cost of the management measure (usually a pesticide application). The threshold number varies depending on the potential of a given insect species to cause economic damage.

Recommended Practices

Properly identify the insects on the bog, both the pests and the beneficials.

The success on any management strategy depends on the correct identification of the players on the bog. There are many insect pests and, for any given species, management approaches may be very specific. Further, there are many species of insects that regularly appear on beds, but that have no pest status. Plus, there are many beneficial insects that prey on or parasitize pest species.

Natural populations of beneficial organisms can help to control insect pests.

Predators and parasites that coexist in the bog environment play an important role in regulating cranberry pest populations, particularly cranberry fruitworm and Sparganothis fruitworm. This role should be enhanced wherever possible by avoiding unnecessary insecticide treatments and encouraging growth of natural enemy populations through conservation. New compounds such as Intrepid and Avaunt preserve natural enemies. Broad-spectrum 'clean-up' sprays, particularly Lorsban, destroy natural enemies and applications should only be considered when numbers exceed the action threshold. Whenever possible, if there is a management option that will preserve beneficial species, use it.

Use appropriate cultural control methods

Late water floods affect many insects in the year of the flood. Emergence of insects is delayed and often synchronous (all individuals hatching over a short period of time rather than spread out over several weeks). Late water can be used to manage the following pests: cutworms, gypsy moth, cranberry fruitworm, and Southern red mite (SRM). Late water is especially effective against SRM; control often lasts for more than one season. It is best to limit the use of late water to every third year. For specific information regarding late water and management of insects and mites, see the Cranberry Chart Book (http://scholarworks.umass.edu/cranchart/).

Summer floods (May 12 to July 20) can be used to manage cranberry root grubs and other white grub species. The drawback to the summer flood is that the crop for that season will be lost, and there may be lowered yield the following year as well. The advantage is that a single season crop loss is less costly than renovation. Additional benefits of the summer flood include control of all insects and reduction of dewberry (bramble) populations.

Detrashing floods and sanding are important in the management of **cranberry girdler**. The girdler insect larvae live in the trash (leaf litter) layer on the floor of the bog. Regular removal of this layer by using detrashing floods and at harvest can aid in the management of this

insect. Sanding on a regular basis also suppresses cranberry girdler by burying the trash layer and insect pupae. Sanding has horticultural and disease suppression benefits as well. For further information see the Sanding BMP.

Adequate nutrition, irrigation, and care with herbicides on beds impacted by soil insect injury may be important to avoid further levels of stress on the vines.

Short floods may be used for effective insect control. **Cranberry girdler** can be controlled by flood of 6 days duration applied between September 20 and 30, beginning no later than September 25. A flood of 12-14 days duration applied immediately post-harvest controls **black vine weevil** and **strawberry root weevil**. A flood on or about May 18 for a duration of 10 hours controls **false armyworm and blossomworm.** A flood of 10 hour duration applied between June 1 and June 12 controls several insects, but crop reduction and impact on fruit quality should be expected if this flood is used.

When planting or renovating bogs, for each chemigation system, interplant only those varieties that bloom at the same time.

Timing of cranberry fruitworm management is based on the percent out-of-bloom of the cranberry plants and relies on determination of when the first berries begin to size up. To get the most effective levels of control, all of the plants being treated should be at the same growth stage. Avoid planting early and late varieties under the same irrigation system. Having all plants at the same developmental stage within each treatment unit (sprinkler system) will also increase fungicide efficacy.

Only apply insecticides if damaging numbers of insect pests are present.

Insecticide use must be restricted to situations where it is needed to avoid crop or plant loss. Intensive scouting and accurate pest identification should be used to measure insect infestations. Action thresholds (where economic loss due to insects is expected exceeds the cost of managing the pest) are then employed to ensure that only essential applications are made. Current standards allow zero tolerance for cranberry fruitworm larvae in fresh fruit. Standards may be slightly higher for processed fruit.

An effective scouting program for insect management should include: **sweep netting** the bog on a weekly basis to monitor populations of cutworms, cranberry weevils, gypsy moths, fireworms, spanworms, and SRM; **calculating percent out-of-bloom**; **inspecting cranberry fruit** for cranberry fruitworm eggs; **trapping and counting** *Sparganothis* fruitworm, cranberry girdler, and black-headed fireworm moth populations with pheromone traps.

The information gathered by sweep netting and counting eggs is used to make decisions regarding the need to apply pest management measures. Percent out-of-bloom and trap information are used to time management sprays. For threshold and timing information refer to the Cranberry Chart Book.

Consider spot-treating when insect pests are confined to small areas of the bog.

Many insect populations are distributed unevenly on the bogs. This is especially true of cranberry weevil, spanworm, and gypsy moth. Weevils fly in from surrounding uplands and gypsy moth larvae blow in from surrounding trees on wind currents. This often leads to a situation where sweep net counts are only high in a confined area of the bog, usually an edge or neck. Treating the population in the infested area may eliminate the need for spraying the whole bog. The earliest infestation of cranberry fruitworm occurs on the bog edges and populations could be limited over time by spot treating these early populations.

Incorporate environmental risk into insecticide selection. Consider the vulnerability of the site and the pesticide toxicity.

When an insecticide application is necessary, product selection should be designed to avoid any potentially adverse environmental effects. Factors such as risk to non-target organisms, toxicity, persistence, and leaching potential should be considered. If the potential for adverse aquatic impact exists (e.g., flow-through or sensitive aquatic sites downstream), use less toxic compounds.

When using insecticides, impound water to protect non-target organisms.

Holding water within the bog and ditch system is extremely important in reducing the potential for adverse aquatic impacts. Regardless of the pesticide, water should be held no less than the required minimum holding times noted on the pesticide label and longer if practical. Check the current Cranberry Chart Book for current holding times.

If chemical pesticides must be used to control insect pests, make every effort to minimize application to non-target areas.

For further information, see the Pesticide Application BMP.

Avoid inducing insecticide resistance in pest populations.

Repeated insecticide applications of the same compound or family of compounds can increase the likelihood of resistance in certain insects, especially to sequential generations in the same year. This may be avoided by integrating biological and cultural controls into management programs and reducing insecticide inputs as much as possible. Alternate materials with different modes of action to minimize resistance. Avoid 'cleanup' and calendar sprays.

Time management strategies properly to target the vulnerable life stage of the insect pest.

Use pheromone traps to time management of black-headed fireworm, cranberry girdler, and Sparganothis fruitworm. Follow the protocol in the Cranberry Chart Book.

Timing of the first fruitworm spray is critical. First fruitworm insecticide applications are timed based on the stage of the cranberry plants. For further information, see Cranberry Chart Book (http://scholarworks.umass.edu/cranchart/).

Do not spray insecticides to target cranberry fruitworm larvae already in the fruit. There is no evidence that such sprays are effective.

Do not spray compounds that are toxic to bees during bloom

If application of an insecticide during bloom is absolutely necessary, apply it by sprinkler after dark. Aerial applications should be delayed as late into bloom as possible and the bee keeper must be advised prior to application. Sevin-XLR+ has been formulated to have minimal toxicity to bees once the spray has dried. However, it is best to avoid all insecticide applications when bees are present.

Use proper techniques to maximize efficacy of nematodes against some soil pest species.

Nematodes may be available for the control of cranberry girdler, black vine weevil, and strawberry root weevil. Timing for the use of nematodes to manage cranberry girdler is based on moth flight data collected via pheromone trapping. For more information on use and timing of nematodes for insect management, see the Cranberry Chart Book.

For more information:

Averill, A. L., M. M. Averill, and C. J. DeMoranville. 1994. Alternative management strategies: impact of late water on cranberry fruitworm and mites. Cranberries Magazine 58(4):4, 23-25.

Averill, A. L. and M. M. Sylvia. 1998. Cranberry Insects of the Northeast. East Wareham, MA: UMass Amherst Cranberry Sta. Ext. Publ. 112 p.

Cranberry chart book-management guide for Massachusetts, UMass Cranberry Station. http://scholarworks.umass.edu/cranchart/.

Franklin, H. J. 1948. Cranberry insects in Massachusetts: part I. Bulletin #445. Massachusetts Agricultural Experiment Station. (Part I covers fireworms, cutworms, spanworms, gypsy moth, cranberry fruitworm, cranberry weevil, cranberry tipworm.)

Franklin, H. J. 1950. Cranberry insects in Massachusetts: part II-VII. Bulletin #445. Massachusetts Agricultural Experiment Station. (Part II covers Southern red mite, blunt-nosed cranberry leafhopper, cranberry flea beetle; Part III covers cranberry girdler; Part IV covers soil insects including grubs.)

Franklin, H. J. 1952. Cranberry insects in Massachusetts: supplement. Bulletin #445. Massachusetts Agricultural Experiment Station. (This volume covers less common pests.)

Integrated Pest Management and Pesticide Application BMPs in this series.

Sandler, H.A. and C.J. DeMoranville. 2008. Cranberry production: a guide for Massachusetts, CP-08. UMass Extension Publ.

Updated by Anne Averill and Marty Sylvia, 2010.

Insect Management Checklist

✓ Consult the most current Cranberry Chart Book for insect management recommendations. http://scholarworks.umass.edu/cranchart/.

✓ Regularly attend educational workshops on insect management.

✓ Use monitoring techniques, such as sweep netting, to estimate insect thresholds.

✓ Use crop phenology to time insect management strategies.

✓ Use reduced-risk insecticides whenever possible.

✓ Practice good plant nutrition to maximize plant health and defense against insect damage.

✓ Use cultural practices, such as flooding, pruning and/or sanding, to manage insect pests.

✓ Routinely maintain and inspect application equipment to ensure proper application of pesticides.

Managing Animal Damage

Certain wildlife species may cause damage to agricultural property at various times during the year. The Animal Damage Control (ADC) program, part of the Animal and Plant Health and Inspection Service (APHIS), recommends using integrated pest management (IPM) to reduce wildlife damage. Animal or varmint IPM may involve adjusting management practices, dispersing animals, and/or removing specific individuals. Residents of Massachusetts may wish to consult CMR 131:37, which details the exception to the game laws when property damage is occurring.

Recommended Practices

Canada Geese

Canada geese are known to dig into the soil surface, looking for food. This activity can be very destructive and cause injury to large areas of vines. They can feed on fruit and new growth and may also affect water quality. Canada geese are protected by the Migratory Bird Treaty Act of 1918. This act states that it is unlawful to hunt, kill, sell, purchase, or possess migratory birds. However, many populations of Canada geese have become non-migratory. Under certain circumstances, time-limited hunting permits may be issued through the U.S. Fisheries and Wildlife Service (see "For more information" at end of the BMP).

Manage floods to minimize goose damage.

In new bogs where goose damage is likely to occur, leaving the bog out of winter flood is advisable unless severe winterkill conditions occur. If fruit is needed or expected on the bed, flood only when winterkill weather arrives. Diligently guard the bog until the flood freezes. Immediately upon thawing, remove the flood as soon as possible. Very shallow floods will reduce damage as geese dig by paddling their feet, not by digging with their bills. If they cannot float on the water, they cannot dig by paddling.

Weed control is key for managing geese populations.

Control wild bean and nutsedge populations, which provide an excellent food source for the birds. Canada geese dig for the ground nuts produced by wild bean plants. Geese will also dig up new plantings while feeding on nutsedge populations. This behavior can cause serious rutting. Some growers opt to hand-remove nutsedge seed heads during the mid-summer to minimize the spread of the nutsedge

Proper management of your weed populations can save you thousands of dollars of damage caused by geese.

Scarecrows, whistle bombs, and the use of dogs are generally not successful deterrents.

As a first step, you need to use common scare tactics on your farm to determine whether or not they will work in your situation. In general, animals are not frightened by sounds alone. Scare tactics will provide some deterrence only if used in conjunction with lethal force tactics. If the employment of scare tactics is unsuccessful, you may then seek to obtain a permit to hunt year-round on your property.

Geese quickly learn whether you are just "making noise" or whether they will actually suffer injury if they do not move away from the site. Growers report that geese will "learn" to recognize the vehicles that carry the hunters.

If your geese problem is severe, consider allowing hunting on your property during the appropriate season(s) of the year.

Geese quickly learn where they are and are not safe. Property owners who allow hunting on their property without collecting a fee are not liable under Massachusetts law for injury, death, or property damage incurred by the hunters unless "gross negligence by the landowner" can be proved.

In addition to the regular hunting season (for which you must obtain a license from the MA Division of Fisheries and Wildlife), Massachusetts allows two additional hunting seasons for non-migratory geese. You must apply for a permit from the U. S. Fisheries and Wildlife Service to hunt geese during these periods. The dates vary depending on your county of residence, but the general time periods are early September and/or late January-February.

Deer

Deer may wander onto cranberry bogs and eat foliage or berries. Anecdotal evidence indicates that a deer may eat 2-4 barrels of cranberries over the course of a season. They can also cause damage by trampling vines and fruit or by bedding down on the vines. They also leave behind feces that are difficult to remove and interfere with harvesting, cleaning, and processing of fruit.

Repellents such as soap, hot pepper spray, predator urine lures, and distasteful compounds such a 'Hinder' or 'Bitter apple' are not approved for use on food crops.

In addition, repellents not associated with a human presence have met with limited success.

Small acreage may be protected by frightening methods.

Deer are wary of humans and may be kept at bay using 24-hour talk radio, flash tape, and motion type devices. The most common scare device is the propane exploder. Shell crackers can also be used to frighten deer.

Deer must have two senses stimulated before they are frightened away. Therefore, they are not repelled by sight or sound only.

Deer may be excluded through the use of fences.

However, this is a very expensive alternative. A straight ten-foot fence provides no barrier to a deer determined to feed on the bog. A 7-foot fence inclined at a 25° angle out from the vertical will deter deer as they have poor depth perception. Deer fences are typically made of poly or steel wire.

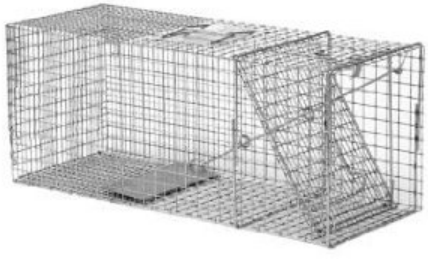
Electric fences can be used and are relatively less expensive than traditional fence. These should also be inclined and not installed straight up and down.

Muskrats

These rodents have been identified as destructive and/ or nuisance species on producing cranberry farms. They can burrow into water control structures such as ditch edges and dikes. Deterioration of these structures can lead to catastrophic results, e.g. personal injury, equipment damage, and loss of harvest or winter flood water.

Non-lethal traps are the first type of trap that must be used against muskrats.

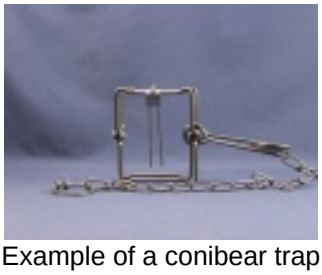
Use of leghold traps are prohibited and growers must use alternative methods to discourage damage by these animals. Growers are allowed to use non-lethal traps on their property for the purpose of capturing nuisance muskrat or beaver. Non-lethal traps include box or cage-type traps that contain the entire animal without grasping any part of the animal.



Example of a box (nonlethal) trap.

Where populations are high and damage is severe, a special permit is available for lethal trapping.

If non-lethal traps prove ineffective for more than 15 consecutive days or if a muskrat or beaver is posing an immediate threat to your agricultural property, which has caused or is about to cause a loss in production or will prevent normal agricultural practices from occurring, you can receive an emergency 10-day permit from the director of the Department of Fisheries and Wildlife. Emergency permits allow the use of body-gripping (Conibear) traps. Leg-hold traps are not allowed under emergency permits. If there is an immediate threat to human health and safety, applicants can instead request an emergency 10-day trapping permit from your local board of health. A 30-day extension can be sought on both types of emergency permits, if not successful during the first 10-day period.



Example of a conibear trap

If you are trapping animals on your own property that is principally used for agriculture, you do not have to be a licensed trapper to use body-gripping traps. Otherwise, you do need to be licensed and your traps registered with the state or you need to hire a licensed trapper or a Problem Animal Control agent.

Other types of traps can be used, but offer variable degrees of success.

Muskrats do not readily enter live traps. Apple and iris baits may attract a few individuals, but are generally unsuccessful.

Growers can use box, cage, or net methods, commonly referred to as the “Havaheart” traps. These traps are typically more cumbersome, require camouflaging, and can be more labor intensive than the grasp traps.

When constructing new dikes in areas with high populations of muskrats, bear in mind that muskrats like steep slopes.

Construct gentle slopes that are much less attractive to muskrats. Place chicken wire around the flume to prevent digging.

Voles, Woodchucks, and other rodents

These animals live underground where moist, sandy soils are common and digging is easy. They can do significant damage by burrowing, cutting tunnels through the vine and eating seeds and berries. Woodchucks cause drainage damage and drought damage by excavating burrows on the sides of bogs and pushing fill into the ditches. Generally, these problems are more severe on "dry bogs" that are not flooded. Chronic damage may cause large portions of the bog to become unproductive. Frightening methods are not effective in reducing rodent damage.

Encourage natural predators.

Consider constructing owl and kestrel boxes beside the bog and provide perches for hawks and other raptors. Consider leaving coyote and fox dens on the property undisturbed.

Mowing around the bog will increase predator success and reduce the seed available for rodent use. Keep in mind that this may also serve to drive voles and other small rodents into the producing area of the cranberry bed.

In severe cases, other alternatives are available.

Runs used by voles, weasels, and mice (but not woodchucks) can be guarded with sticky cards or snap traps if enclosed or covered.

Zinc phosphide (a fast-acting rodenticide) can be used in noncrop areas surrounding the bog and buildings. Bear in mind that rodenticides are toxic to humans, other mammals, and some birds. Handle all baits and poisons with extreme care.

Woodchucks can be trapped easily in live traps, but cannot be legally transported and released in another location.

Woodchucks may be shot year-round if you have a hunting license (no permit needed).

Burrowing rodents can be killed using smoke grenades or engine exhaust piped into the sealed burrow.

For more information:

Code of Massachusetts Regulations: 321 CMR 3.00 Hunting.

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Trapping section of the Massachusetts Division of Fisheries & Wildlife web site at http://www.mass.gov/dfwele/dfw/recreation/trapping/trapping_home.htm.

USDA, APHIS, Animal Damage Control (ADC) web site. http://www.aphis.usda.gov/wildlife_damage/

US Fisheries and Wildlife Migratory Bird Permit Office. P.O. Box 779, Hadley, MA 01035. (413) 253-8643.

Updated by Hilary Sandler and Brian Wick and reviewed by CCCGA Environmental Committee, 2010.

Managing Animal Damage Checklist

- ✓ Use IPM to reduce animal damage.
- ✓ Confirm that any repellent (or similar) products are approved for use on food crops.
- ✓ Familiarize yourself with the relevant state regulations regarding trapping, etc.
- ✓ Contact state agencies if you have any questions about licenses or regulations.
- ✓ Obtain needed permits to pursue lethal control measures.

Nutrient Management

Nutrient elements are required by cranberry plants for the production of vegetation (new leaves and stems), roots, and fruit (crop). Cranberry plants get these nutrients from the soil, from water, or from fertilizers added to the bog. While cranberries require the same nutrients as other plants, they are unique in that the *amounts* required are much smaller than for most crop plants. The reason for this is that cranberries have adapted through evolution for growth on acidic, sandy or organic soils. These soils have little nutrient content, and the plants in the family Ericaceae such as cranberries and blueberries that evolved on them have correspondingly low nutrient needs. Further, cranberries are perennial plants with the capacity to store and reuse nutrients in old leaves, wood, and roots. A unique and important feature of cranberries is that they maintain their leaves over the winter. These leaves also serve as a nutrient source when the plants resume growth in the spring.

Commercially, cranberries are grown in either organic soils modified by surface application of sand, or in mineral soils. On most Massachusetts cranberry bogs, the rooting zone typically contains about 95% sand -- the average organic matter in the surface horizon is less than 3.5% and silt and clay make up less than 3% of the soil. Therefore, the root zone of a cranberry bog has low cation exchange capacity: little ability to hold positively charged nutrients such as ammonium, potassium, magnesium, and calcium. This can present horticultural and environmental challenges. On the horticultural side, it is important to retain nutrients in the root zone where they can be taken up by the plants. On the environmental side, the layered structure of cranberry soils attenuates the downward leaching of nutrients. Layers of sand are added to the bogs every 2-5 years leading to alternating sandy and organic layers. The organic layers, comprised of decaying roots and leaves, have the capacity to hold nutrients. Leaching is further minimized if the subsoil is highly organic, as in a peat-based bog. These characteristics protect the ground water, but growers must still guard against movement of nutrients into surface water.

Cranberry runners, uprights and fine fibrous roots

Why cranberries need fertilizer: Each season nutrients are removed from the bog during harvest and detrashing (removal of fallen leaves and debris from the bog floor). During harvest, the elements removed in the largest quantities are nitrogen (N), potassium (K), and calcium: >20 lb/acre (N) or >15 lb/A (K and calcium) in an average (150 bbl/acre) crop. The amount of nutrient removal increases with larger crops and is less when crops are small. Phosphorus (P) removal is 4-5 lb/acre in an average crop. Cranberry growers add fertilizer to their bogs to compensate for the nutrient removal. Most fertilizer added to producing cranberry bogs contains nitrogen, phosphorus, and potassium in various ratios (N-P-K fertilizer). While P removal is low, some P is included in the mixture to maintain nutrient supply and because much of the P in cranberry bog soils binds with iron or aluminum and is

not available to the plants at crucial growth stages such as bloom. The exact fertilizer composition is chosen based on soil type, time of year (plant stage), and plant requirements, including information supplied in tissue testing and knowledge of the amount of nutrient that will be removed in crop and used in new growth during the season. Fertilizer is applied to cranberry bogs using ground rigs (spreaders and seeders), helicopters (aerial application), and the sprinkler system (fertigation).

Properly managing the amount of fertilizer used on cranberry bogs can have both environmental and financial benefits for growers. Financial benefits (cost savings) may be achieved by not applying more fertilizer than necessary, using split applications to increase efficiency (and reduce amount applied), and limiting N applications to avoid a shift from fruit production to production of vegetation. While it is important to consider financial benefits when choosing nutrient management practices, always consider the potential impact to water quality and requirements for meeting water quality standards when formulating your management plan.

Nutrient and water management go hand-in-hand in cranberry production. Many recommendations for nutrient management BMPs relate to water management. Also review the Water Management BMPs as you design your nutrient management plan.

Recommended Practices - General

Review the Cranberry Chart Book regularly and attend educational programs.

The BMP Guide is revised periodically but the Chart Book Nutrient Management section is reviewed and updated annually. As research results and grower experiences increase our knowledge, the newest information will appear first in the Chart Book and at annual update meetings held during the winter.

Formulate a nutrient management plan for each management unit and review it regularly.

A good nutrient management plan should be part of your whole farm planning efforts and is included in a conservation farm plan. Technical assistance for planning is available through the USDA Natural Resource Conservation Service (NRCS) and the Conservation Districts. Financial assistance for plan implementation may also be available from NRCS.

Base fertilizer use on the properties of your bog – be site-specific.

Nitrogen (N) applications are important in cranberry nutrient management. But the average recommended seasonal rate of N can vary from 10 to 60 lb/acre depending on the characteristics of the soil, the cultivar being grown, the weather that season, the general appearance (length and color of uprights) of the plants, and the amount of crop produced. Some of these factors are fixed on a given bog, but others vary each season. Seasonal phosphorus (P) rate should be adjusted based on cultivar and tissue test results. Additional guidance on choosing a fertilizer rate is provided in the Cranberry Chart Book (http://scholarworks.umass.edu/cranchart/) and in the “Nitrogen for Bearing Cranberries” bulletin.

To accomplish site-specific management, it is important to keep good records of past applications and responses, to be aware of the weather including rainfall and soil temperature, and to observe the bogs frequently to assess vine response and crop potential.

Keep detailed records of fertilizer use, water management, and crop response.

This is the single most important practice you can do when it comes to managing cranberry bog nutrition. Every bog responds differently depending on soil factors, organic matter content, depth of underlying peat, location (spring temperatures), and previous cultural practices. Learn how yield and plant tissue mineral content on your bog respond to fertilizer and plan accordingly. This information will allow you to refine your nutrient management plan each season. Information that you gain in this process can also be shared with fellow growers and extension professionals in order to advance industry knowledge.

Weather records, including rainfall and soil temperature, are also helpful. Record fertilizer applications (rate and date of application) for each management unit. Also record flood practices (e.g. late water), sanding, pruning, and any other practices that can interact with nutrient management.

Test soil for organic matter and pH every 2-4 years. Soil tests can be taken in the spring or in the late summer with the tissue test. Test plant tissue for mineral content every 1-4 years depending on previous results and variability in your fertilizer applications. For example, more frequent testing is called for if you have been changing your management. Collect the samples between Aug. 15 and Sept. 15. Tissue tests are important 'report cards' for how well your nutrient management is supporting the plant needs.

Observe your bog often. Do not be afraid to modify your fertilizer plan as conditions warrant.

Make a plan for the season in the early spring based on your records and expectations, then monitor response as the season progresses. The amount of fertilizer to be applied may need to be adjusted depending on spring temperatures, stress from diseases or insects, or plant response (or lack thereof). However, remember that all fertilizers are not fast-acting and cold temperatures can slow response. Do not add more until you are SURE that it is warranted.

Do not starve the plants before bloom then make a heavy fertilizer application.

Aside from water, the most important constituents of the fruit are carbohydrates (acids and sugars) that the plants make in the green leaves and transfer to the fruit. Plants that are starved for mineral nutrients in the spring will not make enough new green leaf surface to produce the carbohydrates necessary to support a large crop. Adding large amounts of fertilizer to stunted plants will not set a large crop of fruit. By that time, fertilizer is no longer the limiting factor *if* nutrition was inadequate earlier.

Wait for soil temperature to rise to 55º F before applying spring fertilizers.

Cranberry plants have little ability to take up nutrients when the soil is cold. Fertilizers applied too early in the spring may volatilize, wash out of the root zone or become tightly bound to the soil (and not available for uptake) before the soil warms enough for uptake into the plants.

Good drainage and adequate irrigation are essential for best response to fertilizer.

Moisture and aeration in the soil can determine nutrient availability. Plants take up nutrients dissolved in the soil water. If soil is too dry, minerals cannot dissolve and move to the roots and uptake cannot occur. Conversely, if soil is waterlogged, oxygen the plant needs for root respiration to drive active uptake will be limited. In fact, an irrigation study showed that when the bog is too wet, fruit set declines. High manganese levels on a tissue test may indicate poor drainage.

Installation of a drainage pipe on a newly prepared farm surface

Proper soil drainage improves fertilizer efficiency so that less fertilizer is required. Check soil moisture at least twice a week; soil should be moist but not saturated in the top 6 inches. The use of water-level floats, sensors, and/or tensiometers is highly recommended.

Calibrate fertilizer application equipment.

Proper calibration of application equipment including the irrigation system, ground rigs, and aircraft will ensure that the desired dose of fertilizer is applied. Calibrate ground application equipment as recommended by the manufacturer and cross check by observing that the amount applied per desired area is achieved. Directions for irrigation system timing are in the Chemigation section.

Recommended Practices - Protection of water quality

Fertilizer N and P can be environmental pollutants. N is of particular concern in estuarine waters, while P is primarily associated with degradation of water quality in inland, freshwater systems. When excess P is provided in such systems, algal blooms (eutrophication) can result. Some of these algal blooms are comprised of bluegreen algae (cyanobacteria) and may contain natural toxins which can harm humans, domestic animals and wildlife. As the algal population peaks and the algae die, oxygen in the water is depleted, which may ultimately result in fish kills. While leaching is of minimal concern in cranberry fertilizer management, the potential for movement of N and P in surface water should be taken into account in management decisions.

It is always the best practice to limit the off-site movement of N and P in surface water so as to prevent environmental degradation. It is critically important to use all practices available to limit movement of N and P in surface water that will ultimately drain to an impaired body of water. The water quality in many estuaries and ponds has degraded to such critical levels as to warrant being listed by the Commonwealth on the Federal Clean Water Act's 303(d) list, also known as the Integrated List of Waters. In order to comply with the Federal Clean Water Act the State is required to establish federally enforceable limits to pollutants, from all sources, to ensure that water quality is restored. This limit, known as a Total Maximum Daily Load ("TMDL"), is a regulatory limit that defines the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the use of those waters for drinking, swimming, recreation and fishing. You should be aware of whether your bog discharges to an impaired or sensitive receiving water. If a TMDL for nutrients is in place for the water body receiving discharge from your bog, you

must modify your discharge load to comply with the specific reduction in nutrients required by that TMDL.

To ensure protection of aquatic life, maintain water visibility, prevent algal blooms (especially toxic bluegreen blooms) and other environmental considerations, growers need to be aware of the amount of total P in the discharge flow when releasing water directly or indirectly to any impaired water bodies. This may involve testing of the water prior to and/or during the release. Test results can then be compared to accepted impaired water body standards. If the water test results show that standards are not being met, management changes may be required, including full implementation of recommended BMPs.

To determine if a bog directly or indirectly discharges to an impaired water, and for further information on fresh-water TMDLs, consult the Massachusetts Integrated List of Waters Found at http://www.mass.gov/dep/water/resources/tmdls.htm or contact the CCCGA office or your local Conservation District. For information on water testing procedures and analysis, please contact the UMass Cranberry Station.

Avoid large quantities of fertilizer applied at one time.

The root zone of cranberry soils is quite sandy and has little capacity to hold added nutrients. Fertilizer application rates in excess of the amount that can be taken into the plants within a reasonable period of time (generally about 2 weeks) will result in some of the nutrients moving out of the plant root zone during rainfall and irrigation events. These nutrients are potential sources of off-site contamination.

Apply fertilizers to respond to crop demand.

The timing of nitrogen and phosphorus applications is an important factor affecting the potential for nutrient loss to the environment. The greater the time between application and plant uptake, the greater the chance for loss to ground or surface water. It is best to time fertilizer applications based on the stage of plant growth. Applications should be delayed when spring temperatures are cold. Cranberry plants respond to nutritional support during initial leaf expansion in the spring, during bloom, during fruit set, and during bud development for the following season. The greatest demand occurs during vigorous shoot growth, bloom, and early fruit development (set). In most years, this period occurs between mid-June and mid-July. Fertilizer requirements at the other growth stages (early spring and late summer) are less.

Exercise particular caution in applying fertilizer to bogs that are sandy or drain excessively.

Both of these conditions increase the risk of leaching and may be characteristic of new or renovated plantings. Consider the use of organic or slow-release fertilizers and avoid large amounts of soluble materials applied all at once. Sand contributes minimal nutrients so fertilizer requirements may be larger than those of organic-based bogs. This requirement may be best satisfied by frequent small applications of fertilizer or slow-acting, low-leaching materials. Mineral soil bogs may also require occasional minor element supplementation, but the use of these materials should be based on tissue test results.

If some is good, more is not necessarily better.

Over the past 30 years, a body of research has shown that the predominant limitation to cranberry yield is photosynthesis, the process in which green plants harness the energy of the sun in carbohydrates that are then used in the structure of vines and berries. While a nutrient *deficiency* can limit yield, once nutrients are within the required range, adding more will not overcome other limitations to yield. An excellent resource summarizing this body of

research is "The Physiology of Cranberry Yield", (http://scholarworks.umass.edu/cranberry_factsheets/).

Supplying enough N to ensure adequate leaf area and green pigment is important to support carbohydrate production but if you add excess N, you will begin to see plants that are producing leaves and stems at the expense of fruit. Adding more than 20 lb/acre P in the absence of a tissue deficiency has never been shown to increase yield in any research study or in any study of commercial plantings in Massachusetts or Wisconsin. In fact, there is good evidence that less than 20 lb/acre is adequate for native cultivars or beds with high tissue P.

Excess fertilizer N and P can have adverse impacts on the environment. If the plant cannot use the fertilizer and does not take it up, the potential exists for movement into ground or surface waters. The unused nutrients also represent money and energy wasted.

Prevent direct input of fertilizers into surface water.

Preventing direct application of fertilizers to streams and ditch water is the single most important step in reducing the potential for off-site movement of nutrients. Use of part-circle sprinklers or sprinkler guards can be effective in minimizing direct application to water. Persons applying fertilizers with ground rigs should be cautious about keeping fertilizer out of ditch water. It is difficult to control non-target application of aerially applied fertilizer, so consider other methods in environmentally sensitive areas. Avoid heavy irrigation immediately following fertilizer applications to minimize surface runoff and do not apply fertilizers when heavy rain is predicted.

Reduce the level of water in ditches as much as possible prior to application of fertilizer.

Lowering the water level in ditches before a fertilizer application will allow for adsorption of nutrients onto sediment and vegetation in the ditches and increases the water holding time in the system. Research has shown that cranberry bogs have a great capacity to filter nutrients, especially N, from water. Slowing the water movement through the system maximizes this process.

Use of fall fertilizer is not recommended.

Fertilizer applied in the fall has the greatest potential for leaching loss, especially on mineral soil bogs. Fall fertilizer may be moved below the root zone by the weight of the winter flood and any added phosphorus may dissolve into the flood. It is preferable to apply supplemental fertilizer in the following spring, particularly if harvest occurred later in the fall.

Occasionally, fall fertilizer applications may provide cultural benefits on bogs showing symptoms of stress, where the late summer tissue tests show deficiency, or where crops have been especially heavy. Answer the questions in the box to decide if a conservative application of fall fertilizer use is indicated.

Should I Use Fall Fertilizer?

Question	Answer	Fall fertilizer?
Are your vines lush or long?	Yes	No
Did you have a big crop?	No	No

Have you already applied more than 30 lb N (50 lb for hybrids)?	Yes	Probably not
Does the bog have deep organic soil with normally little need for early spring fertilizer?	Yes	Probably not
Did the late summer tissue test show deficiency?	Yes	Maybe

If you still think that fall fertilizer is needed, follow the recommendations below.

- Apply only when necessary (see the box)
- Apply no later than mid-November
- Apply only when soil temperature is >50º F
- Apply no more than 5 lb/acre N
- Choose a product with little or no P but high K

P is not needed in the fall (natural release from the soil is occurring), but added K may enhance hardiness. N and K are the two elements that are removed in the greatest quantity in harvested fruit; P is at much lower concentrations in the berries.

If fall fertilizer is applied too soon after an early harvest, cold tolerance may be reduced. For late harvest, fertilizer should be applied soon after the harvest flood is removed to maximize the time between fertilizer application and the winter flood and minimize nutrient leaching. Applications when soil temperature is below 50º F are not likely to be taken up into the plant.

Limit water discharge during seasonal fertilizer application periods.

Limit the flow out of the bog system during the seasonal period when fertilizers are applied. This may be accomplished by impoundment, dropping ditches prior to fertilizer applications, diverting flow through by-pass canals, or capturing outflow using tailwater recovery channels and ponds. Also be aware of forecasted rain events.

N concentration in discharge water can be attenuated as the water flows through open streams, wetlands, and ponds. This natural attenuation involves the conversion of dissolved N in the water to gaseous forms that dissipate into the air. Additional small amounts of N may be taken up by wetland plants along the pathway. When water must flow out of the bogs, take steps to maximize natural N attenuation as the water moves towards coastal waters. This can be accomplished by installing by-pass canals, tailwater channels and ponds, or by increasing the length of the pathway the water travels, increasing the residence time of the water prior to ultimate discharge to coastal waters. If a tailwater system is employed, water conservation is also accomplished.

If recommended P fertilizer rates are followed, the data suggest that commercial cranberry bogs can achieve relatively low seasonal discharges of P. If the bog discharges to sensitive waters, lakes or downstream impoundments, additional lowering of export rates may be necessary. This could be achieved by the diversion of some or all discharge water within your water management system for reuse or storage, recycling the water to the greatest extent possible.

Manage harvest and winter floods to minimize P mobilization and discharge.

Cranberry soil chemistry, particularly the high iron and aluminum associated with acidic soils, leads to extensive binding of P as iron and aluminum phosphates in the soil. That P can be released from such compounds when flooded soils become anaerobic (depleted of oxygen). In the absence of oxygen, iron and aluminum change chemical state and no longer strongly bind P. This presents a risk during long floods used in cranberry management.

When fertilized bogs are flooded, P is released from the soil into flood water. As the oxygen depletes from the soil (~10 days), additional, and often substantial, P release occurs. The magnitude of both release events appears to increase when fertilizer P applications exceed 20 lb/acre.

Data from laboratory and field studies indicated that native cranberry wetland soils can act as sinks for P under aerobic (oxygenated) conditions. Under commercial management with P fertilizer applications, cranberry soils no longer removed P from water and when fertilizer P applications exceeded 20 lb/acre, P moved from the bog soil into flood water even under aerobic conditions. As beds were held in flooded conditions the soil became anaerobic after ~10 days and P was released into the water regardless of bog management. However, the magnitude to P release from the soil was proportional to previous fertilizer P additions.

Recommendations to limit P discharge from bogs:

- Do not exceed 20 lb/A P (~45 lb/acre P_2O_5) per season to minimize the risk of P moving into floods.
- Reduce P to less than 20 lb/acre P per season if tissue test P is >0.16% and on native cultivars with adequate tissue P.
- Hold harvest floods for about 3 days to allow settling, then complete discharge by Day 10 to avoid mobilizing bound P as oxygen depletes in the flooded soil.
- Once winter flood freezes, remove the water from beneath the ice to minimize soil saturation and P mobilization. Exact timing should be based on sanding plans and ability to re-flood if the ice is lost.

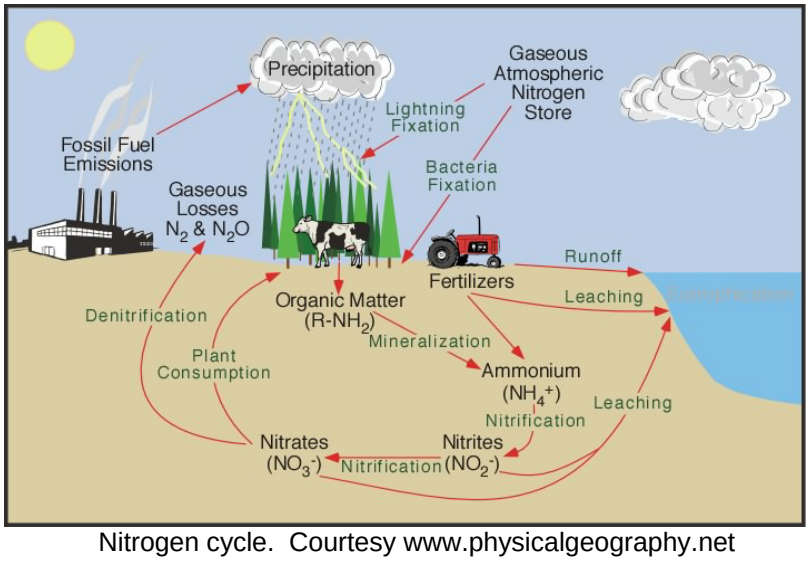
Recommended Practices - Nitrogen

The single most important nutrient element in cranberry production is nitrogen. N is required by cranberry plants for the production of vegetation (new leaves and stems), roots, and fruit (crop). N is an important part of proteins, including the most important plant protein, chlorophyll.

Understand the nitrogen cycle in the cranberry bog.

Approximately 95-99% of the N in soil that becomes available to the plant during the growing season comes from the decomposition of soil organic matter. While cranberry soil is relatively low in organic matter, cranberries obtain some N from that source either directly through the mediation of mycorrhizal fungi that live in a symbiotic relationship with the plant roots or through the process of *mineralization*.

Nitrogen mineralization is a process in which bacteria convert organic N into ammonium-N. This reaction is dependent on soil moisture and temperature. As a result the process provides most N early in the season as the soil dries after the winter flood and in late summer when the soil temperature approaches 70ºF – those are times when added fertilizer is least needed.



Nitrogen cycle. Courtesy www.physicalgeography.net

Ammonium-N from the organic matter or from fertilizer can be converted to nitrate-N by the process of *nitrification*, mediated by nitrifying bacteria. Cranberries use nitrate poorly and nitrate can leach in the soil or be converted to gaseous forms. Conversion of ammonium to nitrate can be minimized by managing soil pH to limit the population of nitrifying bacteria. In sandy or layered cranberry soils (organic matter 0-5%), this is accomplished by maintaining pH between 4.0 and 5.0. If the soil is highly organic (>5%), a pH below 4.5 is recommended.

Each season nitrogen is lost from the bog system in the harvested crop and when the bog is detrashed (removal of fallen leaves from the bog floor). During harvest, more than 20 lbs N/acre is removed in an average (150 bbl/acre) crop.

Apply nitrogen in the ammonium-N form (NH_4).

Field and greenhouse experiments have demonstrated that cranberries preferentially use ammonium nitrogen rather than nitrate nitrogen. Cranberries can use nitrate-N if ammonium-N was also present, but did poorly if supplied with nitrate-N alone. Do not use fertilizers in which all of the nitrogen comes from the nitrate form.

Fertilizers containing all N in the ammonium form (ammoniated or blends with N from ammonium sulfate, ammonium phosphate, or urea) should remain your first choice. Fertilizers containing both ammonium and nitrate may be used - both N types will be taken up by the plants. However, the best practice is to keep nitrate content to a minimum. Nitrate leaches readily in coarse sandy soils, but ammonium does not. By choosing ammonium forms, the potential for leaching nitrate to the surrounding environment is minimized as long as the soil pH is <5.5. At higher pH, ammonium may be converted to nitrate. Organic forms and urea convert to ammonium-N in the soil.

Timing: Plan N fertilizer applications based on phenology, soil type, and temperature.

N must be available in the soil during periods of plant demand – vegetative growth, fruit production, root renewal, and bud set. These periods coincide with the stages of roughneck (1/2 to 1 inch new growth), bloom, fruit set, and early August bud set. Seasonal N application rate should be divided into three to four applications corresponding to those periods: 20-25% at roughneck stage, 30-35% at bloom, 30-35% at fruit set (about 2-3 weeks after bloom), and ~20% at bud development/fruit sizing (early August). Split application timing allows for in-season rate adjustment as conditions warrant.

On sandy soils with little organic matter, nitrogen fertilizer must be used to meet these demands. If organic matter is present, then temperature plays a role in deciding when to apply N fertilizer. For typical cranberry bogs (~3% organic matter), applications of N should not be necessary early in the spring. From flood removal until soil temperatures exceed 55ºF, adequate N should be available through biological processes.

As soil temperatures increase from 55ºF to 70ºF, release of N from soil organic matter is only moderate. Fertilizer applications should be beneficial during this period for all soil types. This corresponds to the period from roughneck stage through bloom/fruit set.

During spells of hot weather, when soil temperatures exceed 70ºF and air temperatures exceed 85ºF, soil N release increases and crop development slows, so planned fertilizer N applications should be reduced, delayed, or eliminated.

Rates: Apply nitrogen fertilizer based on cultivar, plant condition, and response.

Small-fruited cultivars such as Early Black and Howes generally require the addition of 20-30 lbs N per acre per season. Large-fruited cultivars such as Stevens may require more N, up to 60 lbs N per acre per season. Rates should then also be adjusted according to soil type. Rates higher than 40 lbs per acre should be used with caution as they may lead to vine overgrowth and reduction in fruit quality.

Consistency in management is important for achieving predictable yields. Research has shown that N application rate in the year before a crop may be a more important predictor of yield than N rate in the current season. Further, timing of N application may be even more important than rate.

Excess N leads to over-vegetative plants with long uprights, many runners, and few fruit. Excess vegetative growth may increase susceptibility to disease, spring frost, or insect feeding. High N rates may also lead to poor fruit quality and delay color development in the fruit and can have adverse carry-over effects in following years as stored excess N is remobilized.

Additional nitrogen fertilizer should be added if the cranberry plants show signs of nitrogen deficiency - poor growth, loss of leaf greenness, and/or low nitrogen content in the leaf tissue. Reduce use if vines growth is excessive, crop potential is reduced (for example, by frost damage), or tissue test levels are excessive.

After sanding or a late water flood, reduce the amount of nitrogen applied.

Spring fertilizer application may be eliminated on late water bogs (apply first fertilizer at bloom). Overall rate reduction should be 20-30%. Sanded bogs tend to be warmer due to the sunlight being absorbed by the sand. Warm soils release more native N (increased mineralization) so less should be added as fertilizer.

Monitor cranberry plant nitrogen status.

Observe growth and flowering. Adjust fertilizer based on the appearance of the plants and the potential for cropping. Pay particular attention to upright length and growth above the fruit. Length of new growth can be used to indicate nutrient status of cranberry plants until early bloom. Less than sufficient length indicates the need for N fertilizer. From hook stage through early bloom, sufficient-range lengths are as follows:

Early Black – 2.0 to 2.4 inches	Howes -- 1.8 to 2.2 inches
Stevens -- 2.4 to 2.8 inches	Ben Lear -- 2.2 to 2.6 inches

Healthy cranberry plants with adequate N are deep, bright green. If the leaves are light green, fading to yellow, N may be insufficient.

Tissue testing for %N is used to determine nutrient status of cranberry plants. The standard value for all cultivars in August (recommended testing time) is 0.9-1.1%, with up to 1.3% acceptable for high-yielding hybrids. Earlier in the season, higher values (up to 1.5%) are normal. As growth dilutes the nitrogen in the plants, N concentration declines to approximately 1%. Values below normal may indicate the need for added N fertilizer.

Recommended Practices – Phosphorus

Phosphorus plays many roles in plant metabolism. P is involved in energy transfer in plants and is a primary constituent of genetic material (DNA). P plays a regulatory role in photosynthesis and starch synthesis, active transport of materials across membranes, root growth and function, and hormonal balance. This last function is critical to initiation of flowers. While only modest amounts of P are removed from cranberry beds in fallen leaves and fruit, it is essential that soil P be available to the cranberry plants to support seasonal growth and flowering.

P use should not exceed 20 lb/acre per season. Lower rates are often indicated.

Research in Massachusetts and Wisconsin has shown that cranberries require additions of phosphorus fertilizer for sustained productivity. However, there is no evidence in *any* research plot work or commercial bed observations that any more than 20 lb/acre actual P is required for productive cranberries. In some studies on high P sand soils, there was no response to P fertilizer on beds with adequate tissue P. In other studies, on native cultivars, the greatest yields were on plots receiving 10-15 lb/acre P, with no improvement at higher rates.

The only exceptions to the not to exceed 20 pound recommendation are beds with documented deficiencies (tissue P <0.1%) or new beds with fresh sand planting medium (use up to 20 lb/acre at planting and no more than *a total* of 30 lb/acre for the season on those beds).

Twenty pounds of actual P is the amount in ~45 lb/acre P_2O_5 as expressed on the fertilizer bag, 15 lbs actual is ~35 lb/acre P_2O_5.

> Fertilizer bags show P (the middle number) as phosphate. To convert phosphate to actual P multiply by 0.44. For example, 100 lb of 13-13-13 has 13 lb phosphate (100 x 0.13) but only 5.7 lb of P (13 x 0.44). The Cranberry Chart Book (nutrition section) provides additional calculation examples (http://scholarworks.umass.edu/cranchart/).

If tissue test P is >0.12%, especially on native cultivars, reduction of annual P rates to 10-15 lb/acre is recommended. Reduce to even lower rates if tissue P remains >0.16%. The Chart Book provides guidance for tissue testing protocols to use in conjunction with P reduction.

Apply P in N-P-K fertilizer with high N:P ratios.

Since most growers apply P as part of N-P-K fertilizer and choose the rates for those materials based on N requirements, it is important to choose the correct ratio materials to avoid over application of P. The best materials have a 1:1 or 2:1 ratio of N:P. Popular examples that fit these ratios are 15-15-15 or 18-8-18. Even higher N:P ratios are acceptable for beds that have high N requirements and/or high tissue P.

The P in slow release N-P-K materials performed as well as soluble triple super phosphate in field plots, but sometimes at a higher material cost.

Do not apply P to wet soils; they are releasing P.

Classic cranberry bog soils have different soil P retention and release patterns depending upon how saturated the soil is. As the soil goes from the fully saturated conditions after the winter flood, through the wet conditions of spring and the frost protection season, to finally the relatively dry conditions of summer, the soil's retention of P increases and its ability to release this P decreases. For this reason, applying phosphorus to cranberries on traditional soils prior to roughneck stage is not a recommended practice. In the early season, the soil is already releasing phosphorus. Once the soil reaches seasonal dryness (late spring), P is only released if a certain threshold amount is present in the soil, indicating the need for fertilizer applications under those conditions. These recommendations mean that P can be applied with the same timing as N, in convenient N-P-K materials.

Sandy soils readily release P that had been previously applied and bound to the soil. However, the total P holding (and releasing) capacity of these soils is poor, indicating a need for low rate applications at frequent intervals. Uptake and release in sandy soils is not particularly dependent on flooding cycles (aerobic status). This likely explains the response to higher P rates on newly planted cranberry beds.

Monitor cranberry plant phosphorus status.

Use tissue testing to determine if the plants are getting sufficient P. Collect samples between August 15 and September 15. The sufficient range for P is 0.1 to 0.2%. If values are >0.12%, and you are applying 20 lbs/acre, plan to reduce P rates. If you have reduced P and tissue P remains >0.16%, further reduction (with continued testing) is recommended.

No commercially available soil test for P provides useful information for cranberry management. The most common test (Bray) tends to overestimate P availability since it dissolves bound P that is probably not soluble in native soil. When soil iron is >200 ppm, common in Massachusetts bogs, interference completely eliminates any predictive value of a soil test for P.

Recommended practices - other nutrients

Avoid excessive use of potassium (K).

K fertilizer is used to restore turgor (hydration of the vines) in the spring or at other times when vines are brittle and dry. K used for this purpose is often applied in combination with magnesium. Otherwise, K is applied in the N-P-K fertilizer growers use to support plant growth and crop production. To assure adequate K supply, common cranberry fertilizers include K in a 1:1 ratio with N. Seasonal rates of K applied to cranberry beds are in the range of 40-100 lb per acre. Field plot research did not show any measurable benefit to the addition of higher K rates. The sulfate form of K is preferable since research has shown that when K is applied as KCl, chloride may accumulate in the cranberry tissue.

Avoid unnecessary use of minor elements.

While cranberries require many other mineral elements beyond N, P, and K, typically these are in sufficient supply in the soil to satisfy plant needs. When testing shows that these other elements are lacking in the plants or in the soil, they are applied as needed. Calcium is applied as gypsum (calcium sulfate) since the addition of lime can raise the soil pH beyond

the range suitable for cranberry production. Magnesium is added as Epsom salts (magnesium sulfate) or in combination with K (KMag, SulPoMag). Sulfur (as sulfate) is supplied as a component in N-P-K fertilizers (ammonium and potassium sulfates are common ingredients). Therefore, sulfur in the elemental form is not used as a fertilizer in cranberry production but may be used to lower soil pH if necessary.

Micronutrients (iron, manganese, zinc, copper) are very available in acidic soils. For this reason, cranberries seldom suffer micronutrient deficiencies, nor do they require micronutrient fertilizers in general. One exception is the use of micronutrient supplements in fertilizer blends during the first season of a newly planted mineral soil bog. Another exception is the use of calcium-boron supplements at bloom. For bogs with poor yield histories, such calcium-boron supplements may increase fruit set. On established beds, apply micronutrients based on tissue test results.

Recommended practices - New and Renovated Bogs

Nutrient management for establishment of new plantings is focused on the development of a good root system and on rapid growth of runners. Rapid plant establishment is key to limiting problems with weed infestations in the first two years after planting. However, extreme N rates may lead to problems with leaf diseases and with fruit rot diseases as the beds transition into production.

Plants need roots to take up fertilizer - time applications accordingly.

If you plant cuttings, they will not take up fertilizer until roots form. This usually takes 2-3 weeks. The only fertilizer that should be applied prior to rooting are slow-releases materials (these can go on about 1 week after planting) and P applied just prior to or at the time of planting to encourage rooting (limit to no more that 20 lb/acre). Be aware that some fertilizers can burn new roots.

If you plant rooted cuttings, applications may begin immediately. However, be aware that plug plants may experience transplant shock and appear dormant for up to 3 weeks after planting. With this in mind, applications other than slow release materials may be most effective if applied 2-3 weeks post-planting.

Vines colonizing open ground on a cranberry farm

Choose slow-release fertilizer for part of the Year 1 requirement.

Slow-release N applied at the time of planting provides a sustained growth stimulation during stand establishment and may supply all fertilizer requirements for the year. In addition to a slow release application, additional N fertilizer added regularly throughout the first season can

encourage rapid and even vining-in over the soil surface. However, remember that the planting sand does not hold fertilizer well. Slow-release materials overcome the tendency for nutrients to wash below the root zone. Other fertilizers, if used, should be applied at low rates every 10-20 days to avoid wash-through.

Limit use of 'complete' fertilizers on new beds.

It is a good practice to integrate some N-P-K fertilizer with N-only materials in Years 1 and 2. However, N-P-K choices should have no more than a 1:1 N:P ratio, higher P ratios are not necessary. Total P application in the first season should not exceed 30 lb/acre. Periodically including K is a good practice as K tends to move through the sand during the frequent irrigations required on new plantings.

Limit use of P to no more than 30 lb/acre in Year one, then transition to lower rates.

While P is important in rooting, after Year 1 the P requirement is substantially decreased. By Year 3, rates should be not exceed 20 lb/acre per season, similar to any producing bed.

Do not apply fertilizer after mid-August.

N applied late in the summer may lead to vine growth that is too sensitive to cold damage in the fall. Cease fertilizer applications no later than mid-August.

Reduce N use once vine cover is adequate to transition to fruit production.

By the end of the first year, runners should be about a foot long. The plants will have a good root system and will begin to tolerate drier conditions. Late water may help to encourage vining-in if used in the second season.

By the end of Year 2, the fertilizer applications should begin to transition towards those in a plan for established beds. By Year 3, the bog should be well established and should have received a light sanding. An established-bed fertilizer schedule should be used.

For more information:

Caruso, F. L. and Ramsdell, D. C. 1995. **Compendium of blueberry and cranberry diseases.** American Phytopathological Society Press, St. Paul, MN. 84 pp. (for a guide to nutrient deficiency symptoms) *A new, revised edition is due to be published in 2010.*

Cranberry chart book - management guide for Massachusetts. University of Massachusetts Cranberry Station. Available in hard copy at the Cranberry Station or for download at http://scholarworks.umass.edu/cranchart/.

Davenport, J., C. DeMoranville, J. Hart, K. Patten, L. Peterson, T. Planer, A. Poole, and J. Smith. 1995. **Cranberry tissue testing for producing beds in North America.** Fact Sheet. Available from Cranberry Station or for download at http://scholarworks.umass.edu/cranberry_factsheets/.

Davenport, Joan, Carolyn J. DeMoranville, John Hart, and Teryl Roper. 2000. **Nitrogen for Bearing Cranberries in North America.** Available for download at http://scholarworks.umass.edu/cranberry_factsheets/.

Roper, Teryl, Joan Davenport, Carolyn J. DeMoranville, Sebastien Marchand, Art Poole, and Kim Patten. 2004. **Phosphorus for Bearing Cranberries in North America.** Available for download at http://scholarworks.umass.edu/cranberry_factsheets/.

Roper, Teryl. 2000. **Answers to Common Nutrition Questions.** Available for download at http://scholarworks.umass.edu/cranberry_factsheets/.

Roper, Teryl. 2006. **Physiology of Cranberry Yield.** Available for download at http://scholarworks.umass.edu/cranberry_factsheets/.

Sandler, H. and C. DeMoranville, eds. 2008. **Cranberry Production: A Guide for Massachusetts.** University of Massachusetts Publication CP-08, UMass Cranberry Station, UMass Extension. 198 pp. Available for purchase at the Cranberry Station.

Partial funding for this project was provided by the Massachusetts Department of Environmental Protection (the Department) via Federal Funds from the Environmental Protection Agency (EPA) under Section 604(b) of the Clean Water Act. The contents do not necessarily reflect the views and policies of EPA or of the Department. The mention of trade names or commercial products does not constitute recommendation for use or endorsement by those agencies or by the University of Massachusetts.

Prepared by Carolyn DeMoranville, 2010.

Nutrient Management Checklist

✓.Educate yourself by reviewing the Cranberry Chart Book and routinely attending educational programs.

✓.Keep good records, observe plant response often, and tailor your nutrition program for each bog or bog system. Modify your program as needed based on response.

✓ Manage harvest and winter floods to minimize phosphorus discharge.

✓ Apply nitrogen in the ammoniated form.

✓Perform regular tissue tests to monitor plant nutrient levels.

UMass Extension

Organic Cranberry Management

Organic crop production is the fastest growing portion of U.S. agriculture, increasing a minimum of 20% annually during the last 15 years. The establishment of federal guidelines for organic certification in 2002 provided a structure for producers and processors to market certified organic foods. The guidelines provide the general provisions and processes for obtaining and maintaining organic certification, but do not specifically determine the best management practices for crop production within the organically approved methods. There is limited research on organic cranberry production for Massachusetts. This BMP was written primarily with the help of active organic MA cranberry farmers who were willing to share their experiences to help guide others.

Anyone interested in growing organic fruit should first familiarize themselves with the federal and state regulations that define organic food. The USDA's National Organic Program regulates the standard for any farm, wild crop harvesting or handling operation that wants to sell an agricultural product as organically produced. See web sites listed as the end of the BMP.

Growing cranberries under an organic program can be challenging, especially in Massachusetts, where pest pressures can be quite high. Clearly evaluate your risk before starting an organic operation. Pest management can be difficult even when using conventional pesticides; situations may be even harder in organic systems.

Recommended Practices

Select a good location and bog type.

It is best to use bog systems with naturally low pest pressure and an ample water supply to optimize chances of success. In general, native peat-based bogs are more conducive to organic production compared to mineral bogs.

Establish, utilize and operate a bog system and water resource that is isolated from non-organic farms. Your water source(s) is considered part of the farm and will also need to be certified organic.

Choose native varieties.

Native cranberry varieties (e.g., Early Black, Howes) may be better choices for organic production than hybrids (observational input).

Scout weekly for insects by using sweep nets, starting in early May.

Use of sweep nets is important in both conventional and organic systems. This technique allows you to monitor current insect populations and make any needed management decisions as necessary.

Learn to correctly identify insects in your sweep net.

Black-headed fireworm can be a serious problem on organic bogs. Consider holding a winter flood to minimize black-headed fireworm populations.

Cultural practices (sanding and flooding) offer the most effective pest control for organic production.

Use late water floods to control cranberry fruitworm, cutworms, Southern red mite, and minimize fruit rot issues. Fall floods can be used to manage cranberry girdler and dewberry populations. Sanding can help manage girdler and dodder populations. Winter floods can help reduce the abundance of many insect pests.

During the 3-year transition period, hold late water floods for pest management. Consider repairing or renovating weak areas during the transition period.

Engage in any relevant cultural practice that will improve canopy air circulation.

Hand-weeding is the most common form of organic weed control and will typically be needed on an annual basis.

Ensure that the bog is as level as possible; this will help achieve maximize results with flooding techniques and minimize water use requirements. Make sure your pumps run efficiently so you can quickly flood for pest management or other issues as needed.

Keep good records of cultural practices and water use.

Good records will be your best resource for managing your farm in future years. If you experiment with different management techniques, maintaining accurate notes and observations will be a solid practice.

Obtain organic certification.

The farm needs to be certified if you want to sell, label, or represent your product as organic. Certification is the process where a producer or handler is approved by an Accredited Certifying Agent as being in compliance with the National Organic Program (NOP) regulations and is then authorized to sell, label, or represent products as being "certified organic". An applicant must submit specific information to a certifying agent to engage in the process (see USDA NOP web site) and once certified, annual inspections will be conducted. Applicants must keep accurate records for 5 years to show compliance with issues regarding aspects of production, harvesting, and handling of their products. However, producers and handling operations that sell less than $5,000 per year in organic products do not need certification. Although exempt, you must abide by the national standard for organic products and may label your products as organic. Currently, the certifying agent for Massachusetts is Baystate Organic Certifiers.

Visit the Baystate Organic Certifiers web site http://www.baystateorganic.org/ or contact: Don Franczyk, 774-872-5544.

Determine if there are any significant hindrances that would prevent certification of the operation before investing time, energy, and money.

Make sure you are prepared to handle and produce the needed paperwork, reporting, and inspecting to receive and maintain your certification.

Formulate a business plan for how your fruit will be sold and handled.

This is one of the most important decisions that you will make and should be done during the development phase of the organic farming operation. Will you be selling your fruit to an established handler or will you sell your fruit directly to retailers or consumers? Will you be making a value-added product or selling fresh fruit?

Yields will likely drop during the transition phase and your business plan needs to account for this.

The drop in production (if the bog had been in conventional management) will occur without a corresponding increase in fruit market value. This could be a significant barrier to entry into the organic market.

Consult the Organic Materials Review Institute (OMRI) lists of approved compounds.

OMRI provides organic certifiers, growers, manufacturers, and suppliers an independent review of products intended for use in certified organic production, handling, and processing. OMRI reviews products against the National Organic Standards. Acceptable products are OMRI Listed® and appear on the *OMRI Products List*, http://www.omri.org/.

Consult with other growers who are currently growing cranberries organically.

Some of the best advice will come from growers who are actively practicing organic cranberry production. Talk to them about recommendations and pitfalls concerning all aspects of production and business issues.

Attend organic farming conferences to keep current on new and innovative techniques.

Consider attending the annual NOFA conference http://www.nofamass.org/index.php or other meetings relating to organic farming. Although not specifically related to cranberry, these forums provide an opportunity to meet and exchange with other organic farmers.

For more information:

Massachusetts Chapter of the Northeast Organic Farming Association, 411 Sheldon Road, Barre, MA 01005. (978) 355-2853. http://www.nofamass.org/index.php.

Organic Materials Review Institute http://www.omri.org/

USDA National Organic Program web site
http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?navid=ORGANIC_CERTIFICATIO)

Baystate Organic Certifiers (PDF)
1220 Cedarwood Circle
N. Dighton, MA 02764
Contact: Don Franczyk
Phone: 774-872-5544
Fax: 774-872-5545
E-mail: baystateorganic@earthlink.net
http://www.baystateorganic.org/.
Scope: crop, livestock, wild crop, handling
Accredited: 4/29/02

Prepared by Hilary Sandler, Jen Friedrich, and Keith Mann, 2010.

Organic Cranberry Management Checklist

- ✓ Become familiar with all related federal regulation regarding organic farming and certification.
- ✓ Develop a whole farm business plan.
- ✓ Establish working relationships with other organic cranberry growers.
- ✓ Attend organic food and farming conferences and educational workshops.

Weed Management

To select the best management practices for weed management, it is important to understand how weeds grow, how they affect cranberry yields, how weeds are affected by environmental factors, and how the various herbicides work. Often, using several strategies in an integrated program may produce better weed management than any single control measure alone.

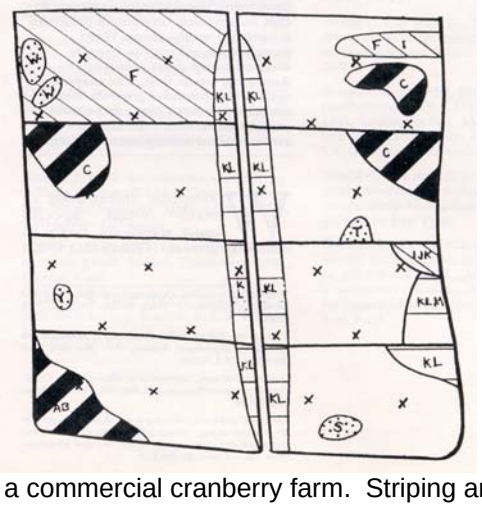
Recommended Practices

Obtain and use weed identification guides and plant biology references.

Identification guides and general plant references are valuable resources for all cranberry growers. The success of any management strategy hinges upon the correct identification of the problem weed as well as knowledge of the plant's life cycle.

Scout for weeds and construct weed maps.

Map weeds to document weed type, severity, and location for future management decisions (treatment selection and application). Weed maps should be updated on an annual basis. For bogs with minimal or no weed infestations, notes on visual observations may serve as a suitable record.



Example of a weed map for a commercial cranberry farm. Striping and stippling indicate different priority ranks and letters denote weed species. Sprinkler heads are marked with an "x".

Know the difference between grasses, sedges and rushes. Postemergence grass herbicides, such as Poast, are only effective against true grasses. Sedges and rushes will not be controlled.

Scout often to detect the first sign of scum or algae on late water floods. If the algal infestation is severe, early withdrawal of the flood may be necessary.

Prioritize weed problems and establish a long-term management plan.

When weed problems are too numerous or severe to be dealt with in a single year, rank management priorities based on the likelihood of the weed to cause yield loss, its ability to spread, and the difficulty of control. Establish a long-term management plan for the top priority weeds. Refer to priority chart in Field Guide to Common Weeds on Cranberry Bogs in Southeastern Massachusetts as well as information in the current Cranberry Chart Book (http://scholarworks.umass.edu/cranchart/).

Make every effort to keep weeds from spreading onto the bogs. Maintain and encourage healthy vine growth to compete with weeds.

Start with a clean, weed-free bog and control weeds as they invade new bogs. Take all necessary steps to encourage good vine growth. Begin new plantings early in the season (before the end of May) if possible.

Manage weed problems when they are small and just getting established in the bog (i.e., hand-wipe or remove dewberries and sawbriers, remove dodder). Replant bare spots to keep weeds from becoming reestablished.

Mow dikes and other surrounding areas to prevent weeds and seeds from moving into the bog.

Weeds can be introduced when vines are sanded. Try to use clean sources of sand to minimize new inoculations of weed seeds.

Weed seeds that float (e.g., dodder) can be moved around in water. Consider this when making harvest plans.

Clean harvest equipment between bog systems to remove weed seeds.

Integrate different strategies for best possible dodder control.

Minimize infestations by maintaining thick, healthy vines with few weeds and bare spots. Eliminating early-season hosts, such as asters, narrow-leaf goldenrod, and loosestrife can be important.

Make preemergence herbicide applications prior to dodder emergence or soon thereafter. Scout for dodder emergence in bare spots to time herbicide applications properly. Apply the herbicide evenly and water immediately for at least 2 hours. Applications during cool/cloudy weather may be more effective.

With light infestations, hand removal of dodder early in the spring may prevent spread.

Yield losses and seed production from dodder that escapes control may be reduced by raking.

Minimize herbicide use whenever possible. Consider environmental and horticultural impacts of long-term/high rate herbicide use.

Selecting an herbicide should include consideration of environmental risks as well as other established criteria such as experience with the product and cost. Growers should consider alternating herbicides and using postemergence options.

Use the lowest effective rates. The lowest rate at which optimal weed control can be achieved may vary from bog to bog. Factors such as soil composition, weed density, and drainage can influence this rate. Spot treat if possible.

Fall applications of herbicides are generally not recommended.

Use cultural and non-chemical practices where possible.

Sanding and hand-weeding can be effective non-chemical alternatives for controlling some weeds. Use freshly excavated sand rather than stockpiled sand to minimize weed-seed contamination.

To suppress populations of weeds that prefer more alkaline soils, maintain soil pH below 5.

Remove flowers or wipe before plants go to seed to minimize production and dispersal of weed seeds.

Late water floods, summer re-floods, and fall floods reduce dewberry (running bramble) populations. Late water floods may retard the emergence of some weeds. Follow late water and summer floods with postemergence wipes in late summer to eliminate dewberries that survive the flood. Note that severe crop reduction is associated with summer floods.

Use techniques that will promote optimal application and performance.

Apply herbicides when vines and bogs are dry.

Preemergence herbicides (except Devrinol) should not be applied to new plantings for at least the first 12 months or until the vines are established. Norosac/Casoron should not be used until the vines are well established (usually the third year). Consider using postemergence herbicides and hand-pulling for control of invading grasses and perennial weeds.

Gephardt drop spreader delivering granular herbicide to the cranberry farm surface. Note white droplet of foam at left, which helps to guide the driver.

Do not apply Norosac/Casoron to bogs that will be sanded within 4-6 months or to stressed bogs. Use foam markers to insure proper application.

Water in granular herbicides (especially Norosac/ Casoron products) as soon as possible after application. Do not allow water to puddle on the soil or bog surface.

If you are unsure whether an herbicide will cause plant injury, first test the mixture on a small area. Symptoms should be visible within several days to a week or more, depending on the weather and herbicide/spray adjuvant used.

Calibrate application equipment as often as necessary to ensure proper delivery of herbicide material.

Yearly calibration is advised to check for changes in output due to wear of equipment components. Calibrate herbicide spreaders every time a new material is used.

Ground equipment is the preferred method of granular herbicide application, providing uniform coverage and minimal off-target exposure.

Consider weather and method(s) of application to minimize off-target exposure. Conditions favoring high humidity increase the potential for off-target injury with 2,4-D products. Do not apply these products when air temperatures are hot (85 F or above) to minimize herbicide volatilization and possible crop injury.

Applying postemergence grass herbicides during bloom or the heat of the day may cause plant injury. Blossoms are particularly sensitive to spray adjuvants/additives, especially crop oil.

Use check strips to evaluate herbicide performance and estimate weed pressure.
Compare treated and untreated areas to help you evaluate the performance of your herbicide and to establish the appropriate management strategy. If a small section of the bog is left untreated, a visual observation of the effectiveness of the herbicide application can be made. Check strips are also valuable in estimating actual weed pressure.

Use caution when applying fumigants.
Fumigants may be used as part of a renovation program. Do not use fumigants as a spot-treatment if any vines within a diked section will be harvested. However, if you are renovating an entire section, you can spot-treat a portion of that section with a fumigant.

Vapam and Basamid will control a variety of soilborne pests. Apply these products when 3-inch depth soil temperature is above 50°F. These materials are highly leachable so use only on bogs that can hold water. Do not allow material to get into surface water. Do not use where fumes may enter nearby houses. The fumigants, Vapam and Basamid, will kill fish if used improperly.

For removal of shallow-rooted weeds, wiping with glyphosate should be tried first. If control is not obtained (weeds persist or get worse), then consider fumigating.

Many growers have had good success fumigating in the fall. This timing is advantageous because planting can start in the early part of the next spring (early-mid April). A layer of sand (at least 3 inches) should be applied to the section after the fumigation, but before the winter flood. If you need to use heavy equipment to apply the sand, you should wait about 2 weeks after the fumigation. Otherwise, the seal may be disturbed and the vapors will be prematurely released.

Fumigating can be done in the spring. However, keep in mind that vine planting may be delayed until late May-early June or later, depending on soil conditions and weather. Do not plant until the chemical odor has disappeared from the soil (usually 2 weeks). Plant fast-growing seeds or seedlings (e.g., lettuce, beans, cabbage, or tomatoes) in a number of places in the treated area to test whether the fumigant is still in the soil. Be sure the fumigant has dissipated before planting cranberry vines.

Basamid application: Basamid is a granular material. Gas is released when the material degrades in the soil. Strip and/or rake bog surface prior to application. You may rototill the soil beforehand, but it is not necessary. The soil should be moist prior to treatment. Apply the Basamid and rototill as soon as possible. Water for 3-4 hr immediately after application.

Vapam application: Vapam is a water soluble liquid. When properly applied to the soil, the liquid is converted into a gaseous fumigant. For best results, rototill before application to loosen the soil deeply and thoroughly. One week before treatment, moisten the soil.

Vapam is typically applied through the irrigation system or by a tank truck set-up, though it may also be soil injected. If you are applying by sprinkler system, carefully read the label, paying particular attention to the 'precautions for use' section. Water in immediately for at least 3 hr to avoid evaporation. Rototilling after a Vapam application is not recommended. This may stir up new viable weed seeds which will not be controlled by the fumigant.

Keep accurate records.

Careful records of herbicide applications are essential for farm planning and performance evaluation. Use weed maps to plan long-term herbicide and weed management strategies. Herbicide application dates, impacts and responses of weeds to implemented control practices should be recorded.

For more information:

Cranberry chart book - management guide for Massachusetts. UMass Cranberry Station. http://scholarworks.umass.edu/cranchart/.

Demoranville, I.E. 1984, 1986. **Weeds of Massachusetts cranberry bogs, parts 1 and 2**. University of Massachusetts Cooperative Extension Publication.

Else, M. J. **Calibrating granular herbicide spreaders.** Fact Sheet. Cranberry IPM Notebook.

Else, M. J., H.A. Sandler, and S. Schluter. 1995. **Weed mapping as a component of integrated pest management in cranberry production**. HortTechnology 5(4):302-305.

Sandler, H. A. and M. J. Else. 1995. **A field guide to common weeds on cranberry bogs in Southeastern Massachusetts.** University of Massachusetts Extension Publication.

Updated by Hilary Sandler 2010.

Weed Management Checklist

- ✓ Scout for weeds and correctly identify weeds prior to treatment.
- ✓ Use the lowest effective dose.
- ✓ Prevent introduction of weed seeds by using clean sand and plant material.
- ✓ Prioritize weed problems when numerous weeds are present on the farm.
- ✓ Calibrate application equipment yearly.
- ✓ Use untreated check strips and keep accurate records.
- ✓ Integrate chemical and cultural management options whenever possible.

Fresh Fruit Production

Practices recommended for the preservation of environmental quality and effective management of the bog physical plant (e.g., water control structures, erosion control, pesticide storage and handling) are universally applicable regardless of whether a bed is producing fruit for processing or for the fresh market. However, certain practices require modification to effectively produce abundant, high quality cranberries for fresh fruit. This document should be used in conjunction with and in addition to the remainder of the Best Management Practices Guide, providing additional recommendations for the fresh fruit grower. This document was developed by the University of Massachusetts Cranberry Station and Ocean Spray Cranberries, Inc. and was reviewed by Massachusetts fresh fruit growers who provide fruit for several local brands.

Recommendations in this document are designed to be specific to fresh fruit production. For general recommendations regarding cranberry management, consult other portions of the Best Management Practices Guide and the Cranberry Chart Book.

Recommended Practices

Varietal factors relevant to fresh fruit:

The varieties 'Early Black' and 'Howes', native selections from Cape Cod, have been utilized for fresh fruit from the very beginning of the cranberry industry in Massachusetts. Although 'Early Black' is not as productive as other varieties, it became popular because of its earliness in ripening and its ability to grow in many types of cranberry soil. 'Howes' gained favor because of its attractive, well-colored, glossy berry that was frost resistant and had especially good quality. Several of the "fancy" cranberry varieties were preferred for fresh fruit from the 1850's until the 1970's. These included 'Black Veil', 'Centennial', 'Holliston', 'Matthews', 'McFarlin', 'Paradise Meadow', 'Shaw's Success' and 'Vose's Pride'. As water harvesting was established and became increasingly popular with growers, fresh fruit became restricted to 'Early Black' and 'Howes'. Lately, 'Howes' has become more in demand with handlers due to the need for additional quantities of late season fruit.

Choose varieties for fresh fruit based on favorable characteristics.

Those characteristics favorable for a good variety for fresh fruit include: earliness or lateness of ripening, frost hardiness, good productivity, fruit rot resistance, cranberry fruitworm and Sparganothis fruitworm resistance, and texture that avoids damage caused by the picking machines. Most handlers have preferences for certain varieties.

Nutrient Requirements:

Apply moderate rates of fertilizer. Avoid excessive use of nitrogen.

Productive cranberry beds require seasonal application of nitrogen, phosphorus, and potassium. Good production in Early Blacks and Howes is supported at rates of 10-35 lb/A N, 20 lb/A P, and 40-60 lb/A K per season. Hybrid cultivars may require additional N. In a fresh fruit bed, it is critical to limit nitrogen use to a rate that supports good upright growth and cropping but avoids excessive growth and runner production. Overly thick vine stands will encourage poor fruit keeping quality and disease, and also interfere with harvesting.

Use split applications for better control of growth.

It is too late to go back if excess N is applied early in the season. Apply low rates in the spring as needed to support adequate upright extension. This will vary by soil type and may be eliminated in some cases. Apply moderate rates during bloom and fruit set. A final application in early August will support bud development for the following year but should be limited or eliminated if runners are occurring.

Remember to reduce fertilizer use if late water was held.

Rates should be reduced up to 30% by elimination of the spring application and reduced rates during bloom. However, drastic reductions that could limit cropping in the following year should be avoided.

Water Management:

Use late water to reduce the incidence of fruit rot disease and improve keeping quality.

Late water is an especially helpful practice for fresh fruit growers. Late water floods typically reduce fruit rot disease and improve the keeping quality of the cranberry fruit. Late water should not be used more than one year in three and should be limited to years when demand for carbohydrate reserves has been minimal (good sunshine in previous year, healthy plants, and no winter injury or oxygen deficiency). Fungicide use may be reduced; consult the keeping quality forecast to determine how much reduction can be safely attempted. Unless the keeping quality forecast predicts fair to poor or worse keeping quality, one fungicide application should be necessary during the year that late water is held. Two fungicide applications should suffice during the year after late water. Fungicide rates can also be reduced during those two years to the minimal registered rate. Do not apply less than the lowest recommended rate. Late water also provides control of Southern red mite and cranberry fruitworm, but does not affect population levels of *Sparganothis* fruitworm. Late water will also reduce the spread of dewberries.

How to use:

Flood early to mid-April when plants have begun greening but buds are tight and red.

Do not use in more than once in 3 years or if vines are stressed. Use no herbicides prior to flooding.

Hold the flood for 30 days.

Scout for algae along bed edges. Check water temperature periodically beginning in the third week — if consistently greater than 65ºF early in the day, consider early removal.

Frost tolerance will be 25ºF if the flood is removed at 2-3 weeks. After 3 weeks, the tolerance will be 30ºF upon removal.

Expected outcomes:

Fruit rot suppressed — reduced fungicides possible.
Cranberry fruitworm suppressed — treat only if eggs are found after scouting.
Southern red mites controlled.
Dewberry growth suppressed.
Bloom compressed and synchronized — take note for cranberry fruitworm management.
Growth enhanced - use 20-30% less nitrogen fertilizer.
Keeping quality improved.

Use a fall flood to control pests when possible.

Depending on harvest schedules, fall flooding may be used post-harvest for the control of several pests. Because the flood cannot be initiated until after harvest, timing may be difficult. A one-week flood beginning no later than September 25 will control cranberry girdler. A three- to four-week flood beginning as late as the first week of October will control cranberry fruitworm (however, you should still scout during the following season). Four weeks of flooding suppresses dewberry.

Use a trash flood to minimize sources of disease inoculum and to limit girdler habitat.

Since leaf trash is not removed during a dry harvest operation, the trash flood is an important sanitation practice for a fresh fruit bed. Cranberry girdler feed on the bark just below the trash line. Thorough removal of trash limits habitat for this insect. In addition, fungal spores harbored on the trash are also removed, reducing the inoculum available the following year for the infection of the flowers and berries. Most beds will benefit from an annual trash flood.

The flood is applied post-harvest but before freezing conditions in order to remove missed fruit and leaf litter. Passing over the flooded bed with a water reel may be beneficial prior to collecting and removing the 'trash', but is not essential. Trash should be removed from the edge of the bed. Consider composting leaf trash (see the Composting Cranberry Leaves BMP for instructions)

Be particularly vigilant in frost management when protecting the fruit in the fall.

Fresh fruit handlers are quite intolerant of deliveries containing frost-damaged fruit. Growers must balance the need for a dry bed for harvest with the risk involved in allowing fruit to suffer frost damage. Be aware of weather conditions and monitor individual beds as needed. Make sure that sprinkler systems are well calibrated and uniform — the system must deliver 0.1" per hour for effective protection. Remember that fruit may begin to lose frost tolerance by late October due to physiological breakdown. This can increase the risk of sustaining damage when the bog is held at or near the tolerance without protection. Consult the Frost Protection Guide (available for no charge from UMass Cranberry Station) for more information (http://www.umass.edu/cranberry/pubs/factsheets.html).

Monitor soil moisture and depth to water table to schedule irrigation.

Most cranberry beds in Massachusetts are too wet, especially in the spring. This can lead to poor rooting, resulting in poor ability to survive dry periods and scald conditions. On the other hand, newly constructed upland beds can dry out quickly. Monitoring soil moisture with a water level float or tensiometer is a recommended practice.

Dry-harvest, fresh fruit beds can benefit from good irrigation scheduling and proper drainage by developing deeper roots. This leads to plants that are more resistant to environmental stress. In addition, proper water management can assure good fruit quality and high yield. When the bed is too wet, fruit rot disease is more likely to be a problem. Conversely, under-irrigating can lead to poor fruit quality due to transient shriveling/ softening on hot days, a condition that can hasten physiological breakdown of the fruit.

Be aware of scald conditions. Green fruit are especially susceptible.

Even if no scald damage occurs, temporary softening of the fruit due to inadequate moisture can result in compromised fruit quality at harvest and in storage. During hot conditions, it is critical that the bed be adequately watered prior to the onset of the heat. Critical conditions include: off-bed temperature greater than 80ºF, dewpoints less than 55ºF midday and early afternoon, clear skies, winds, and dry soil (no rain or irrigation in 48 hours). Remember that

under these conditions, the on-bed temperature can be as much as 20-30ºF higher than the temperature in the shade. In a well-rooted cranberry bed with adequate moisture in the soil at the beginning of the day, plants should be able to move enough water through and out of the leaves to provide cooling to the fruit and avoid scald damage. However, if soil moisture is not adequate at mid-morning, scalding of the fruit may occur unless sprinklers are turned on for 1-2 hours around noon. Remember that early morning irrigation is preferable.

Remember to monitor moisture and irrigate as needed up to harvest.
Approximately 10% of the final fruit weight is accumulated in September — most of this is water.

Horticultural Practices:

Do not sand fresh fruit beds heavily.
In fact, some growers are able to harvest only processed fruit in the year of sanding for a particular bed. Heavy sanding, in addition to reducing crop, can lead to physical difficulties for fresh harvest — machines need to be set closer to the soil surface and the teeth may dig into the sand.

Ice sanding is the method of choice.
Compared to ice sanding, barge sanding is less effective in anchoring runners. Dry sanding can result in rutting of the bed, as will any uneven sanding. Both of these outcomes are particularly negative for a fresh fruit bed since runners tend to interfere with harvesters and uneven ground can lead to increased fruit left unharvested. Dry sanding directly on the vines can cause significant injury to the plants and create an additional stress on the developing fruit the following year.

Vines training.
Vines should be trained with the particular dry picking machine to be used in subsequent harvests. The picking machines should never be used in a counter-clockwise rotation if the rotation is usually clockwise. Significant damage to the vines and runners will result.

Pruning is beneficial in a fresh fruit bed.
Pruning can reduce to some extent the need for sanding and can be used in training the vines for fresh harvesters. Pruning also improves light penetration and air circulation, limiting the incidence of fruit rot fungal infections and removes runners that can interfere with harvest. Western and Furford harvesters prune during harvest, while the Darlington harvester does not. Care should be taken to minimize vine injury as machines are moved around ‘corners’ in the beds.

If pruning is not part of harvesting, it can be done after harvest or early in the spring.
In fact, additional pruning of very dense stands by a second pass with a Furford harvester may be beneficial. In either case, no more than 0.5 tons/A of vines should be removed if pruning yearly or up to 0.75-1.0 ton/A every other year. Heavier pruning is usually associated with crop reduction. Pruning may be more critical for varieties like ‘Early Black’ that readily produce runners.

Cranberry pruning machines are usually a series of vertical knife blades set at an angle to the direction of movement and spaced at 1-foot intervals on a rotating frame. This device is mounted on a buggy or small tractor. A water picker modified to carry the pruning head has been used in Oregon. Such pruners move through the bed, removing runners and some uprights. The severity of pruning relates to knife spacing and speed of operation.

Disease Management:

Fruit rot management is critical for quality fresh fruit production.

This disease complex consists of more than a dozen different fungal pathogens. Some of these fungi can cause field rot, others can cause storage rot, and some can cause both types of rot.

In most situations, fruit rot can be effectively managed through the use of well-timed fungicide applications. Cultural strategies that are also helpful include regular sanding, properly timed irrigation, trash removal, late water floods, and vine pruning.

Under most circumstances, three fungicide applications, with the first one being applied at 10-20% open blossoms and the subsequent two applications spaced 10-12 days apart, will effectively manage fruit rot in Massachusetts. The choice of fungicide used for each application depends on the history of fruit rot in the particular bed in question and on the label of each fungicide. Particular care must be taken with the final application so that the pre-harvest interval does not delay the harvest of the fruit. One or two fungicide applications may suffice for 'Howes' or 'Stevens' that have greater fruit rot resistance than 'Early Black'. These fungicides should be applied at mid to late bloom. Once berries have been set and are sizing, further fungicide applications are unnecessary. Be careful to avoid the use of chlorothalonil on days where the temperature will exceed 90°F to avoid damage to the flowers or the young berries.

Fungicide use has already been described in the previous section on late water. Growers should utilize cultural strategies such as late water and judicious use of irrigation wherever possible, as these can also help reduce chemical inputs.

Since beds weakened by Phytophthora root rot can be more susceptible to fruit rot, Phytophthora management is important.

The fungus *Phytophthora cinnamomi* can cause tremendous crop losses in beds with significant areas of vine dieback. These areas of "acute" stress will produce no harvestable berries. Vines in peripheral areas of "chronic stress" caused by the fungus will possess fewer and smaller berries. In addition, the entire bed that is infested with the pathogen will often have very high levels of fruit rot because the plant's defenses are weakened by the stress on the root system.

The disease is managed primarily through drainage improvement and the application of either Ridomil or Aliette on a regular basis to the entire bed or as a spot treatment to the areas of worst infestation. Sanding low spots and fertilizing vines peripheral to the dead areas will also be helpful. Prevent infestation of uninfested beds by cleaning equipment and footwear before going from a bed that has the disease to one that is free of the disease.

Keeping Quality Forecast:

Observations conducted by Franklin and Stevens in the early 1900's revealed that cranberries had excellent keeping quality in certain years, terrible keeping quality in other years and that the variation could be predicted based on weather factors. Franklin and Stevens began making their first predictions of keeping quality in 1923 based on weather data and on incubator tests of berry samples. These forecasts proved to be accurate most years and they

continued until 1935. Franklin and Cross reinstated the forecast in 1949, putting out a preliminary forecast on April 1 (primarily for growers to decide whether to use late water) and a final forecast on June 1 (primarily for growers to plan their fungicide schedules).

The KQF is based on sunshine hours during February and March of the previous crop year, and for the current crop year, mean temperature and precipitation during March, April and May. Points are assigned for the various parameters; 10 total points for the preliminary forecast and 16 total points for the final forecast. The scoring system is set up such that the lower the total point score, the more vigilant the disease control tactics need to be.

Although the forecast continues to be accurate most of the time, cranberry cultivation is very different today, as opposed to the practices employed when the forecast was originally devised. Fresh fruit growers can still reliably depend on the forecast to help the planning process for the growing season. However, the KQF requires an in-depth evaluation to determine whether it can be improved and revised, based on the current management practices.

Use the KQF to determine whether to use late water and to schedule fungicides.
If the KQF predicts good or better quality fruit for that growing season, three fungicide applications or less should be required for a fresh fruit bed. If the forecast is fair or worse, a fourth or fifth application at shorter time intervals may be necessary, particularly for 'Early Black' beds. Fungicide rates should not be reduced unless the forecast is better than fair.

Insect Management:

Cranberry fruitworm egglaying may continue into late August and can be a serious problem for fresh fruit growers.

Berries should be monitored for eggs to prevent late-season infestation by larvae in fruit.

Although there is a single generation of cranberry fruitworm per season and although peak activity occurs in June and July, cranberry fruitworm moths may emerge in low numbers throughout the remainder of the season. Where population pressure is high, some beds may have substantial late-season moth flight. It is advantageous to keep populations checked by careful timing of applications of insecticides based on percent out-of-bloom counts, to make every effort to use fall floods, and to regularly utilize late-water floods. Consult local entomologists for information on availability of biorational insecticides for this pest.

Scout rigorously for Sparganothis fruitworm during the spring sweeping season. Sparganothis can be a critical pest for fresh fruit beds since the second larval generation may remain active at harvest. Fruit infestation by larvae is a cause for delivery rejection. Sparganothis is well controlled by monitoring and treating the spring generation (visible in sweeps by mid-May). Good control in the spring will greatly improve control of the summer generation, preventing late season breakouts and is critical when using the newbiorational insecticides. Late water does NOT control this pest but does tend to synchronize moth flight, making management easier.

Use alternative pesticides for *Sparganothis* management.
Natural enemies (wasps and flies that are parasitoids of *Sparganothis*) are very often key in successful management of this pest. Elimination of broad-spectrum compounds and the substitution of biorational compounds that specifically target *Sparganothis* will allow natural enemies to build up. Further, a large area of organophosphate-resistant *Sparganothis* exists in

Massachusetts. If your bog is in this area, treatment with Guthion, Orthene, or Lorsban will not be effective. Consult local entomologists and use alternative insecticides such as Confirm and spinosad products.

Use pheromone traps to determine peak flight of *Sparganothis*.
Insecticide applications to manage second generation larvae as they hatch, or just prior to hatching, are timed based on information gathered with the traps. Moth counts in traps need to be made weekly over a multi-week interval in order to determine peak moth flight. For insect growth regulators, e.g. Confirm, the onset of flight must be determined. Since timing varies depending on material used, it is important to consult the label.

Use an IPM approach to minimize pesticide use and residues.
Spray only when damaging numbers of insects are present. Use cultural controls, such as late water and fall flood, to enhance management of cranberry fruitworm, cutworms, and cranberry girdler (see the Chart Book for specifics).

Weed Control:

Map and prioritize weeds. Concentrate management resources on weeds that limit yield and interfere with harvesters.
In addition to their impact on yield, trailing dewberries can interfere with harvesting equipment. Clipping of tall weeds may eliminate seeds and limit tangling in harvest equipment. When weeds become tangled in harvest equipment, the likelihood of mechanical damage to the fruit is increased, leading to reduced keeping quality.

Be aware of how weeds invade the bog.
Limit 'walk-on' land bridges — though convenient, they are a route for weed invasion. Clean harvest equipment that might harbor weed seeds (especially dodder seeds).

Use care in applying oil with grass herbicides.
Crop oil can injure bloom, especially on hot days.

Manage dodder populations to limit spread and seed production.
In small infestations, consider hand-removal of seed capsules prior to harvest. Seed capsules may break open during harvest, spreading seed across the bog. If the infestation is extensive and pre-harvest removal is not possible, attempt to remove seed capsules from the bed by post-harvest trash flooding. Dodder seeds are long-lived and this pest can significantly reduce yield.

Timing of Harvest and Other Factors Specific to Harvest:

Berry harvesting conditions – moisture, heat, and sun.
Berries should be harvested when they are free from any moisture (dew or otherwise). Berries that are brought into the receiving stations moist will remain moist for an extended period of time and this will adversely impact keeping quality and pack-out percent.

Likewise, when warm berries are delivered, the berries remain warm for an extended period of time even if they are quickly put into refrigeration. Warm fruit are more susceptible to handling damage and decay because of their undesirably high respiration rate. The adverse impacts of moisture and field heat are especially conspicuous because berries stored in bulk tend to equilibrate much less rapidly than one might expect.

It is also important that direct sun exposure of the fruit be minimized — this includes berries left in boxes out on the bed, on the trucks adjacent to the beds, or on trucks sitting in the sun at receiving stations. Once the fruit is removed from the plant, it no longer has the ability to self-cool. Whenever feasible, shade the harvested berries.

Impact of berry maturity on keeping quality.

Less mature berries keep better in storage than fully ripened berries. For delivery of high quality berries one should harvest when the berries are ripe, but not overripe. Another reason not to delay harvest is the increasing likelihood of frost damage as the season progresses.

Berries continue to color in storage, so delivering berries at less than maximum color is not always a disadvantage to the handler. It is a known fact that color development in storage will continue but the rate will depend on storage temperature (the higher the temperature the quicker the rate).

How to judge optimal time for harvest.

'Early Black' has good keeping quality if harvested before the berries become overripe, prior to the end of September according to Eck (1990). Since 'Howes' ripen later, they can be harvested as late as the end of October. Harvesting prior to maximum color development will enhance keeping quality.

For early season berries, when the handler storage period is short, there is an increased need to pick berries when the color is adequately to fully developed since storage of these berries will be short. As the fresh season progresses, handler flexibility should increase, in which case, the grower can deliver berries that are a bit short of fully-colored.

Harvest method impact on fruit quality (harvester type, etc.).

The less the berries are handled the better the quality, and this starts right from harvest. In fact, it has been shown that hand-harvested berries have a much higher keeping quality than machine harvested berries. Of course no one can maintain an economical operation without utilizing mechanized harvest; therefore, one should deploy all reasonable methods to make machine harvesting as gentle as possible.

Furford dry picker

Darlington harvester

Three mechanical pickers are in use in Massachusetts, the Darlington, the Furford, and the Western (least used). Both the Furford and Western pickers prune the vines. The Darlington and Western pickers are limited by low capacity (fewer acres per day), a tendency to leave fruit behind, and berry bruising. These drawbacks are less severe with Furford pickers. The Furford is known for high harvest capacity. However, it has been reported that the Furford machine is more damaging than the Darlington machine. Conversely, Darlington pickers seem to require more maintenance time. For each machine, there are equipment modifications that can make these machines less injurious to the berries. Consult local fabricators and distributors for more information.

Impact of physical abuse on keeping quality.

Berry handling is arguably the single most important factor determining berry quality. Even if crop management has been perfect up to harvest, poor fruit handling can be your downfall. As soon as a fruit is damaged (in the field, during harvest, etc.) the fruit respiration rate increases and the keeping quality of that fruit decreases. The presence of damaged fruit indicates that other berries not yet showing damage may also be deteriorating.

Anything that minimizes the impact of berry handling and injury will improve keeping quality. This in turn will mean higher pack-out rates for the handler, and better quality berries for the consumer.

Harvest employees should be trained in proper fruit handling and harvester operation. Fruit damage may be increased by improper equipment operation and tangling of the machine in weeds or runners. Fruit should be handled gently - minimize the drop distance to the bin floor when transferring fruit. Do not dump the fruit from a height. Avoid larger bulk bins, as there will be a certain amount of fruit that are crushed at the bottom of the bin.

On-farm detrashing to remove prunings generated by the harvester will introduce another handling step prior to fruit delivery. Again, this operation should be evaluated to eliminate any practices that bruise the fruit and employees should be properly trained to avoid fruit bruising.

Post harvest storage:

The quality of the harvested berries has much to do with their ability to be held in storage. Any adversity in the form of disease, sunscald, frost damage or especially mechanical damage will adversely impact the ability of the berries to keep, and the quality of the finished product.

For ideal cranberry storage and post-harvest handling, fruit should be refrigerated at a constant temperature. Storage between 36ºF and 40ºF is optimal. Storage at cooler temperatures (below 36ºF) is not recommended because cooler temperatures increase the incidence of physiological (sterile) breakdown. Refrigeration works by slowing the respiratory activities of the fruit and the spread of any pathogens the fruit may contain.

Whether or not a handler chooses refrigerated storage will depend on a number of factors. Refrigerated storage is expensive and sometimes hard to justify, especially considering the short length of the fresh cranberry season. Accordingly, the cost of refrigerated storage must be weighed against the quality of the incoming fruit, expected period of fruit storage, and the expected ambient temperature conditions postharvest. Refrigeration helps to maintain fruit quality but it is by no means the only factor impacting quality.

Little is known about the impact of relative humidity on storage quality of cranberry but conditions leading to moisture on the berry surface will accelerate fruit deterioration.

Familiarize yourself with handler standards for fresh fruit.

There are three major, and many minor fresh-fruit handlers in Massachusetts. Each handler sets standards based on their own needs, and as dictated by government rules and regulations. Handler standards vary from year, and the following is a list of those standards that are most important.

Fruit contamination – all delivered fruit must be at or below EPA set tolerance levels for any approved pesticide that is used on cranberries. Further, fruit must not be contaminated with any form of food-grade or non-food grade based lubricant of any kind.

Standard tests – Each handler will have specific standards by which they grade or accept fruit. Standards may be based on the USDA's standard for fresh cranberries. This standard includes grading criteria for the presence of bruises, frost, mold, fruit-firmness (soft or decayed), scald, insect presence, or insect damage.

Additional factors - Handlers also require that fruit be delivered dry, and with a minimum of chaff. Fruit keeping quality and pack-out percentage are also very important quality and profit components and payments may reflect these factors.

Learn about Good Agricultural Practices (GAP) standards.

With food safety becoming a greater concern among consumers and retailers, there has been an increased demand that fresh fruits and vegetables meet certain conditions. One of those conditions has been Good Agricultural Practices, or GAPs, which seek to put in place practices that will help to limit microbial contamination on the farm. To date, this is a voluntary program that is not mandated by law. However, the buyers that your handler sells to are calling for fresh fruit cranberries to come from GAP certified farms. Currently this is being limited to those berries bound for fresh fruit markets. To receive certification, you will then have to pass an audit by a third party, either the USDA or one of the many commercial firms available.

Please go to the Cape Cod Cranberry Growers Association web site and read the many relevant documents relating to GAP: http://www.cranberries.org/growers/alerts_gap.html.

Prepared by Carolyn DeMoranville, Frank Caruso, and Joseph DeVerna (Ocean Spray Cranberries, Inc.), 2003.

Fresh Fruit Production Checklist

- ✓ Choose varieties for fresh fruit based on favorable characteristics.
- ✓ Incorporate the many flooding options available into pest and vine management.
- ✓ Be particularly vigilant in frost management when protecting the fruit in the fall.
- ✓ Use ice sanding whenever possible and do not heavily sand vines in general.
- ✓ If pruning is not part of the harvesting procedure, plan pruning events for the spring.
- ✓ Use the KQF to determine whether to use late water and to schedule fungicides.
- ✓ Practice good management in terms of insect and weed management as well.
- ✓ Become familiar and get training in GAP standards if applicable.

CULTURAL AND RESOURCE MANAGEMENT BMPs

Composting Cranberry Leaves

Natural by-products of harvesting and handler operations are cranberry leaves that have abscised (either naturally or mechanically) from the cranberry plant and have fallen on the bog floor. During the harvest flood and post-harvest trash flood, leaves and small fruit may be removed from the bog surface. Leaf piles may contain up to 12% fruit (mostly small berries). This debris is commonly stockpiled in close proximity to the actual producing farm acreage.

Piles of leaf trash can be found at almost every commercial cranberry farm operation. It is estimated that one acre of bog can generate 0.5-1.5 cubic yards of leaf trash each year. A local handler facility reported that they receive 10,000-30,000 cubic yards of leaves each year. Thus, leaf trash piles may accumulate on-site very quickly.

Leaf trash has been identified as a source of secondary inoculum for many fungi that can cause fruit rot in cranberries (Oudemans et al., 1998). Trash piles can also serve as a secondary source for weed seeds that can blow back onto and re-infest the cranberry beds. Presently, pest management BMPs recommend removal of trash piles to sites at least 1/4 mile away from the bog. However, this can be difficult or impossible. Once established, trash piles tend to persist, decomposing slowly, if at all. It is likely that the thick waxy epidermis (Croteau and Fagerson, 1971) of cranberry leaves may slow the natural decomposition of abscised leaves (assuming no additional amendments).

Composting may offer a reasonable alternative to facilitate the management of these leaf piles. Composting hastens natural breakdown processes associated with biological materials. Farm-produced compost fits well as part of a more sustainable food production system. The organic matter produced from the composting process could be incorporated back into the cranberry production system, used in other agricultural settings, or marketed to the public as a soil amendment or mulch. Owners of both large and small cranberry operations could incorporate composting into their current farm activities. The overhead is usually minimal and any necessary equipment is typically present on site.

Before beginning a composting process on a large scale, check local and state requirements and obtain any necessary permits. Contact William Blanchard (MDAR) at 617-626-1709 or go to http://www.mass.gov/agr/programs/compost/index.htm.

Recommended Practices

Select an appropriate site.

The location of the compost site should allow easy access and a minimum of travel and materials handling. A firm surface to support heavy vehicles under various weather conditions is preferable. The convenience of a site must be weighed against other factors such as proximity to neighbors, visibility, drainage, and runoff control. The best site may not be the most convenient or a convenient site may need modification.

Choose an upland site with well to moderately drained soil and a slope of 1-4% to prevent ponding or runoff. If your site is subject to surface runoff, a berm or diversion can be constructed to divert surface runoff away from your compost pile. Runoff leaving your site can

be filtered through vegetated buffer strip that will reduce the velocity of your runoff and prevent sediment from moving offsite. Contact Natural Resource Conservation Service (NRCS) for assistance in developing your compost site.

Promote optimal composting conditions.

Composting is most rapid when conditions that encourage the growth of microorganisms are established and maintained.

Organic materials are appropriately mixed to provide the nutrients needed for microbial activity and growth, including the proper carbon-to-nitrogen (C:N) ratio. Appropriate oxygen levels are maintained to support aerobic organisms.

The material is moist, but not saturated, to permit biological activity without hindering aeration.

Temperature is high enough to encourage vigorous microbial activity from thermophilic (heat-loving) organisms.

Table 1 lists the recommended conditions for rapid composting.

Include a high nitrogen source in your recipe.

To compost cranberry leaves, you need to add a moist, high-nitrogen source, which helps to establish a reasonable carbon-to-nitrogen (C:N) ratio. On-site demonstration cranberry leaf piles at the UMass Cranberry Station were successfully composted when hydrolyzed fish waste (obtained from a local distributor) was added as a nitrogen source. A recipe using 10:10:1 or 10:10:2 ratios of cranberry leaves:horse bedding and manure:liquid fish fertilizer was capable of producing temperatures within the reasonable range (110-150°F) for 20-30 days. Both recipes prevented the germination of several common cranberry weed seeds (see Table 2). Other researchers have reported similar results (Eghball and Lesoing, 2000).

Continued experimentation by researchers and growers will most likely yield other suitable amendments.

Table 1. Recommended conditions for rapid composting (from: On-farm Composting Handbook, p. 7.)

Condition	Reasonable range[z]	Optimal range
C:N ratio	20:1-40:1	25:1-30:1
Moisture content	40-65%	50-60%
Oxygen concentration	greater than 5%	much greater than 5%
Particle size	1/8-1/2	varies[y]
pH	5.5-9.0	6.5-8.0
Temperature (F)	110-150	130-140

[z]Recommendations for rapid composting. Conditions outside these ranges can also yield successful results.
[y]Depends on the materials, pile size, and/or weather conditions.

Proper blending of feedstock materials facilitates the composting process.

The proper initial mixture can be achieved by adding the feedstocks (in the proper proportions) to a manure spreader, feed wagon, or by utilizing a loader or backhoe.

If a well-constructed pile, made with a good recipe, is maintained at the proper moisture and is

thoroughly blended, a static compost pile (see Figure 1) should need to be minimally turned. If conditions are just right, the pile may not need to be turned at all until the composting process is complete. A properly blended mixture will allow air and moisture to move uniformly through the pile allowing the microbes to do their job.

Table 2. Percentage seedling germination of weed seeds placed in various cranberry leaf compost recipes.

Seed	No. planted	Potting soil	20:0:0	10:10:1	10:10:2
Common goldenrod	200	5	0	0	0
Dodder	200	4	2	0	0
Lurid carex	100	2	17	0	0
Narrow-leaved goldenrod	100	10	2	0	0
Nut sedge	200	13	8	0	0
Poison ivy	50	26	30	0	0
Switchgrass	100	6	0	0	0

[z] Sandler et al. 2003.

Strive to achieve a balanced C:N ratio.

Microorganisms use carbon for energy and nitrogen for protein synthesis and reproduction. It is important to provide these nutrients in the appropriate proportions. The optimum C:N ratio is in the range of 25-30:1 (see Table 1). Tested cranberry leaves fell in the range of approximately 35-40:1. The horse manure/bedding material used in the test piles had a C:N of 55:1. These values are certainly acceptable and will give good results.

Materials will release their carbon at different rates and this will affect the composting process. For example, straw releases its carbon more quickly than woody materials (that contain lignin, such as stems and cranberry leaves), but more slowly than the simple sugars found in fruit wastes.

See Table 3 for a list of common raw materials used in composting and their associated C:N ratios.

If using new or innovative materials, consider analyzing the materials prior to use.

Commercial laboratories are available that will analyze raw materials as well as finished compost. If you are using materials from a new or unknown source, the lab analysis may provide you with valuable information. Most labs test for bulk density, C:N ratios, pH, moisture content, and other indicators of a material's potential as a successful compost pile ingredient.

Composting trash piles should be well aerated.

This is particularly important in the initial stage of the process when oxygen demands are the highest. The most readily degradable raw materials are rapidly metabolized in the beginning and the microbes performing these activities need oxygen. If the supply of oxygen becomes limiting, the composting process slows. Therefore, it is most critical to monitor the pile in the beginning to insure that the most favorable conditions (adequate oxygen, moisture, and temperature) prevail.

Consider adding a 6" or 8" perforated pipe to the base of the pile (see Figure 1). A perforated pipe will encourage air movement through the pile and act as a drain for excess moisture. If water is coming out of the pipe, the pile is too wet.

Regularly turn the compost pile.

Consistent turning exposes all of the raw materials to the high internal temperatures. This permits the breakdown and conversion of the materials into a useable product. Regular turning promotes aeration.

Consider adding a bulking agent.

On farms, a composting recipe usually contains a blend of materials. Bulking agents provide structure so that the material can stay in the pile without collapsing (provides aeration). Bulking agents increase pore space needed for air movement. Since cranberry leaves are so small, bulking agents (such as horse manure with bedding) are recommended.

If you have the bulking material on your farm, you can compost according to the Department of Food and Agriculture (DFA) guidelines, without registering with the DFA. If you need to bring in material from outside your farm, you need to register with the DFA (see following information).

If you need to bring in any bulking materials from off the farm or will be receiving fruit or leaves from another farm, you must register with the Department of Food and Agriculture as part of an agreement with the Department of Environmental Protection (DEP).

To register, an application must be submitted to DFA. The application can be found in the Department's Guide to Agricultural Composting. To receive a guide, contact William Blanchard (MDAR) at 617-626-1709 or http://www.mass.gov/agr/programs/compost/index.htm or the Cape Cod Cranberry Growers' Association (CCCGA) at 508-866-7878. The publication gives detailed explanations about what a grower would need to do. The application asks for information about acreage, land uses, vegetative buffers, and more. Growers may also join together to register as one composting unit.

Table 3. Summary of common raw materials that can be used for on-farm composting (from: On-farm Composting Handbook, p. 16.)

Material	C:N
Bark (hardwood)	110-435
Corrugated cardboard	560
Cattle manure	11-30
Corn stalks	60-75
Cranberry (leaves and stems)	35-60
Cranberry presscake	30-40
Finished compost	25-30
Fish processing wastes	2.5-5
Fruit wastes	20-50
Grass clippings	9-25
Hay	15-32
Horse manure	22-30
Leaves	40-80
Newspaper	400-850
Paper mill sludge	54
Poultry manure	7-10
Sawdust and shavings	200-750
Seaweed, other aquatic plants	5-27
Straw	50-150
Swine manure	9-19
Vegetable wastes	11-13
Wood chips (hardwood)	450-820

In most cases, water should be added to the cranberry leaf pile.

Moisture is necessary to support the microbes that perform the composting activities. If the moisture content is below 15%, microbial activity will cease. Optimal moisture content is between 40-65%. Below 40%, microbial activity slows; above 65%, anaerobic conditions predominate.

A simple "squeeze" test gives a good estimate of a pile's moisture content. The material should feel damp to the touch with just a drop or two of liquid expelled when the material is squeezed tightly. If the pile is too wet, turn the pile. Adding dry materials may be helpful. If the pile is too dry, it can be rewetted with a trickling hose or similar device.

During field trials, water was added to the piles after the ingredients were initially mixed together. If rainfall is insufficient, additional water may be needed periodically (every 2-3 weeks). Monitor pile temperatures. A drop in temperature indicates decreased microbial activity. This may be due to lack of moisture.

Covers (e.g., burlap, tarps, non-spun row covers) can be used to maintain moisture.

Monitor pile temperatures.

Probes should be used to check temperatures every few days. Many companies sell probes that can be successfully used in active compost piles. Consider monitoring the interior portion of the pile as well as the exterior. Depending on the size of the pile, use a probe with a 2 to 4-foot stem for monitoring interior temperatures. Probes with one-foot stems should be adequate for exterior pile measurements.

Make piles the correct size to encourage the compost process.

Piles less than 3.5 feet tall may fail to heat. On the other hand, piles taller than 8 feet or wider than 20 feet may overheat (temperatures exceed 150°F). Piles that are too large may become anaerobic, and therefore, excessively odorous.

Identify the machine that you will be using to turn your piles and adjust the size of the pile accordingly.

Monitor the odors emanating from the pile.

Temperature and odor are probably the most important indicators of how well composting is progressing. Some odor is to be expected. However, if putrid odors persist, the pile has probably become anaerobic and needs to be turned.

Minimize odor concerns by properly managing the site.

Anaerobic conditions promote foul-smelling odors. To avoid problems with odors, use a good mix of materials, avoid overly wet mixes, monitor temperatures, and turn or aerate piles regularly.

A key to minimizing odors is to start composting your raw materials as soon as possible and then keep them aerobic.

Odors can be controlled by the choice of raw materials. For example, a layer of peat moss or finished compost can be placed on top of a composting pile to trap odors. Mixes with large amounts of sawdust, compost, or peat moss can help absorb odors coming from other ingredients.

Build or use a site with a crown (~3%) to promote surface runoff. Puddling rain water promotes odors and inhibits your ability to properly work the pile.

Keep the site well drained.

Good drainage at a composting site must be a priority. Locate the site on moderately to well drained soil.

Ideally, the site should have not have rocks. These can get mixed into the composting materials and damage machinery. If mud could be a potential problem, consider resurfacing the composting pad with gravel or sand.

Consider sloping the site (1-4%) to facilitate water run-off.

The site should be graded for handing surface runoff without creating erosion. Runoff, if needed, can be directed towards pasture areas, an infiltration area, or collected in a holding pond for later use. Runoff should be diverted away from the compost pad and storage areas.

Determine when the composting process has finished.

A sustainable drop in temperature is probably the most reliable indication that active composting has been completed. Failure to reheat after turning is also another indication that the compost has proceeded to the point that it can be cured. However, be sure that the lower temperature is not due to the lack of moisture or similar factors. This can be checked by placing a small sample in a sealed plastic bag at room temperature. If the compost does not emit a foul smell within one week, it can be considered stable.

Commercial kits are also available from certain laboratories (see “For more information”).

Use finished compost around the farm.

Finished compost can be used in many areas around the farm. Consider using compost as a dressing on sandy dikes to facilitate the establishment of grass cover. Depending on the components of the compost, impacts on plants can be varied and not all may be positive (Krogmann et al., 2008, Ramirez-Perez et al., 2007). Try the compost on a small area before doing large broadcast applications.

If enough finished material has been generated, it may also be used as part of the organic layer in the lining of new bed construction.

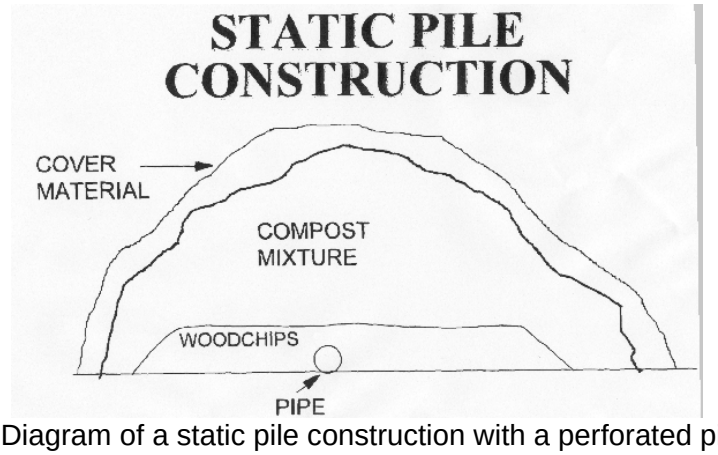


Figure 1. Diagram of a static pile construction with a perforated pipe insert.

Cranberry fruit can be made into a pomace and used to supplement potting media.

Cranberry pomace is a by-product obtained from the juice extraction process. This pressing residue maintains the natural color and flavor of the cranberry. In work done by Cox and Lopes (2008), two types of cranberry pomace were tested. One had been composted (just left to decompose; nothing was added) for about 3 years and had the appearance and consistency of coffee grounds. The second type of pomace was about 6 months old and was not probably completely composted as seeds and recognizable fruit skins were still obvious.

The pomace was added in various proportions with potting soil or other media. Some plants did well, while the growth of others was inhibited. Be sure to test any mixture before using it on a large scale for plant propagation.

Portions of this text were excerpted from:

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University of Maine Composting School Web Site. http://www.composting.org.

University of Massachusetts Soil and Plant Tissue Testing Lab. Compost analysis. West Experiment Station, Amherst, MA 02001. 413.545.2311. http://www.umass.edu/soiltest/pdf/compbrochfeb2004.pdf and http://www.umass.edu/plsoils/soiltest.

Woods End Research Laboratory, Inc. Old Rome Road, Box 1850, Mt. Vernon, ME 04352. 207.293.2457. Lab analysis and suppliers of Solvita test kits for determination of finished compost. www.woodsend.org.

Updated by Hilary Sandler, 2010.

Composting Cranberry Leaves Checklist

✓ Contact the Massachusetts Department of Agricultural Resources Composting Program for information on state and local regulations regarding composting (http://www.mass.gov/agr/programs/compost/index.htm).

✓ Contact state regulatory agencies prior to starting a large-scale composting process.

✓ Add a high nitrogen source to the cranberry leaves to achieve a good C:N ratio.

✓ Provide good aeration; regularly turn the pile.

✓ Site the pile in a responsible manner. Minimize odors and keep the site well drained.

✓ Use the finished product on-farm whenever possible.

Erosion and Sediment Control

Erosion and sedimentation pose problems for soil conservation and water quality maintenance. Erosion control is an important component of non-point pollution prevention programs since soil itself can be both a contaminant and a carrier of other pollutants such as pesticides and nutrients. Under the Massachusetts Wetlands Protection Act, erosion and sediment must be kept to a minimum in order for practices to continue to qualify as Normal Maintenance or Improvement of Land in Agricultural Use. Since cranberries are grown in proximity to sensitive water bodies and wetlands, it is essential that growers use the best practices available to control erosion.

Most cranberry agricultural activities do not give rise to significant levels of off-site erosion. In fact, many of the strategies recommended for reducing erosion and sedimentation are normal farming practices of the cranberry industry. Bogs are typically constructed on nearly level to slightly depressed landscapes, so runoff and erosion are minimized. Secondly, strict control of water flow through the bogs is critical to successful growing and harvesting of cranberries. Water control structures function to control water volume and velocity. Therefore, waterways in cranberry bogs tend to be less subjected to storm-related erosion events. Also, cranberry water systems often include water storage ponds that act as settling ponds that further reduce off-site sediment discharge. Finally, cranberry growing conforms to conservation farming principles in that the soil is not disturbed once the crop is established.

Sources of water and wind eroded sediments associated with cranberry production are generally related to atypical or occasional activities, such as land clearing, new bog construction or renovation, operations associated with sanding (namely excavating and stockpiling of sand resources and sand application), and ditch cleaning and maintenance. In some bogs, especially those with perennial streams flowing through them, stream or ditch bank erosion can pose a concern. This BMP is designed to point out ways to minimize erosion and sediment during these activities.

Information is also provided regarding the construction and maintenance of sediment barriers.

Make sure that you are familiar with and in compliance with State and Federal Wetlands Protection regulations.

For more information on E&S Best Management Practices, you can reference the Massachusetts DEP document, “Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: a guide for planners, designers and municipal officials”. This document is also available on-line at: http://www.mass.gov/dep/water/essec1.pdf.

Recommended Practices

Erosion and sediment prevention methods-New construction and bog renovation

Disturbing large areas of land carries with it the risk of erosion. Soil erosion can damage water bodies and aquatic life. Small plants and invertebrate animals can be smothered by silt that may also damage the gills of fish. Sediments may also serve to carry pollutants into water. For example, phosphorus is often bound to soil particles at low pH and may be carried with sediment, stimulating algal growth in receiving water bodies. Proper planning for the control of

erosion prior to the start of any construction or earthmoving activities will ensure that wetlands and water bodies are protected and that you remain in compliance with the Massachusetts Wetland Protection Act. The Act **requires** that erosion and sediment be minimized as part of the Normal Maintenance or Improvement of Land in Agricultural Use practices.

It is important to formulate an erosion control plan **prior** to the start of any construction activity. The erosion control plan, including planning for where runoff water will go during construction, should be part of your overall project plan. Materials needed for implementing that plan should be on hand or installed prior to earth disturbance. It is vital to have erosion control measures in place prior to substantial rainfalls or storms.

For most effective erosion control:

- Formulate a plan for erosion control.
- Minimize and stabilize disturbed areas.
- Protect disturbed areas from runoff and minimize runoff velocity.
- Prevent sediment from moving off of your site.
- Regularly inspect and maintain erosion and sediment control structures and materials.

Pre-construction planning

Plan for water movement on your site. If possible, plan to divert water around the site. Soil laden runoff should be kept out of sensitive water bodies. It may be necessary to plan for retention ponds to hold such runoff for sedimentation prior to release. All such plans should be based on handling a large rain event, e.g. 4+ inches in 24 hours.

Plan dikes with side slopes no greater than 1:1. While steeper slopes allow for a larger planting area, they are more vulnerable to erosion. Steep dikes will continue to be more difficult to maintain for the life of the planting.

Plan to install silt fencing and barriers.

Have all required erosion control materials on site.

Erosion control during construction

Before starting a project, develop a plan to control construction related impacts (e.g., erosion, sedimentation) during construction and land disturbance activities. Construct water management and control features first. Recovery ponds constructed now can act as silt basins. The captured material may be useful later in dike construction. Divert channeling water around the disturbed area, as common silt barriers are only effective against sheeting runoff across the site.

Install silt fencing and barriers.

Silt fencing should be installed along the down slope property edge. It must be in place before any soil is disturbed. Instructions for constructing silt barriers are found in the last section of this BMP. Silt fences must be inspected after every rainfall and properly maintained to minimize soil movement. These barriers protect water bodies as well as neighbors properties and public ways.

Disturb as little of the site as possible.

When constructing multiple beds, open up the site progressively. Stabilize the site as you go along. Leave existing vegetation in place elsewhere on the site as much as possible. If you have problems with dust and wind erosion, control by sprinkling water on dry soil or sand. Keep your site neat. This will help to control erosion and will also be looked upon favorably by your neighbors.

Maintain soil and sand stockpiles properly.

Excavated sand should be stockpiled as far away as possible from water bodies and drainage ways. Soil stockpiles can be stabilized by seeding or mulching. This should be done if stockpiles will remain for more than a week or two. Down gradient silt barriers may also be needed. The potential impact on neighbors should be determined when establishing height and location of stockpiles.

Avoid loss of soil from roadways during construction.

Dust on roadways can be controlled by sprinkling water. Grass or vegetation should be established on roadways, dike roads, etc. as soon as possible. Placement of coarse gravel in the site roadways at the exits will prevent tracking of soil onto public roadways. For this practice, coarse gravel (2-3 inches) is placed 6 inches deep by 7 feet wide for the final 50 feet of the exit roadway.

Avoid disturbing soil during adverse weather conditions.

Work during dry seasons.

Do not work on the site when the soil is frozen or saturated or during heavy rain or wind storms. When large rain events are predicted, putting a shallow flood over the bed can be protective against erosion losses.

Dike construction and stabilization

Construction.

Embankments should be built no steeper than 1:1. Site the shallower slope on the outside of the dike to minimize off-site erosion. The dike should be built and compacted in layers using fill materials containing no sod, brush, roots, stumps, or rocks larger than 6 inches. Core materials in the dike should be the most impervious materials available. In Southeastern Massachusetts, this will often be compacted glacial till. Dikes should be constructed to a height 1 foot above the normal flood elevation. In order to establish vegetation on dikes or embankments, surface soil must have the capacity to hold adequate water to support plant growth (see NRCS standard for cranberry bog dike construction, http://efotg.nrcs.usda.gov/references/public/MA/356.pdf).

Stabilization.

Stabilize dikes and other disturbed areas by seeding to grass or other types of vegetation stabilization plants, by mulching, or by placing soil stabilization fabric (geotextile, netting, or burlap). Mulch should be anchored with a biodegradable netting. Grade 2-3 turf sods have been used successfully for this purpose. Pay particular attention to dike edges, they remain prone to erosion during rainstorms until stabilized. Keep woody plants off of dikes as their roots can destabilize the structure. Avoid ponding (wheel tracks) on top of dikes.

Erosion control blankets (e.g., Curlex), have been successfully used to stabilize bankings and on-bed ditch edges. Ditches stabilized with these products required 60% less cleaning than those left untreated. Erosion blankets are preferable to loose mulch on the bog side of a dike,

as mulch may contain weed seeds that will end up in the bed. Erosion control blankets are biodegradable, decomposing in 6-8 months. The material must be in good contact with the underlying soil or erosion can occur under the blanket.

Grass is best planted in spring or fall and may benefit from a layer of mulch or netting and periodic watering during establishment. Top dress dikes with 3-4 inches of topsoil prior to seeding. Hydroseeding or gel seeding can be used. Erosion control blankets have been successful in conjunction with grass planting. Studies have shown that germination rate rose from 50-60% to 85-95% when blankets were used over grass seed. Pre-seeded blankets are available.

Choose non-weedy species for seeding dikes. Recommended examples include clovers, fescues, and perennial ryegrass. Mixtures of species in the seed mix are preferable to a single species. Fertilize and lime grasses as needed during establishment. See the reference “Is it time to rethink grass slopes?” at the end of the section.

Flume installation, protection, and stabilization

Installation.

Flumes should be fitted with antiseep collars and constructed into native soil if possible. Fill and compact around the culvert to prevent piping (formation of eroded channels). Packing with bentonite or other dense materials may be helpful.

Placement of concrete blocks around the flume may also help.

The size of the outlet pipe is important. If it is too small, the culvert may wash out. Size is determined based on the amount of water required for flooding, de-flooding, and handling of a chosen storm event. Consult an engineer or NRCS for this calculation.

Water should be discharged into a stable ditch or channel.

Protection and stabilization.

Use a riprap apron with underlying geotextile at the entrance and exits of outlet flumes where the velocity of flow could cause erosion. The geotextile protects the riprap from undercutting and can be placed directly on leveled soil. A gravel base may be substituted for the fabric. The riprap apron is necessary if capacity flow from the outlet results in the formation of plunge pools. These can severely weaken embankments and threaten stability. The riprap apron also prevents scouring at the culvert mouth and prevents gully erosion that could gradually extend upstream.

The riprap structure should be installed early in construction but can be added later. Once installed they should be inspected regularly for any movement or displacement of the rock. Removal of sediment buildup may be difficult and generally requires hand labor.

Erosion and sediment prevention methods - all beds

Controlling steam bank and ditch bank erosion.

A common result of this type of erosion in cranberry systems is the loss of functionality of ditches and canals. Ditches lose drainage capacity due to sedimentation and canals can lose capacity due to bank slumping.

Manage water to minimize erosion, slumping, and undercutting of bankings.

Stream or ditch bank erosion commonly occurs when saturated, unstable soil materials are subject to high volume and velocity water flow followed by rapid drawdown (common in sandy soils). Reduce the erosive potential of moving water by slowing the flow velocity at the flume.

Lower water levels in ditches to improve slope and bank stability during times of the season when soil is wet. This is especially common in the spring during periods of rain and/or sprinkling for frost. Water levels in ditches should be higher in times of drought. Saturated soil has very little strength; lowering water levels in ditches dries out the soil and reduces slump and failure of sidewalls.

Use vegetation or other materials to stabilize bankings.

Establish a good stand of grass on dikes. This will stabilize the soil and prevent waterlogging (vegetation facilitates water loss by transpiration).

Try to establish cranberry vines or other vegetation on the sidewalls of ditches. The roots will anchor the soil, increase soil stability, and reduce slumping. Erosion blankets such as Curlex may be used to aid in establishment of vegetation on bankings and in holding the bed edges in place until the cranberry plants are well established.

Apply geofabric or geogrid materials to unstable embankments to increase shear strength and reduce slumping.

Install protective features.

Install energy dispersing or deflecting barriers (e.g., rocks, riprap) wherever discharging water flows in direct contact with a ditch sidewall. This will occur where discharging internal flumes are set at right angles to the shore ditch or canal and large volumes of water are being released, e.g. harvest flood.

Add rip rap stone to the down gradient side of flumes to prevent stream or ditch bed scouring. Large irregular stones placed in the stream or ditch bed dissipate the energy of high velocity water exiting the bog. The loss of energy by the water significantly reduces scouring and sediment transport. This practice is regulated under the Massachusetts Wetlands Protection Act - make sure you are in compliance when using rip rap stone.

Sanding

Stockpile sand responsibly.

The stockpiling of sand should be limited as much as possible. Loss to water and wind erosion is inevitable if sand piles are left in place for long periods of time.

Excavated sand should be stockpiled as far away as possible from water bodies and drainage ways. Down gradient silt barriers may also be needed. All efforts should be made to minimize wind erosion.

Consider the impact on neighbors when establishing height and location of stockpiles.

Avoid discharge of sand laden waters.

This is critical when barge sanding. Retain flood water for an adequate period to allow settling, usually 5-7 days or longer.

Sand laden water may also be generated following other sanding methods if sand is ‘watered-

in' by hosing or shallow flooding. Precautions after such practices should be similar to those used when barge sanding.

Follow practices recommended in the Sanding BMP.

Ditch cleaning

Take precautions to preserve the integrity of stream and ditch bankings. Be careful not to undercut stream or ditch banks or to dig ditches too deeply during ditch cleaning. Undercutting leads to instability and bank failure.

Avoid discharge of sediments during ditch cleaning.

If fine textured sediment is being dredged from ditch bottoms, consider using a silt fence to trap sediments before they move offsite.

Cleaning ditches from the point most distant from the flume (moving towards the flume) will enhance settling of sediments.

Allow dredged sediments ample time to drain of excess water before being moved significant distances. Use a sediment barrier as necessary to keep the sediments contained.

Construction and maintenance of sediment barriers

General

Growers should employ all reasonable sediment capture and removal techniques to receive and cleanse waters exiting the bog. Growers should also consider diverting sediment charged water to holding ponds to allow settling of solids. Filter strips or filter booms with hanging cloth may also be effective.

Sediment barriers are necessary if drainage across a disturbed area could deposit sediment into a water body, a wetland, or a neighbor's property. They are not needed if the site drains into a tailwater recovery pond or the bog itself.

Note: Most sediment barriers are designed to handle sheet erosion only.

All sediment barriers should be inspected immediately after any rainfall, at least daily during rainy periods, and if there is any sign of downstream erosion.

Sediment must be removed from behind the barrier if it reaches ½ the height of the barrier. If there are signs (small and localized) of undercutting or impounding of large volumes of water behind a sediment barrier, a second barrier should be installed. If the undercutting or water impoundment is more extensive or is occurring from flow greater than sheet flow or the contributing drainage area is too large, then switching to a more suitable BMP might be a better choice.

If the barrier shows signs of decomposition or clogging, it should be replaced promptly.

Once the barriers are no longer needed, they should be removed and the remaining sediment should be graded and seeded.

Do not install bales or fencing across streams, ditches, or waterways.

Straw or hay bales

This is a temporary and inexpensive sediment barrier consisting of a row of entrenched and anchored straw/hay bales. This structure will intercept and detain small amounts of sediment from disturbed areas and will prevent offsite movement to a limited extent. The velocity of sheet flows will also be decreased.

Contributing drainage area should be less than one acre. These structures are effective for no more than 3 months.

Planning and installation.

Locate the barrier where there will be sediment laden runoff — near the base of the drainage area. Ideally there will be an undisturbed, vegetated area further downslope of the barrier.

Dig a trench at least 4 inches deep, removing all grass. Flare ends uphill to increase storage capacity.

Place wire-bound or string-tied bales tightly, end to end, in the trench.

Anchor each bale with at least 2 stakes or re-bars driven through the bale. Angle stakes to force bales together.

Fill gaps by carefully wedging loose straw between bales.

Backfill excavated soil against the barrier. Fill to ground level on downslope side and build up 4 inches on upslope side.

Loose straw scattered on upslope side will increase effectiveness of barrier.

Potential problems with bales.

These barriers are not effective in areas with high water velocities or volumes.

If improperly constructed, water flow will undercut the barrier and actually increase erosion.

These barriers are effective for approximately three months; less if improperly maintained.

Maintenance of bales.

Inspect after each runoff-producing rainfall and daily during prolonged rainy periods. Check for flow around ends of barrier. Repair damaged bales and under cut areas promptly.

Remove sediment deposits when they reach 1/2 of the height of the barrier.

When the barrier is no longer effective or the project is finished, remove the barrier and dispose of it properly. The remaining sediments should be leveled and vegetated.

Sediment fencing

This is a temporary sediment barrier consisting of filter fabric stretched across and attached to supporting posts and entrenched. Additional, rigid wire fencing may be needed in some areas of the barrier as support. This structure will intercept and detain small amounts of sediment from disturbed areas during construction and reduces runoff velocity down a slope. As with

the bale barriers, these structures are designed for sheet runoff only (no channeling). Sediment fences may also be used to catch wind-blown sand.

Contributing drainage area should be less than 1/4 acre per 100 feet of fence; and no more than 1.5 total acres. These structures are effective for approximately 6 months. In addition to their longer effective life, sediment fences trap a much higher percentage of sediments than do straw bales. Currently, it is common to use both and this approach is endorsed by MassDEP.

Compost blanket

Geotextile mats

Planning and installation.

Locate the barrier where there will be sediment laden runoff -- but at least 10 feet past the base of the slope in the drainage area to provide sediment storage and access for cleanout. Access must be provided to locations where sediment accumulates and reinforced, stabilized outlets must be in place for emergency overflow. Do not locate where ponding behind the fence will cause property damage or create a safety hazard. The fenceline should be nearly level along its length, but should swing slightly uphill for the last 10-20 feet at each end (approx. 6 inch elevation) to provide storage capacity.

Dig a trench 8 inches deep and 4 inches wide or a V-trench.

Drive support posts in at least 16 inches, on the downslope side of the trench. Use 4 inch diameter pine, 1.33 lb./linear ft. steel, or 3 inch diameter quality hardwood posts. Steel posts should have projections for fastening fabric. Posts should be placed no more than 6 feet apart; 8 feet if support wire is to be used.

Fasten support wire to upslope side of posts. Wire should extend 6 inches into the trench. Use 14 gauge wire with 6-inch mesh.

Attach continuous length of filter fabric to upslope side of supports. Avoid joints, especially at the low point of the fence.

Extend fabric one foot into trench and backfill with compacted earth or gravel.

If large amounts of sediment are expected, a shallow storage area may be excavated upslope of the fence.

Provide for safe bypass of storm flow. Set stabilized, reinforced outlet so that no more than 1.5 feet of water is held behind the fence at the lowest point. Set the outlet within the fence with posts no more than 4 feet apart and fabric no more than 1 foot above surface. Install a horizontal brace to hold the fabric. Provide a riprap splash pad 5 feet by 5 feet by 1 foot deep on level grade on the downslope side of the outlet in the fence.

Potential problems with sediment fencing.

These barriers are not effective in areas with high water velocities or volumes and will not control runoff for anything deeper than sheet flow.

If improperly constructed, water flow will undercut the barrier and actually increase erosion. The bottom of the fence should be buried at least 8 inches deep and the trench should be backfilled with compacted earth or gravel.

Maintenance of sediment fencing.

Inspect after each runoff-producing rainfall and daily during prolonged rainy periods. Check for flow around ends of barrier. Repair as necessary.

Remove sediment deposits to provide adequate storage and remove pressure on the fence but take care not to undermine the fence when removing sediment.

If the fabric tears or decomposes, replace it immediately.

When the barrier is no longer effective or the project is finished, remove the barrier and dispose of it properly. The remaining sediments should be leveled and vegetated.

Source materials:

NRCS Fact Sheets.
Straw / hay bale barriers:
ftp://ftp-fc.sc.egov.usda.gov/WSI/UrbanBMPs/water/construction/strawbale.pdf.

Sediment (silt) fences: http://www.wy.nrcs.usda.gov/technical/ewpfactsheets/siltfence.html.

Geotextiles: http://www.cabmphandbooks.org/Documents/Construction/EC-7.pdf.

Rock outlet protection and stabilization.
http://www.wy.nrcs.usda.gov/technical/ewpfactsheets/rockoutlet.html.

Cranberry beds construction planning guide: Erosion control for cranberry bed development. Maine DEP in cooperation with the Cranberry Technical Workgroup. http://extension.umaine.edu/cranberries/growing-cranberries/erosion-control-guidelines/.

For more information:

Dike standard. 1980. Natural Resources Conservation Service Practice Standard #356. NRCS-NHCP. Amherst, MA. http://efotg.nrcs.usda.gov/references/public/MA/356.pdf.

Howland, M.A. 1998. **Is it time to rethink grass slopes?** Cranberries 62(7): 16-17.

Howland, M.A. 1997. **Building with erosion blankets from slope to bed.** Cranberries 61(9): 14-15.

Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: a guide for planners, designers and municipal officials". This document is also available on-line at: http://www.mass.gov/dep/water/essec1.pdf.

Planer, T.D. 1993. **Recommended procedures for using turf to stabilize roadways, dikes and ditchbanks.** Proceedings 1993 Wisconsin Cranberry School. pp. 31-33. http://www.library.wisc.edu/guides/agnic/cranberry/proceedings/1993/recpla.pdf.

Updated by Hilary Sandler, Carolyn DeMoranville, and Larry Boutiette (senior engineer, NRCS). 2010.

Erosion and Sediment Control Checklist

✓ Make sure you are familiar with and in compliance with State and Federal Wetlands Protection regulations.

✓ The MA Wetlands Protection Act (WPA) requires that erosion and sediment be minimized as part of the Normal Maintenance or Improvement of Land in Agricultural Use practices.

✓ Formulate an erosion control plan prior to the start of any construction activity.

✓ Protect disturbed areas from runoff and minimize runoff velocity.

✓ Regularly inspect and maintain erosion and sediment control structures and materials.

✓ Understand the limitations associated with the various sediment barriers.

✓ Periodically check the elevation of the earthfills and restore to grade, if necessary.

✓ Check all areas where embankment protection was installed (rock riprap, woods turf, sod, etc.) for accelerated weathering or displacement repair or replace as needed.

Flood Management

Cranberries are native to wetland habitats, requiring plentiful water supplies for their cultivation. During most of the season, well drained soil is required for the development of healthy, functional cranberry root systems. However, evolution in a wetland setting has resulted in the ability of cranberry plants to withstand periodic flooding without harm. In fact, cranberry growers use flooding as a management tool to protect the plants from the cold, drying winds of winter, to harvest fruit and remove fallen leaves, and to control pests. In the past, flooding was also used for frost protection in the spring and fall and for irrigation in the summer, tasks which are now accomplished using sprinkler irrigation. Flooding is so important in cranberry cultivation that bogs that cannot be flooded are no longer considered profitable.

Because of the periodic need for sizable amounts of water, impoundment of water adjacent to the bogs is a normal farming practice in cranberry production. Many cranberry growers have constructed reservoirs adjacent to their bogs to store the water needed for seasonal flooding and irrigation needs. As a general rule, each acre of cranberries will require up to 10 acre feet of water storage capacity to meet all production, harvesting, and flooding needs. The actual figure will vary depending on the rate of recharge of the water supply and water conservation measures possible in the bog system.

Recommended Practices

General Flood Management:

When establishing a flood and releasing flood waters, use caution to avoid causing erosion or discharging sediment.

Avoid bank undermining when applying or discharging flood waters. This can occur if flow is rapid and the flume is at a right angle to the banking or ditch edge.

To avoid discharge of sediment, impound the flood after any activity that causes suspension of sediment in the water. Examples include barge sanding, harvest, and trash floods.

It is best to release all floods slowly over the top flume boards. This limits sediment suspension and discharge and scouring of the outlet channel.

Special care should be taken when flooding mineral soil bogs.

In order to protect ground water and retain nutrients in the root zone, avoid deep floods on mineral soil beds. A large ‘head’ of water can force nutrients out of the upper soil layers, making them unavailable to the plants.

Fertilizers and pesticides should not be applied just prior to flooding.

Materials applied prior to flooding can be dissolved into the flood water or forced through the upper soil layers by the flood. In either case, efficacy is reduced and water quality may be compromised.

There is no experimental evidence that herbicide applied prior to a late water flood is more effective in controlling weeds than the flood alone.

If fall fertilizer (post-harvest) is to be used, apply after the plants have achieved dormant color

but as far ahead of the winter flood as possible. Do not use fall fertilizer if holding a post-harvest flood (fall flood) or on mineral soil beds.

Winter Flood:

Flooding should be used to protect the cranberry bog from winter injury.

Cranberry vines may be injured or killed by severe winter weather. The injury is classified as a 'physiological drought' where moisture lost from the vines due to wind and evaporation cannot be replaced due to freezing in the root zone. Such injury can occur within three days if the root zone is frozen to a depth of four inches, the air temperature is below freezing, and strong drying winds occur. Injury is prevented by protecting the vines with a winter flood that should be in place when winterkill conditions exist. To be effective, the flood should cover the plants entirely (no vine tips sticking out).

The recommended practice is to maintain a winter flood for the minimum time required to protect vines from winterkill injury. Short winter floods are associated with improved yield. The exposure of the vines in winter and early spring slows the development of terminal buds, improving their frost hardiness in the spring.

Proper winter flood management is necessary to prevent oxygen deficiency injury.

A lack of dissolved oxygen in the winter flood water will cause injury to the plants, which in turn reduces the yield potential. **Oxygen deficiency injury** may occur when oxygen levels in the winter flood water drop below 4 mg/l (40% of full oxygenation 10 mg/l). If the flood remains unfrozen (open water) or light penetrates the ice covering the flood, oxygen levels in the flood should remain adequate. However, if the ice is cloudy or covered by snow or sand, oxygen levels will begin to fall as the plants use the oxygen supply. Under such conditions, growers should monitor oxygen levels and remove water from beneath the ice when oxygen levels are 5 mg/l or less. Be aware that sample collection in areas with significant algal growth can give falsely high readings. Failure to prevent oxygen deficiency can result in leaf drop, inability of blossoms to set fruit, and crop reduction.

Avoid oxygen deficiency injury by removing the water from beneath the ice. It is critical that the water level be drawn down well in the ditches so that no shallow puddles are trapped beneath the ice. Vines trapped in such shallow pools of water deplete oxygen rapidly leading to severe injury in those areas.

While the ice rests on the vines, daytime melting followed by night-time freezing usually incorporates some of the vines in the lower surface of the ice. If it becomes necessary to reflood the bog to protect areas where the ice cover has melted away, the remaining ice will float and trapped vines may be uprooted. Gradual flooding will usually melt enough of the existing ice so that the vines are released unharmed.

The winter flood should be reapplied to prevent exposure to temperature extremes.

If the water has been removed from beneath the ice to prevent oxygen deficiency, the remaining ice may melt during a mid-winter thaw, leaving the vines exposed. Bogs may be left exposed as long as winterkill conditions are not present. However, if winterkill conditions occur, the bog should be reflooded.

Long exposures to abnormally warm temperatures (>55°F) may lead to loss of chilling. The result could be a reduction in hardiness - greater susceptibility to spring frost. Depending on the conditions prior to the winter flood, loss of chilling during a mid-winter thaw could also lead to reduction in bud break and flowering the following season. This is especially true if the

previous fall was warmer than usual, leading to lack of chilling accumulation. To guard against these possibilities, the bogs should be reflooded if a long warm spell is forecast during mid-winter. The water will cool at night and re-warm slowly during the day, buffering against the warm daytime temperatures.

Late Water Flood:

A one month spring flood (late water) can be used to control certain insects and disease organisms.

A month or more after the removal of the winter flood, a spring flood (late water) may be re-applied to the bog for the control of Southern red mite, cranberry fruitworm, spring caterpillars and fruit rot organisms. The late water flood should be applied on or about April 15th and kept on the bog for 30 days. The flood depth should be maintained so that all vines are well covered by water. Shallow floods and/or flood temperatures consistently greater than 65ºF should be avoided to prevent injury and crop reduction. Flood water temperatures will generally be cooler if the flood is deep (> 12 inches above the vines).

Late water is only recommended under certain conditions.

To minimize crop reduction, late water should not be used more often than once every three years.

It should be noted that on occasion, crops on late water bogs are poor. A likely cause is depletion of carbohydrate reserves during the late water flood. Any factor that leads to low carbohydrate reserves prior to the late water flood may affect subsequent yield. Possible negative factors include lower than average sunlight the previous summer and fall, heavy crop the previous season, and oxygen deficiency conditions during the winter flood.

Bogs with poor quality water supplies may not be good candidates for late water.

Late water floods should be terminated early under adverse conditions.

If air temperatures become unseasonably warm, and flood water temperature becomes too high, the late water flood may need to be removed before 30 days have passed.

Growers should scout the flood water for the presence of algae. If algae are found, early withdrawal of the flood may be necessary.

Weed management strategies should be modified when using a late water flood.

DO NOT apply herbicides prior to the flood.

The germination and growth of certain weeds may be retarded with the use of a late water flood. After withdrawal, scout for problem weeds. If necessary, treat with post-emergence herbicides.

Late water does NOT control dodder.

Modify bog management following a late water flood.

After removal of a late water flood, cranberry buds are sensitive to frost injury. Frost tolerance after late water is 29.5ºF. This is the case even if you must remove the late water early (after 2 weeks). Research has shown that shorter spring floods (1 week duration) have no effect on frost tolerance.

Following a late water flood, pesticide and fertilizer needs should be reduced for that season.

Late water controls Southern red mite - no miticide should be needed for up to two seasons.

Late water also controls cutworms and cranberry fruitworm. However, because these pests can migrate back onto a late water bog, careful monitoring is required after the flood. Cranberry fruitworm may be managed with one timed insecticide spray followed by egg monitoring or by egg monitoring alone.

Late water decreases the incidence of fruit rot disease. Fungicide treatments (number of applications and/or amount of active ingredient applied) for fruit rot on late water bogs should be reduced and may be eliminated if the bog has a history of low disease pressure and fruit are being harvested for the processed market. Number and rates of sprays may also be reduced in the following year.

Late water bogs respond readily to fertilizer, so nitrogen dose should be reduced to avoid overgrowth. A 20-30% reduction of nitrogen is possible by eliminating the spring application and/ or reducing the fruit set dose. However, severely cutting back on fertilizer may compromise bud development for the following crop.

Harvest Flood:

Harvest floods should be managed so that water use is minimized.

The most common method used to harvest cranberry fruit involves flooding the cranberry bog with a shallow layer of water followed by a deepening of the flood to facilitate removal of the fruit from the bog. In order to conserve water, harvest should be managed so that water is re-used to harvest as many sections of bog as possible before the water is released from the system.

Manage harvest water to minimize release of sediments.

During harvest, sediments are suspended into the flood water. Discharge of sediment into wetlands and waterways is not permitted. Sediments should be allowed to settle and flood water should be discharged over the top flume boards gradually to avoid sediment discharge to surface water.

A novel practice of holding the harvest flood for up to 4 weeks is under investigation by scientists at the Cranberry Station and a team of growers. This practice may have additional benefits in pest and weed control. Refer to the Harvest and Postharvest Management BMP.

Avoid moving pests from bog to bog.

Plan harvest water flow from bog to bog so that, whenever possible, water is **not** moved from disease or weed infested bogs into clean bogs.

Other Flood Practices:

Spring and summer floods of various durations may be used to control certain insect pests.

Flooding can be used to control insects without the use of pesticides under certain conditions. When using such floods, depth of flood and duration of flood are key. Failure to manage these floods properly may result in lack of control or damage to the plants and crop. Summer floods for grub control result in crop loss for that season and may kill vines. For more

information on management of these floods, see the Insect Management BMP and the Cranberry Chart Book (http://scholarworks.umass.edu/cranchart/).

Fall floods may be used for insect and weed control.

Fall flooding in late September is a recommended option for the control of cranberry girdler. Cranberry girdler can be controlled with a fall flood beginning between September 25 and October 1 and lasting one week. The flood should completely cover the cranberry plants and is considered 'reasonably safe' even if fruit remained on the vines.

Ongoing research (suggested by grower practices) has shown that holding the harvest flood for up to 4 weeks post-harvest suppresses dewberry populations. Emergence of cranberry fruitworm the following spring was also suppressed. No reduction of crop has been reported after several years of experimentation with post-harvest floods.

Flooding may be used for removing leaf trash and disease organisms from the bog.

Water supplies permitting, cranberry bogs may be flooded after harvest for the removal of 'trash'. Dead cranberry leaves and twigs and bruised berries float to the surface and are wind-driven to the bog edge where they can be skimmed from the flood for disposal. By removing fallen cranberry leaves, the grower may not need to sand as frequently. These leaves are a source of disease inoculum and a habitat for insect pests and as such are best removed from the bog.

Flooding may be used for frost protection under certain circumstances.

While sprinkler irrigation is the method of choice for frost protection, flooding may also be used for this purpose. In the early spring, flooding may be the superior method when temperatures are very low and below the bud tolerance and wind is present. Under such circumstances, sprinkler heads will freeze, offering little protection to the buds. A flood may also be necessary if there is a failure in the sprinkler pump. Flooding for frost protection in the fall is most unusual. However, a flood may be applied to a bog a day or so ahead of harvest to protect it from frost once the sprinkler heads have been removed in preparation for harvest. Probably the most important consideration in flood frost protection is the fact that water must be present on the soil surface under the cranberry vines before the occurrence of critically low temperatures. This requires sure knowledge of the length of time required to put the protecting flood in place in advance of the coming frost. It is practically useless to apply the frost flood after the arrival of critically low temperatures.

For more information:

Cranberry chart book - management guide for Massachusetts. UMass Cranberry Station. http://scholarworks.umass.edu/cranchart/. Sections on late water and winter management.

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Water Resource Protection and Enhancement and Harvest and Post-harvest Management BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler. 2000.

Flood Management Checklist

✓ When releasing a flood, use caution to avoid discharge of sediment.

✓ Nutrients and pesticides should not be applied just prior to flooding.

✓ Consider the proper use of the numerous flooding options in your overall management plan.

Frost Management

Cranberries, like many other temperate crops, are sensitive to below-freezing temperatures during the active growing season. This sensitivity is an important factor in cranberry management. Cranberry bogs have traditionally been placed in lowland areas such as swamps and marshes, compounding frost concerns since the temperatures on cranberry bogs tend to be lower than those in surrounding lands. In recent years bogs have also been constructed in upland areas on mineral soils. However, all bogs are constructed with the planted area at a lower level than its adjacent surroundings. This arrangement contributes to the development of 'frost pockets' on the bogs. The cold air drains from the adjacent high ground into the low areas on clear, calm nights. In addition, the enormous amount of vegetation present on a cranberry bog is extremely efficient at radiating heat under clear, calm skies, a process known as *radiational cooling*. Due to these factors, it is not unusual for bog temperatures to be 10 degrees colder than those of nearby non-bog areas. There may be as much as a 20 degree difference in some locations.

Sprinkler irrigation systems (and flooding on rare occasions) are used to protect the cranberry plants and fruit from freezing temperatures. Sprinklers are the most common method of cranberry frost protection. As the water applied to the plant cools, heat is released preventing the plant from freezing. If a film of water is maintained by continuous application of water, the temperature of the plant tissue will remain above freezing, even if a layer of ice forms.
The critical temperature or *frost tolerance* varies with plant development and color of the fruit. Protection is required to keep the plants above the critical temperature and avoid injury. Preventing frost injury to the flower buds in the spring and to the fruit in the fall is arguably the single most important cultural practice in cranberry production. Frost injury is the only hazard in cranberry production where major crop loss can occur in as little as one hour and total crop loss in one night.

Recommended Practices

General Practices:

Conserve water. Manage irrigation for frost protection so that the objective is achieved with the minimum water necessary.

Protect the bog only when frost is imminent. The first rule of frost protection is to observe the bog and determine the tolerance. The system is then turned on at from 2-3º above the tolerance. This will ensure that the bog is protected even if the monitoring thermometer is not located in the coldest spot on the bog. However, all efforts should be made to locate monitoring thermometers at the coldest parts of the bog. The thermometers or sensors should be placed at the level of the vine tips, the tissue to be protected.

Sprinkler lines may freeze at temperatures below 25ºF, so keep lines open by starting the pump and running the system at idle until the critical temperature is reached.

Once started, run the sprinklers until the ice melts or until the bog temperature is at least 3-4ºF above the tolerance.

Optimize irrigation system performance.

Sprinklers applying a minimum of 0.1 inch per hour are required to afford adequate frost protection. Use catch-cans to determine if your system is delivering adequate water.

Sprinklers should rotate at least one revolution per minute if they are to be effective for frost protection.

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.

For information on how to maintain sprinklers, refer to the Irrigation Management BMP.

Specific Practices

Determine frost tolerance on your bog.

Spring. Flower buds and new leaves are susceptible to frost damage in the spring. Examine the buds to determine tolerance. By the time the foliage is showing signs of re-greening in mid-April, the tolerance of the buds has risen to 18ºF. At this stage, the buds remain tight and red (winter dormant color). As the buds begin to swell, sensitivity increases dependent on cultivar. Cultivars with large buds (and large fruit later) tend to become sensitive earlier in their development compared to small-budded cultivars. For example, 'Ben Lear' and 'Stevens' tolerate temperatures no lower than 30ºF once the terminal bud begins to elongate, while at that same developmental stage, 'Early Black' and 'Howes' will tolerate 27ºF. Frost tolerances of terminal buds during spring development are listed in the Frost Protection Guide (see references).

Fall. In the fall, it is the berries that must be protected from frost injury. With the exception of summer-flooded bogs, there has been no report of *bud* injury in the fall in Massachusetts. As the fruit ripen and red color develops, frost tolerance increases (i. e. the critical temperature drops). Green fruit will not survive temperatures below 20ºF, while fully red fruit can survive temperatures from 24ºF to as low as 20ºF depending on cultivar. Short exposures to even lower temperatures may not cause injury to fully ripe fruit. Frost tolerances of fruit during fall development are listed in the Frost Protection Guide (see references).

Development of frost tolerance is *site-specific* and should be monitored on all bogs.

An important frost warning service is provided by the Cape Cod Cranberry Growers Association to its members.

Dr. Henry Franklin developed formulas using temperature and dewpoint data for predicting frost events on cranberry bogs in Massachusetts. Today, CCCGA uses this information along with weather forecasts to determine a predicted low temperature for Massachusetts cranberry bogs. This information is provided *as a member benefit*.

The formulas predict the minimum temperature that can be expected on average cranberry bogs under 'ideal' frost conditions - clear skies and no wind. This is a baseline forecast developed for the East Wareham area. ***However, where weather is concerned, there are no sure bets.*** The Frost Warning Service is just that - a warning to watch conditions on each bog for danger of critical temperatures.

Monitor conditions that may favor the development of frost on your bog.

Dewpoint. High dewpoints are favorable - the danger of frost is less.

Wind. Cold wind during the day often dies during the night, increasing the danger of frost. The presence of wind can mitigate the effects of radiational cooling by mixing the cool surface air with warmer upper-level air. This can protect the bog from frost but should not be relied upon. If the wind drops, bog temperatures may drop as much 10 degrees in two hours. Winds of less than 10 mph associated with high pressure seldom hold through the night.

Air masses. The most dangerous location for a high pressure cell is directly over the cranberry area or slightly to the south and west. As the high approaches and the winds die, quite cold temperatures may develop.

*Clouds***.** High clouds are of little value in preventing frost conditions. On the other hand, low clouds persisting until after midnight can be protective - temperatures often drop only one degree per hour after they dissipate.

*Precipitation***.** Substantial rain (1-1.5 inches) within a day or so of cold conditions may prevent temperatures from reaching the critical level. However, this is not a sure thing. Drought conditions increase the danger of frost.

*Timing***.** Critical temperature is often not reached until near dawn in the spring. In the fall, the critical temperature may be reached quite early in the evening. Late in the fall, the temperature may fall below the tolerance just after dark.

Monitor temperatures on your bog if there is potential for frost.

All efforts should be made to locate monitoring thermometers at the coldest parts of the bog - these may vary with season and direction of dying winds. The thermometers or sensors should be placed at the level of the vine tips or fruit, the tissues to be protected.

Temperature relationships among locations do NOT remain constant. Do not rely on upland or home temperatures to predict the temperature on your bog. Monitor on-bog temperatures.

Remember that irrigation should be started before the tolerance is reached -- set sensors and alarms accordingly.

Alarms are available that notify you of critical temperatures using phone land lines or cellular technology. Consult local vendors for options.

Take safety precautions.

Floodlights on vehicles can aid in scouting for malfunctioning sprinkler heads and provide lighting to avoid accidents.

Remember that ice will form on ditch edges and bridging planks, exercise caution.

Work in teams or remain in radio or phone contact with others.

For more information:

DeMoranville, C. J. **Frost protection guide for Massachusetts cranberry production**. UMass Cranberry Station Extension Publication. April 1998. 8 pp.

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Irrigation Management BMP in this series.

Norton, J. S. 1968. **Sprinkler frost protection, parts I-III.** Cranberries Magazine 36(4):6-8, 36(5): 8-10, 14, 36(6):8-11, 14.

Prepared by Carolyn DeMoranville and Hilary Sandler. 2000.

Frost Management Checklist

✓ Frost protect to achieve the objective with minimum water necessary.

✓ Optimize irrigation system performance.

✓ Monitor the progression of frost tolerance on your own bog.

✓ Exercise appropriate safety measures when working at night.

Harvest and Post-harvest Management

Cranberries are harvested by two basic methods, dry harvest and water harvest. The dry harvest fruit is destined primarily for the fresh market while the water harvested fruit is processed. Growers manage cranberry plantings to facilitate these harvest methods and fruit uses. Ideally, the fruit are harvested at full maturity with good color (anthocyanin content) but prior to the fruit becoming over-ripe. Timing of harvest is important for fresh-market fruit so that the berries are sufficiently red but retain good storage quality, while fruit for the process market ideally has maximum color. Cranberry marketing companies produce 'no color added' products, so the color at harvest is of great importance in processed berries.

Following the harvest, management practices focus on minimizing harvest stress and preparing the bogs for the dormant season. To minimize disease and weed infestations, leaf litter and fallen fruit are removed from the bogs.

Recommended Practices

General

Plan harvests based on cultivar and weather.

Ben Lear and Early Black generally ripen before Stevens and Howes. It is important to remember that the earliest ripening cultivars are subject to physiological breakdown (sterile rot) by the end of the harvest season.

Ideally, the fruit are harvested at full maturity with good color (anthocyanin content) but prior to the fruit becoming over-ripe. Timing of harvest is important for fresh-market fruit so that the berries are sufficiently red but retain good storage quality, while fruit for the process market ideally has maximum color.

Factors that may slow color development are warm temperatures, particularly at night, and low exposure to sunlight (thick canopy).

Observe all Pre-harvest Intervals (PHI) as required by law.

Pre-Harvest Interval is defined as the number of days which must pass between the application of a pesticide and harvest. The interval varies for each pesticide and formulation and is designed to allow enough time to pass for the pesticide to breakdown so that consumer exposure is minimized.

Always observe proper PHIs for any pesticides that have been applied during the season. These intervals are listed on the pesticide labels.

Do not neglect irrigation needs in the early fall.

Prior to and post-harvest, do not neglect the water requirements of the plants. Continue to monitor soil moisture and irrigate as needed. See the Irrigation BMP for more information.
Dry-harvested beds:

Water-harvested Beds

Manage the bed during the season to facilitate harvest.
Dry harvested beds should be managed so that runner production and rank upright growth is minimized. Fertilizer rates should be low to moderate.

Pruning may be required periodically. This can be accomplished in the early spring or during harvest (Furford or Western pickers) or postharvest.

Plan fruit rot control based on the UMass Extension Keeping Quality Forecast.
Dry harvest fruit is generally sold in the fresh market, therefore, keeping quality is important. Often dry harvest beds are treated with additional fungicide applications to insure post-harvest quality. However, additional applications may not be required if the Keeping Quality Forecast is good to excellent.

Late water is an excellent tool for promoting good keeping quality and limiting fungicide requirements if the Preliminary Keeping Quality Forecast is poor. See the Flood Management BMP for more information.

Avoid moving weeds and disease inoculum from bed to bed.
Dry harvest equipment should be cleaned of debris that might contain weed seeds prior to moving to the next bed. If a harvested bed is known to have *Phytophthora* infestation, sterilize equipment prior to harvesting any uninfested beds.

Use a post-harvest flood to relieve picking stress and remove leaf litter.
Dry harvest techniques are stressful to the cranberry plants. A post harvest flood can minimize this stress and remove leaf trash at the same time (see below).

After detrashing, allow the flood to settle and release gradually over the top flume board to minimize discharge of sediments.

Manage the bed to maximize harvest returns.
Fruit with good quality and high color (anthocyanin content) may command a premium price. While it is easier to water harvest fruit from overgrown beds (compared to dry harvest), overgrowth is often associated with poor color. Fertility, sanding, and pruning should be managed to promote adequate growth while allowing good light penetration into the canopy. This will promote yield and color.

Harvest floods should be managed so that water use is minimized.
In order to conserve water, harvest should be managed so that water is re-used to harvest as many sections of bog as possible before the water is released from the system.

Avoid moving pests from bog to bog.
Plan harvest water flow from bog to bog so that, whenever possible, water is **not** moved from disease or weed infested bogs into clean bogs. This is particularly important in controlling the spread of *Phytophthora* and dodder.

Hold harvest water to allow sediment to settle prior to release from the bog system.
During harvest, sediments are suspended into the flood water. Discharge of sediment into

wetlands and waterways is not permitted. Sediments should be allowed to settle for several days and flood water should be discharged over the top flume boards gradually to avoid sediment discharge to surface water.

A novel practice of holding the harvest flood for up to 4 weeks is under investigation by scientists at the Cranberry Station and a team of growers. This practice may have additional benefits in pest and weed control. See post-harvest section below.

Post-harvest Management

Post-harvest floods may be used for insect and weed control.

Fall flooding in late September is a recommended option for the control of cranberry girdler. Cranberry girdler can be controlled with a fall flood beginning between September 25 and October 1 and lasting one week. The flood should completely cover the cranberry plants and is considered 'reasonably safe' even if fruit remains on the vines. Ongoing research (suggested by grower practices) has shown that holding the harvest flood for up to 4 weeks post-harvest suppresses dewberry populations. Emergence of cranberry fruitworm the following spring was also suppressed. No reduction of crop has been reported after several years of experimentation with post-harvest floods.

Use a trash flood to remove leaf litter and disease organisms from the bog.

Cranberry bogs may be flooded after harvest for the removal of 'trash'. This is particularly important if the bed was dry harvested. Although trash is removed during the water harvest, an additional trash flood may be beneficial if the bog has not been recently sanded. The leaf litter that builds up on the floor of the bed is a source of disease inoculum and a habitat for insect pests and is best removed from the bog.

After detrashing, allow the flood to settle and release gradually over the top flume board to minimize discharge of sediments.

T**he use of post-harvest fertilizers is not recommended.**

If fall fertilizer (post-harvest) is to be used, apply after the plants have achieved dormant color but as far ahead of the winter flood as possible. Do not use fall fertilizer if holding a post-harvest flood (fall flood) or on mineral soil beds.

Clean ditches and waterways now.

In bogs that have adequate soil drainage, some actively growing aquatic vegetation should have been left in the ditches during the growing season to provide filtration in removing nutrients and residues from the water. Ditches should be cleaned post-harvest to facilitate moving water during the winter and to promote drainage in the spring. See the Erosion and Sediment Control BMP for more information.

Limit the post-harvest use of herbicides to spot treatments of existing, defined weed populations.

Post-harvest use of Casoron is not considered to be a best management practice.

Due to the high rates needed for efficacy of fall applications, post-harvest use of Evital should be limited to the spot treatment of well-mapped areas of existing sensitive weeds such as nutsedge.

Glyphosate products may be used post-harvest and are effective if the target weed is still actively metabolizing (not yet dormant).

Refer to the Cranberry Chart Book for current herbicide rates and recommendations.

For more information:

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Water Resource Protection and Enhancement and **Flood Management** BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

Harvest and Post-harvest Management Checklist

✓ Observe pre-harvest intervals as required by law.

✓ Use a post-harvest flood to remove fallen leaf litter.

✓ Manage harvest floods to minimize water use.

✓ Limit use of post-harvest herbicides, especially prior to winter flooding events.

✓ Clean ditches and waterways post-harvest.

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

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

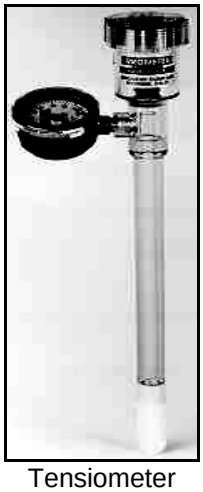
Maintain the water level in the ditches at a level that is adequate to supply water to the root zone while still allowing adequate drainage from the center of the bed (generally about 14-16 inches below the bed surface, although this will vary based on bed width, soil texture and grade).

Monitor water level in the center of the bed using:

Water level float - 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 more information, see the “Construction, Installation, and Use of Water Level Floats” Fact Sheet available at the UMass Cranberry Station.

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

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.

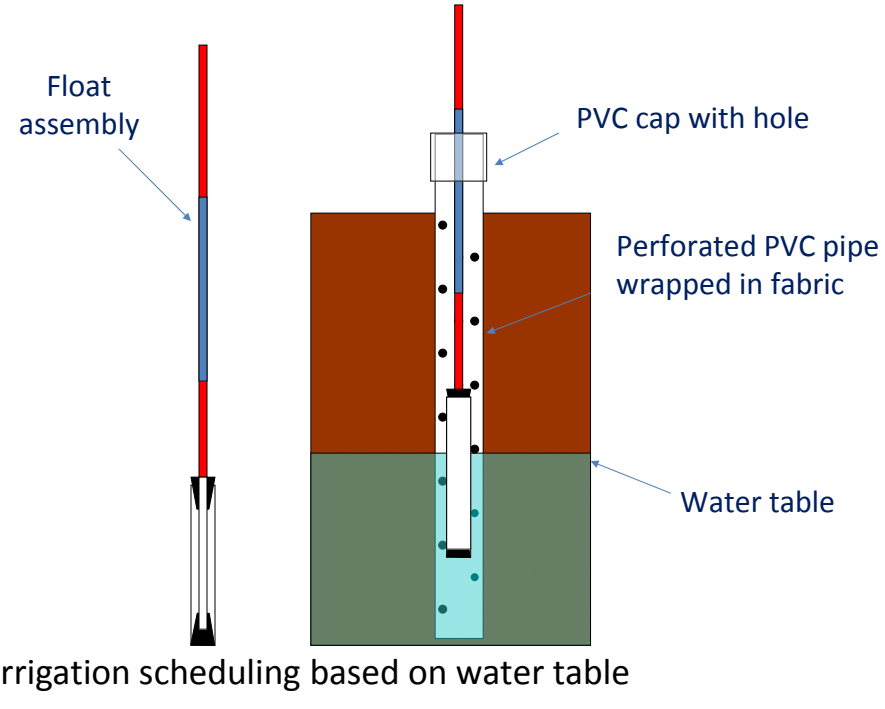


Illustration of a water float device to monitor water table level.

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 below the soil surface. 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 before the hot conditions arrive.

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.

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 more information on safety, calibration, and techniques for chemigation.

For more 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 Station. Section on irrigation. http://scholarworks.umass.edu/cranchart/.

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

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

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Prepared by Bruce Lampinen, Carolyn DeMoranville, and Hilary Sandler, 2000.

Irrigation Management Checklist

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

✓ Combine subirrigation and sprinkler irrigation to maximize efficiency.

✓ Modify water use management during periods of high plant stress.

✓ Maintain good ditch drainage and water table management.

✓ Apply irrigation based on soil water status and plant needs.

On-farm Energy Conservation and Efficiency

Recommended Practices

Take advantage of cost-sharing opportunities.

National Grid (NGrid) offers some financial incentives to help farmers make changes and reduce their energy costs. If your farm is in the NGrid service territory, you may be eligible for rebates to install several new technologies.

NGrid has an incentive program for commercial customers, including farms. These can help reduce the cost and the payback time for purchasing and installing more efficient electrical equipment.

NGrid considers measures on an individual case basis, and all proposed improvements are subject to NGrid's approval. In general, a farmer can receive rebates for:

Variable Frequency Drives installed on vacuum pumps and ventilating systems.

Three phase motor replacements for motors of 1 horse power or greater. The rebate varies with the amount of horsepower being replaced.

NGrid will rebate a certain amount for each qualifying hardwire lighting fixture, for example tube fluorescents or outdoor incandescent floodlights that are upgraded, provided it meets certain performance criteria. (NGrid will also take care of the proper disposal of the old lamps and ballasts.)

Consider utilizing farm energy calculators to assess energy use.

Farm energy calculators are planning tools designed to help producers save electrical energy, fuel or fossil-fuel-based fertilizers. Go to http://attra.ncat.org/energy_calculators.html.

The USDA Self-Assessment tool helps farmers conserve energy and explore renewable energy options. The energy conservation tools include irrigation, greenhouses, lighting, and ventilation and others. Renewable energy tools are provided for solar water heating, solar electric (photovoltaic), wind turbines, biomass, and biogas.

Make your irrigation system as efficient as possible.

Maintenance and efficiency are key components to on-farm energy conservation for cranberry growing. Keep irrigation engines serviced and well-tuned. Make sure electric motors, switches, and control panels are clean and free of dirt, insects, or bird nests. Check for proper belt tension and alignment. Check connections to ensure they are tight, and lubricate moving parts that require it.

Use an irrigation scheduling method to time irrigations for more efficient fuel and water use. Start irrigation before soils are completely dry.

Properly maintain trucks and tractors.

Regularly scheduled tune-ups can save 10% on fuel usage. Keep tires properly inflated.

Avoid lengthy idling. Idling can consume 15 to 20% of the fuel used.

Run equipment in the proper gear for the load.

Clean or replace air filters, and use appropriate equipment ballast to keep wheels from slipping and using more fuel. Keep tires properly inflated.

Practice good nutrient management.

With high energy prices, sound nutrient management is more important than ever. Start with soil testing. Soil testing allows you to optimize applications of nitrogen fertilizer, which is influenced by natural gas prices. Also, consider other fertilizer sources such as animal manures where available.

Calibrate application equipment for uniform application.

Apply nitrogen fertilizers close to the time of actual crop need. As always, use environmentally sound management practices to keep fertilizer out of water sources.

Conserve electricity.

Replace 3 hp or larger motors with high efficiency ones to reduce electric consumption by 2 to 5%.

Install motion detectors to control security lights so they are not on all the time.

For more information:

Alternative farming systems information center. http://afsic.nal.usda.gov. Click on Farm Energy Options/On-farm energy efficiency.

Bonner J., J. Thomas, H. Wilcutt, M. Broome, and L. Oldham. 2001. **Reduce Energy Costs in Agriculture.** Mississippi State University Extension Service. Information Sheet 1621. http://msucares.com/pubs/infosheets/is1621.html. (portions of this BMP are excerpted from this publication).

Energy calculators. http://attra.ncat.org/energy_calculators.html.

Energy tips for irrigators. http://attra.ncat.org/attra-pub/energytips_irrig.html.

Comparing energy use in conventional and organic cropping systems (summary). http://attra.ncat.org/attra-pub/summaries/croppingsystems.html.

Maintaining irrigation pumps, motors, and engines. http://attra.ncat.org/attra-pub/maintaining_pumps.html.

MDAR's Energy efficiency, conservation and renewable program. Contact Gerry Palano at Gerald.Palano@state.ma.us or 617-626-1706. http://www.mass.gov/agr/programs/energy/

Prepared by Hilary Sandler and reviewed by Gerry Palano and CCCGA Environmental Committee, 2010.

On-farm Energy Conservation and Efficiency Checklist

✓ Practice good nutrient management.

✓ Consider used oil as equipment fuel.

✓ Keep equipment maintained.

✓ Keep irrigation engines serviced and well-tuned.

✓ Consider the cost of different fuels in terms of energy value.

Pollinator Enhancement

Cranberry requires pollination (pollen transfer from male to female flower parts) to maximize yields. Bees are the most important pollinators in cranberry. One bee, which has special structures on it body to carry pollen, may visit thousands of flowers, and in the process carry pollen from flower to flower. Taking steps to conserve and enhance a diverse assemblage of pollinators on a cranberry farm is an important best management practice. This helps to assure adequate pollination, carried out by many species, rather than depending on a single species. On most cranberry beds, many species of bees are associated with bloom, including bumble bees, mining bees, sweat bees, and leaf-cutter bees. This is in addition to the honey bee, a species introduced to the US nearly 400 years ago by European settlers. Honey bees come from managed hives, either via rentals from migratory operations or from local beekeepers; as of this writing, there are few feral colonies. Some of the practices detailed below show that even small changes may have significant impacts on pollinator numbers.

Recommended Practices

Be familiar with pollination levels on each bed.

Walk the beds during bloom and assess pollinator numbers. Cranberry beds vary enormously in the level of bee activity during bloom. On an average bed, counts of pollinating bees should be in the range of 1-2 individuals per minute. Native bee counts (e.g. bumble bees) may be lowest on beds that are flooded by honey bees or on beds that are surrounded by extensive tracts of cranberry bogs or forest; on the other hand, isolated beds surrounded by varied land uses may have a high and diverse assemblage of pollinators.

Be familiar with the types and diversity of native bees on each bed.

Take note of bees that are carrying loads of pollen (yellow blobs on the leg or abdomen) on sunny days. This will include several species of **bumble bees** (*Bombus*), which all have hairy bodies with various and black and yellow patterns. All bumble bee species are social, meaning that there is a queen and workers that live together in a colony and share the labor of its maintenance. Bumble bees are the most important native pollinators on Massachusetts cranberry. They are several times more efficient at pollinating cranberry flowers than honey bees and may start to forage very early in the morning and continue towards dusk. A mated bumble bee queen overwinters and emerges in early spring. These large (ca. ¾ inch long) robust females can often be seen flying low to ground in search of next sites where rears a first worker brood. This new brood of workers (ca. ½ inch or smaller) takes care of the nest and collects food for other developing immatures in the nest. After the colony is established and grown, new queens and males are produced, some as early as June and through late summer. Depending on species, bumble bees nest at varied sites, usually cavities, for example, in abandoned rodent burrows, or in slash piles, stone walls, vegetative debris, or matted grass.

Some of the most common species of native bees are considerably smaller than honey bees, but may be highly efficient pollinators that forage under poor weather conditions. The may be social or solitary, but most are solitary. In a solitary species, a female constructs and provisions a nest by herself; she typically produces 20-30 offspring. Most solitary bees are active for only a few weeks and have only one generation per year. The different species may be difficult to tell apart. **Mining bees** (Family Andrenidae) are common in cranberry habitats and are ground-nesting bees. They carry pollen on the sides of the abdomen and on their hind legs. They create tunnels in the ground with entry holes that are ¼" or smaller; the entry holes may have mounds of excavated sandy soil around them and be easily confused with

anthills. The burrows are located in areas of well-drained, exposed soil.The different species range from small to medium-sized. Some of the larger and more common *Andrena* species are about the size of honey bees, and although they have furry thoraxes (central part of the body), the backside of the abdomen is shiny black and much less fuzzy than a honey bee. Others are considerably smaller and may be black, striped, or metallic green. **Sweat bees** (Family Halictidae) are also a common group of small native bees found on bogs. Most species nest in the ground and most are solitary. Large numbers may create nests close together. They are very diverse, are often small, and can be black, brown, striped, or metallic-colored. They carry pollen on their hind legs. **Leafcutter bees** (Family Megachilidae) are also found and are medium-sized native bees. Pollen is carried on the underside of the abdomen. See: ftp://ftp-fc.sc.egov.usda.gov/NH/WWW/New%20England_NRCS_Pollinator_Tech_Note_FINAL.pdf

Determine whether good native bee habitat surrounds a bed.

To enhance populations of wild pollinators, the cranberry agroecosystem should provide pollen and nectar in spring and summer, nest-site areas, and protection from insecticides. The entire landscape, not only the cranberry beds, but all of the surrounding upland, perhaps within 1/8 mile may be included in this assessment. Bees move extensively through these areas, so that resources may be somewhat distant from the cranberry bed: larger species like bumble bees may travel ½ - 1 mile, while smaller bees such as the mining and sweat bees may move only ¼ mile or less while foraging. Pollen and nectar-rich wild flowering plants in the open edges around cranberry beds and in the habitat surrounding the bog will be important in maintaining abundant bee populations. Observe plants where bees are foraging, for example, low-growing bramble and clover. Plants that are common pre-cranberry-bloom are bunchberry (*Cornus canadensis*), cherry (*Prunus*), blueberry, dangleberry, dangleberry, *Viburnum*, maple, birch, willow, and alder. After bloom, dewberry, aster, goldenrod, fireweed, sweet pepperbush (*Clethra alnifolia*), meadowsweet (*Spirea*), and buttonbush (*Cephalanthus occidentalis*) produce flowers that are visited by foraging bees. Habitat that might be favorable should be noted, for example, edges of ponds and streams, hedgerows, fence areas, road edges, standing dead trees, or bare areas. Bumble bees often nest in at the interface of a grassy area and woods, particularly in grassy thickets. Nesting areas for the many of the solitary bee species are well-drained or sloping ground sites that are free of plants or have patchy areas of bare ground. Others nest in dead/dying trees or rotting logs, particularly in abandoned beetle tunnels, and

Conserve and protect good bee habitat.

After you have determined that good bee habitat exists, take measures to protect it. Leave dead trees standing or piles of tree trunks in place. Allow areas of grasses along edges to create matted areas. Do not disturb patchy bare areas where there are nesting holes. Avoid mowing blooming plants, for example, clover or dandelions that are in grassy areas around the bog or stands of fall goldenrod that are distant enough to limit risk of invading the cranberry bed. Or, consider leaving strips of flowers or even mowing later in the season to allow bee-plants to flower.

Consider enhancing stands of flowering plants.

If floral resources are poor in the foraging area of the bog (before and after cranberry bloom), provide other areas of flowering plants. Blocks of flowers are more attractive and easier to find. The plantings do not have to be very close to the bog, but there is an advantage of having the plantings close to nesting habitats. Choose a large variety of species that bloom from very early in the spring to late fall. The continuous sequence of flower sources around the bog is probably one of the most important ways to support bumble bee populations since they are active all season and are unable to store food reserves for more that a few days. A diverse selection allows for bees with different preferences to be supported. For the

Northeast area, the Xerces Society for Invertebrate Conservation suggests that these flowering plants that would be well suited to local conditions: aster (*Symphyotrichum*), azalea, basil (*Ocimum*), basswood (*Tilia*), beebalm (*Monarda*), blazing star (*Liatris*), blueberry, boneset (*Eupatorium*), borage (*Borago*), catmint (*Nepeta*), cosmos, goldenrod, hawthorn, hyssop (*Agastache*), lavender, *Lobelia*, lupine, meadowsweet (*Spiraea*), milkweed, mountain mint (*Pycnanthemum*), New Jersey tea (*Ceanothus*), purple coneflower (*Echinacea*), Russian sage (*Perovskia*), serviceberry (*Amelanchier*), sneezeweed (*Helenium*), spiderwort (*Tradescantia*), squill (*Scilla*), sunflower, turtlehead (*Chelone*), wild geranium, wild indigo (*Baptisia*), wild mint (*Mentha*), wild rose, and willow (*Salix*). If there is a concern that plants that bloom concurrently with cranberry will draw pollinators away from the bog, this should be taken into account during selection of plantings.

Create undisturbed bee zones for ground-nesting bees.

Strips of land around the cranberry bed that are protected by a double row of evergreens (windbreak) or by a hill or hummock could support good bee habitat. Most of the native bees nest in the ground by burrowing tunnels down to chambers. Preferred locations are often on southern-exposed areas that are dry and warm. Thus, clearing vegetation (e.g., a 9'x9' area on a sunny slope or on flat bare ground) may provide nesting sites. Clearing of sites should occur only in the (early) spring (vegetation would provide insulation for overwintering bees).

Protect bees from pesticides.

Most insecticides are deadly to bees or may have sublethal effects, even newer chemistries such as Delegate or Belay. The insecticides used in cranberry vary enormously in toxicity to bees, ranging from highly toxic (Admire, Actara, Belay, Delegate, SpinTor/Entrust, Lorsban, Diazinon) to less toxic (Assail and Intrepid). When bloom is on the bed, do not spray or choose insecticides with the least toxicity to bees. Spray after dark; risk is reduced once the spray dries. Be careful that spray drift does not contaminate flowering weeds adjacent to the bed.

Consult USDA's Natural Resource Conservation Service (NRCS).

Programs may be available that support conservation and may cost-share efforts to enhance pollinator habitat. NRCS has programs that instruct growers how to establish and maintain pollinator plantings, providing not only specific methods, but also, plant lists that are suitable for a given crop and area.

Appreciate the important role of native pollinators and recognize that even small changes in the habitat may conserve their numbers and diversity.

For more information:

Loose, J.L., F.A. Drummond, C. Stubbs, S. Woods and S. Hoffman. 2005. Conservation and management of native bees in cranberry. Maine Agric. Forest Exp. Station Technical Bull 191, 1070-1524

Mader, E. and M. Shepherd. Northeast plants for native bees. Invertebrate Conservation Fact Sheet, Xerces Society for Invertebrate Conservation www.xerces.org

Pollinator biology and habitat. 2009. USDA-NRCS New England Biology Technical Note

Using farm bill programs for pollinator conservation. 2008. USDA-NRCS Techinical Note No. 78.

Vaughan, M., M. Shepherd, C. Kremen, S. Hoffman Black. 2007. Farming for bees: Guidelines for providing native bee habitat on farms. Xerces Society for Invertebrate Conservation.

Prepared by Anne Averill, 2010.

Pollinator Enhancement Checklist

✓ Familiarize yourself with the habitat around your farm and its importance to pollinators.

✓ Consider enhancing stands of flowering plants.

✓ Protect bees from pesticides.

Pruning

Growers can improve the canopy environment with either sanding or pruning. Although both practices will give physical improvements such as increased potential for photosynthesis, better aeration, and improved vine health, each practice offers unique benefits and consequences when compared to the other.

Mechanical pruning can be used to improve the architecture of the canopy and remove runners. Severe pruning and mowing of the vines may be used to generate cuttings for the planting of additional acres. Although mechanical pruning can be difficult due to the trailing nature of the cranberry growth habit and the potential to remove upright tips bearing flower buds, it is becoming more popular due to the high cost of obtaining and transporting sand.

Pruning vines in the spring.

Recommended Practices

Use pruning to improve the structure of the canopy.

When runners are present and upright stands become dense, light penetration to the individual plants is limited. This light limitation leads to declines in yield either due to decreased flower bud initiation or limitations on pollinators reaching the flowers to set fruit or both. A dense canopy also provides a moist micro-climate for the growth and spread of fruit rot disease fungi.

Prune in the spring, while the vines are dormant.

If your vines are commonly water harvested, it is best to prune the vines in the spring, prior to bud break. Growers who dry harvest can combine pruning with their fall harvesting operations.

Do not cut when vines are wet, especially if the canopy is thick. The blade will not cut as well as in drier conditions and the vines may drop more leaves if cut when wet.

Vigorous hybrid varieties may require yearly pruning.

Hybrids typically have a higher growth rate than native varieties. To keep the canopy architecture optimal, vigorous vines may need more frequent pruning.

Prune to remove runners mostly, while minimizing removal of uprights.

The main objective with pruning is to improve and maximize the structure of the vine canopy (e.g., reduced humidity, improved light penetration, improved pollination, etc.). Severe pruning that results in the removal of an excess of uprights will negatively impact yield.

Prune in the direction that the vines are growing.

Other pruning patterns may be useful to maintain the canopy and this should be evaluated on a site-by-site basis.

Removal of more than 1 ton/acre of clippings may reduce crop in the following year.

More severe pruning is associated with crop reduction of at least 10%. However, crop reduction may be compensated for by increased production in the second year.

Consider incorporating pruning as a supplement to sanding.

Results from a replicated study (Suhayda et al., 2009) indicated that light pruning or sanding (a single pass with a knife-rake pruner or 1.5 cm of sand) can be a useful tool for cranberry canopy management as both practices can open up the canopy resulting in decreased wetness duration and improved light interception. Sanding is more risky (and expensive) than pruning due to its greater negative impact on yield when treatments are heavy and because nonuniform application of sand may not provide the intended benefits. Heavily pruned treatments were able to recover after the first year, whereas heavily sanded treatments still had lower yields in the second year. This is an important consideration since the pest management benefits of sanding are only effective with the equivalent of the moderate or heavy treatments used in this study. Due to the potential benefits of light pruning and the reduced risk of over-treatment compared to sanding, it may be a viable option for cranberry growers as a replacement for or as a supplement to sanding for canopy management.

Grower-manufactured pruner with knives attached to a rotating head in front combined with a hydraulic rake attachment in the rear.

Dry harvesting with a Furford picking machine that prunes vines as well as picks fruit. Photo courtesy CCCGA.

If picking fresh fruit, prune at the same time as fruit removal.

Some modern dry harvesters, notably the Furford Harvester (or the Western picker, but this model is less common), combine pruning action with harvesting. This approach can save time when labor is limiting.

Maintain the pruner by keeping pruning knives sharp and perform other maintenance on the machine as needed.

Sharpen knives at least yearly and replace as needed.

Prunings may be used on-farm to plant new areas or fill in thin spots or may be sold for planting elsewhere.

If you will be using cuttings for planting, be sure to keep the cuttings well-watered and out of the sun as much as possible until they are planted. Try to minimize the amount of time between pruning and planting if possible.

Farm worker using a hand-held knife rake that can prune lightly or heavily.

Use caution when applying herbicides (preemergence) to recently pruned vines.

Recent research indicated that minor vine injury may occur the year after the vines are pruned if treated with herbicides (vines were treated with preemergence herbicides in both years). Data were variable but there was evidence that vines that received the high herbicide rates had lower yields in the year after pruning than vines that received low-end rates.

Injury sustained can vary by the type of pruner used (rotating head vs. stationary head).

If vines are treated with Evital in the fall, vines will grow poorly if pruned in the spring and then planted. Consult the Cranberry Chart Book for current information on pruning and herbicide use.

For more information:

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Suhayda, B., DeMoranville, C.J., Sandler, H.A., Autio, W.R., and Vanden Heuvel, J.E. 2009. **Sanding and pruning differentially impact canopy characteristics, yield and economic returns in cranberry**. HortTechnology 19:796-802.

Prepared by Hilary Sandler and reviewed by CCCGA Environmental Committee, 2010.

Pruning Checklist

✓ Regularly prune vigorously growing hybrids.

✓ Maintain equipment and keep knives sharp.

✓ Consider using cuttings on-farm or selling to increase revenues.

Sanding

Sanding is the most commonly used cultural practice in cranberry production in Massachusetts. Growers apply a thin (1/2 to 2 inch) layer of sand on the surface of producing cranberry bogs at 2 to 5 year intervals in order to promote growth, improve productivity, suppress disease, and reduce insect populations. Sanding, as a pruning mechanism, is particularly well suited to the cranberry system: runners are anchored and bare wood, at the base of uprights, is covered thus promoting rooting and the production of upright stems (the portion of the plant that bears the crop). Mechanical pruning can be less than optimum due to the trailing nature of the cranberry growth habit and removal of flower buds (upright tips) during such pruning.

Sanding covers the leaf litter ('trash') layer on the floor of the cranberry bog. This has several benefits, including stimulation of organic matter decomposition (nitrogen release and relief of root congestion), suppression of fruit rot fungus inoculum, and limitation of the habitat of cranberry girdler larvae which feed on the area of the stem that is covered by the leaf litter layer. Sanding improves soil drainage and can physically strengthen peat soils so that mechanical operations on the bog are easier. The sand layer reduces moisture in the upper layer of the soil leading to accelerated warming in the spring and increased release of nitrogen from organic matter in the soil. This increases the potential for growth and productivity without additional fertilizer input. Development of the plants may also be accelerated, so frost hardiness may be lost earlier in the spring. Sand absorbs and releases more heat than the organic layer that it covers so that frost danger is less on sanded bogs (temperatures remain 2-3°F higher on freshly sanded bogs if sand is moist).

By choosing sanding instead of mechanical pruning, growers gain the benefits of insect and disease suppression, improved drainage, better root growth, and some frost protection. This can lead to lower pesticide, fertilizer, and water (frost protection) requirements.

Sanding can be accomplished by several different methods. Those commonly used include sanding on ice, sanding in water (barge sanding), or applying dry sand directly to the vines using ground rigs run directly on the vines or on rails (rail sanding). When choosing a method, growers should weigh several factors, including the following. Ice may not be available when a bog needs sanding. Barge sanding may not anchor runners well (less pruning benefits). Sanding on the vines (dry sanding) is the most likely to be associated with vine injury even if the sanding is done when the vines are dormant. Recent developments in the use of rail sanding may lessen the impact of dry sanding. Sanding is considered important enough that even damaging methods are preferable to no sanding for many growers.

Recommended Practices

General

Stockpile sand responsibly.

While the stockpiling of sand is the most efficient, least costly way to make sure that sand is available when needed, loss to water and wind erosion is inevitable if sand piles are left in place for long periods of time.

Excavated sand should be stockpiled as far away as possible from water bodies and drainage ways. Down gradient silt barriers may also be needed. All efforts should be made to minimize wind erosion.

Impact on neighbors should be considered when establishing height and location of stockpiles.

Ice sanding is the preferred method.

Less sand is used in this method and water is held longer (compared to barge sanding) before discharge allowing for better settling of fine particles. This method is generally less costly as well. Barge sanding may not be possible for bogs that have low dikes and are out of grade or where holding a flood for settling is difficult. When ice has not been available, dry sanding and rail sanding may be good alternatives. Differences in efficacy and vine damage have been found for the various sanding methods as follows:

Some growers rate barge sanding benefits more highly than others. It should be noted that a study of evenness of sand distribution showed that, for both ice sanding and barge sanding, less than 25% of the area received close to the target depth of sand. Distribution was quite non-uniform for both methods.

Vine and bed damage (least to most):
barge — ice — rail — dry

Horticultural and pest-control benefit (most to least):
ice — rail — dry — barge

Use screened or washed sand with few fines (e.g., fine sand, silt, clay).

This is particularly important when barge sanding. Avoid sloughed banking materials and subsoil layers which can be high in silt and clay particles. Sand with a high percentage of fine particles can form a surface crust on the soil which restricts water penetration and limits plant growth. Compaction of such soil can limit drainage.

Fine particles are particularly a problem with barge sanding – they are slow to settle and may lead to sediment discharge when the flood is released. A jar test can indicate the potential for slow settling after barge sanding due to high levels of 'fines'. To conduct such a test: combine 1 oz. sand and 12 oz. water. Agitate for 1 min., allow to settle for 8 hr and reagitate. With good quality sand, the water should be clear in another 24 hours.

Choose coarse sand and apply the proper amount.

Coarse sand promotes proper drainage and increases root growth. Particle sizes of 0.5-2 mm are best. Approximately 70% of the particles in the sand should be in this size range. Avoid large gravel, especially if the bog will be dry-harvested.

The amount of sand to be applied depends on how recently the bog has been sanded and the sanding method chosen. Avoid heavy sand layers applied on deep peat bogs as this can cause compression of the peat and uneven settling of the bog. Applying extra sand to low areas on deep-peat bogs only raises the soil surface temporarily and should be avoided.

If the bog has been sanded recently, 1/2 to 3/4 inch is adequate. Use more if the last sanding was 4 or more years ago. When barge sanding, apply at least 1 inch. Monitor your sand applications and modify practices to achieve maximum uniformity of sand deposition. GPS technology may be useful in this regard, particularly when barge sanding.

Sanding is particularly important in the management of new plantings.

Cranberry cuttings are heavily fertilized to promote the production of runners on the new bed. As these runners cover the soil surface, thin layers (1/2 inch) of sand should be applied in order to anchor the runners, promoting rooting at the nodes and leading to the production of upright stems which will then bear the crop. At minimum, new plantings should be sanded after the second season and may be sanded after the first season as well, depending on how much growth has occurred.

Know how sanding interacts with late water.

Do not use late water following fall or winter sanding. However, you may barge sand in the late water flood. Such barge sanding should occur near the end of the 30 day late water flood period so that the flood may be released after the sanding impoundment time has passed. Avoid sanding in the late water flood if water temperatures are greater than 65º F or if algal growth is present in the water.

Know how sanding interacts with herbicides.

Casoron: Do not sand on top of this herbicide as the vines will be damaged. Application on top of sand may be made, but must be watered in *immediately* or loss of efficacy will result.
Evital: Rates of 50 lb/A or less have given good results on sanded bogs. Evital may cause vine damage on poorly drained bogs.
Devrinol: This material may be used after sanding but must be watered in immediately. Otherwise, the increased light reflected from the sand will enhance breakdown of the herbicide. The use of devrinol after sanding can be critical in controlling nutsedge that may come in with the sand.

Iron sulfate: Do not use at rates greater than 70 pounds per 1000 ft^2 if the bog has been sanded within 18 months.

Sanding stimulates vine growth, use less fertilizer.

The spring fertilizer application may be reduced or eliminated in the year of sanding.

Sanding helps in the management of cranberry girdler and may suppress and synchronize dodder seed germination.

Ice sanding effectively suppresses cranberry girdler, but spring sanding seems to be ineffective. Further treatment such as nematode application may be necessary to adequately control this pest.

For germination to be effectively suppressed, the dodder seed must be buried by at least 1 inch of sand. Regardless of sanding depth, dodder germination tends to be synchronized after sanding, facilitating control measures.

Sanding can be dangerous – take precautions to protect yourself and your workers.

Regularly check sanding machines to make sure that protective features are functioning properly. Train all operators to observe safety precautions. Do not clear sand jams with the equipment running. Disc agitators are preferable to bar agitators in preventing jams.

Ice Sanding

Exercise caution when moving over deep water covered by ice.

This is especially true when moving over ditches and edges. Generally, the ice should be at least 5 inches thick to support the weight of the equipment. Water should be released from

beneath the ice if there is a question that the ice is not thick enough to sand safely.

Ice sanding.

Avoid oxygen deficiency damage when ice sanding.

Thick layers of sand on top of the ice impede light from reaching the vines. Lack of light can lead to low oxygen levels in the water under the ice and subsequent leaf drop in the spring. This can be remedied by removing the water from beneath the ice after sanding is completed (but before the sand filters down into the water). Drain the ditches sufficiently to avoid leaving puddles on the bog surface.

Cracks in the ice and uneven ice settling may be associated with uneven sand deposition.

If heavy rains follow ice sanding, sand may be washed through cracks or crevasses and bury vines. Scout the bog after the ice melts and rake or hose excess sand off of the vines.

During sanding make every effort to apply the sand evenly on the ice. Spotters may be helpful.

Barge Sanding

Some bogs should not be barge sanded.

Barge sanding should not be used if discharge is to a sensitive water body or if water cannot be impounded to allow settling prior to discharge. Avoid sanding at times when water flow through the bog is heavy. If only poor quality (high 'fines') sand is available, barge sanding should not be used.

Paddle-wheel barge sanding equipment requires approximately one foot of clearance above the vines. If dikes are low and the bog is out of grade, this may not be feasible. Cable barges require approximately two inches of vine clearance.

Barge sanding.

If you choose to barge sand, certain steps should be taken to minimize sand discharge into outlet water.

Particle settling rate is a function of water temperature. Avoid sanding when water temperature is between 40 and 45º F. Settling is slowest in this temperature range. If sanding must be done at these temperatures, longer impoundment periods for settling may be required.

Do not sand into harvest water. This may lead to discharge of nutrients off site. Fall barge sanding appears to be less effective than winter or spring sanding.

When barge sanding, avoid passing over areas which have already been sanded in addition to avoiding overlap. Sediments that are re-agitated will settle more slowly.

Water should be impounded for at least 5 days; 7 days is preferred. Field studies have shown that significant clearing of the water does not occur for 4-5 days after barge sanding.

Release the flood water slowly during a 2-3 day period over the top flume board to avoid sediment release.

When possible, flood water should be released onto another bog and held for an additional day or two. This will further reduce sediment discharge potential. Water may also be released to a retention area.

Silt traps may be used to retain sediments and prevent offsite deposition

Some special considerations when barge sanding.

Avoid sanding if water temperatures are above 65º F. High water temperatures may damage the buds, leading to crop reduction.

If barge sanding in the late water flood or late in the spring, remember that frost tolerance will be affected. After a late water flood, buds will not tolerate temperatures below 30º F.
Barge sanding leaves a sand deposit on the vines. This will be removed by rain or sprinkler use. Shallow reflooding may make this condition worse by depositing more sand on the vines.

Do not sand too soon after harvest. An early flood for sanding may delay dormancy and promote winter injury. Many growers have found fall barge sanding to be minimally effective.

Dry sanding:

Dry sanding has been associated with more vine damage and crop reduction than other methods.

Dry sanding machines may cause ruts on the bog and injury to the vines. Crop reduction in the year of sanding is likely with this practice. To minimize vine damage, dry sanding should only be done when the vines are dormant and the soil surface is not frozen.

To minimize damage to vines:
Avoid overlaps. Move ramps frequently. Reduce air pressure in sander tires. Limit sander loading, use 1/2 loads of sand.

Dry sanding was associated with crop reduction in research plots.

Sanded plots showed a decrease in interception of photosynthetically active radiation (less photosynthesis potential). While light interception had recovered to presanded levels by late summer, crop was reduced that year. Due to that recovery and to the increase in new uprights due to sanding, recovery in the second year is likely but may not compensate for the first year loss.

Sanding directly on vines

It is likely that all sanding methods will have some effect on light interception and cropping.

Methods that keep sanders off of the vines will minimize damage when dry sanding.

Growers have begun to use sanders mounted on rails to minimize the impacts of dry sanding. Dry sanders have also been mounted on booms. Both of these methods are preferable to running heavy sanders directly on the vines.

Rail and boom sanding may also facilitate more even application of sand, a critical factor when pest control is an expected outcome. An additional advantage of the rail system is the ability to go back over areas to fill in grade drops without incurring additional vine damage.

For more information:

Barge sanding BMP. Fact sheet. Cape Cod Cranberry Growers Association.

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Water Resource Protection and Enhancement and Erosion and Sediment Control BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

Sanding Checklist

✓ Stockpile sand responsibly.

✓ Ice sanding is the preferred method of sanding.

✓ The texture of the sand is very important; coarse sand is an important component.

✓ Know how sanding interacts with other management techniques.

✓ Sanding can be dangerous; protect yourself and your workers.

Sprinkler System Design and Use

A sprinkler system is a collection of component devices which, powered by a pump, transports water from either groundwater or surface water (e.g., a small man-made reservoir, or a natural water body like a pond, stream or lake) that projects water into the air and deposits it onto the surface of the ground. It consists of metal or plastic pipes, which are either horizontal (mains, submains, and laterals) or vertical (risers), and rotating sprinkler heads, made mostly of metal, with nozzles mounted in them. The horizontal pipes are typically buried under the surface. There are also a number of other parts including fittings, valves, vents, filters, etc.

Purchasing and accepting a design of a sprinkler system are probably some of the most important decisions that a cranberry grower will make. Before designing a system, examine the water source to be sure that it is of acceptable quantity and quality. One should consider the wide range of present and future water needs when deciding on pump specifications, capabilities, and location, as well as the traits of all the components to be sure that they will function in a compatible and integrated manner. The design of the system should avoid excessive water velocities, and limit the pressure loss due to friction as water moves through the system. An irrigation system will only perform well if it is engineered correctly and is properly operated and maintained.

Recommended Practices

Optimize irrigation system performance.

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 90° 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 and risers.

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.

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.

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.

System operating pressure should fall within the range of 45 to 60 psi (for solid set sprinklers) with pressure requirements increasing as system spacing increases.

Nozzle pressure at the last or weakest 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 pressure gauge (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 standard solid set sprinkler heads.

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.

Use sprinkler heads with one open outlet.

Sprinkler heads with two outlets (front and rear) are available, but do not deliver acceptable performance on cranberry beds.

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.

Consult with a professional when re-designing or making significant improvements to the sprinkler system.

Technology and product availability change frequently. New and innovative systems are constantly being developed. Check to make sure you are using the right components to achieve your water management goals.

Use half-heads, partial heads and/or screens to prevent application to non-target areas.

These should be used especially if the irrigation system will be used for chemigation.

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 more information on safety, calibration, and techniques for chemigation.

For more information:

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

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.

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Updated by Hilary Sandler and Jack Heywood and reviewed by CCCGA Environmental Committee, 2010.

Sprinkler System Design and Use Checklist

✓ Consult with a professional when re-designing or making significant improvements to the sprinkler system.

✓ Maximize system performance and uniformity.

✓ If using sprinklers for chemigation, familiarize yourself with the Chemigation BMP.

Water Control Structures

Commercial cranberry management requires the ability to manipulate water during the course of the season. Activities that rely on diking systems and water control structures include flooding the beds, impounding water, manipulation of the water table in the bed, and drainage functions. Dikes are used to separate the cranberry beds into manageable units for flood harvest.

Recommended Practices

Flumes

Flumes are water control structures, usually constructed of steel, aluminum, or concrete, which are installed in a dike to convey water, control the direction of flow, or maintain a required water surface elevation.

In cranberry systems, the primary purpose of the flume is to control discharge, distribution, delivery, or direction of water flow in open channels (ditches, canals) or on the cranberry beds. They are also used for water quality control, holding back sediment and impounding water following pesticide applications.

Flumes should be designed to meet site-specific needs.

Structures should be designed to meet the needs of the individual site and use (applicable NRCS designs may be adapted). A Conservation Farm Plan is critical if major changes to or construction of water control systems is planned. The plan will include design (location, grade, dimension, materials) and maintenance plans for the flume.

Flume with riprap

When planning flume design, consider water quantity requirements.

When designing flumes for controlling water movement onto cranberry beds, plan structure elevation so that a foot deep flood can be maintained on the bed and so that the water table can be lowered to an adequate depth for proper rooting during the growing season. See the Irrigation Management BMP for information on water table depths.

Design flume size to accommodate the proper volume of water. This will determine how quickly a bed can be flooded or drained. For example, an undersized outlet flume may lead to poor drainage, particularly in the early spring after the winter flood and during the spring frost-protection season.

Flumes should be installed and maintained so that erosion during and after installation is minimized.

Flumes should be fitted with antiseep collars. Fill and compact around the culvert to prevent erosion and undermining -- packing with bentonite or other dense materials may be helpful. Placement of concrete blocks or turf sods around the flume may also help. When conditions permit, stabilize disturbed soil surfaces by seeding or with the placement of sods (see more information below in dike section).

The size of the outlet pipe is important. If it is too small, the culvert may wash out. Size is determined based on the amount of water to be discharged. Consult an engineer or NRCS for this calculation.

Water should be discharged into a stable ditch or channel.

As part of normal maintenance, inspect flumes on a regular basis. Look for leakage, erosion, or undermining. NRCS will inspect existing flumes as part of the Conservation Farm Planning process.

Consider aquatic life when planning water control structures.

Design and use the flume properly so that fish are protected. If watercourse fisheries are important, special precautions or design features (e. g. 'fish ladders') may be needed to insure continuation of fish migrations. Exercise caution when discharging warm, oxygen poor waters as these may adversely impact fish and other aquatic species.

Dikes

Dikes are embankments constructed of earth or other suitable materials to protect land against overflow or to regulate or contain water. In cranberry management, perimeter and interior dikes are used to temporarily impound water for harvest, trash (leaf litter) removal, pest control, and winter protection. Dikes are also used to impound water for the preservation of water quality, limiting the discharge of sediments and segregating waters following the application of pesticides. Dikes allow the control of water levels to maintain the depth from rooting zone to water table for optimum cranberry growth and productivity (see flumes section). Dikes surrounding tailwater or other irrigation ponds facilitate water storage.

Dikes should be designed so that settling and slumping are minimized.

Minimum top width of the dike should be 4 feet. Embankments should be built no steeper than 1:1. Site the shallower slope on the outside of the dike to minimize off-site erosion. The dike should be built and compacted in layers using fill materials containing no sod, brush, roots, or stumps. Core materials in the dike should be the most pervious materials available. In Southeastern Massachusetts, this will often be compacted glacial till. Dikes should be constructed to a height 1 foot above the normal *flood elevation*. In order to establish vegetation on dikes or embankments, surface soil must have the capacity to hold adequate water to support plant growth.

Adding a dike within a bog area presents unique challenges. Seek expert planning assistance.

It may be beneficial to add an interior dike within a cranberry bed that is severely out of grade to facilitate flooding activities. Generally, these would be older bogs built on peat. Stabilizing interior dikes on such beds can be difficult as peat tends to compress under the weight of the dike. Consult NRCS for planning assistance, including mapping of underlying peat using ground penetrating radar, prior to beginning any such project.

Dikes should be stabilized to prevent erosion.

Stabilize dikes and other disturbed areas by seeding, mulching, or placing soil stabilization fabric (geotextile, netting, burlap). Mulch should be anchored with mesh. Grade 2-3 turf sods have been used successfully for this purpose. Pay particular attention to dike edges, they remain prone to erosion during rainstorms until stabilized.

Erosion control blankets (e.g., Curlex), have been successfully used to stabilize bankings and on-bed ditch edges. Ditches stabilized with these products required 60% less cleaning than those left untreated. Erosion blankets are preferable to loose mulch on the bog side of a dike, as mulch may contain weed seeds that will end up in the bed. Erosion control blankets are biodegradable, decomposing in 6-8 months. The material must be in good contact with the underlying soil or erosion can occur under the blanket.

Grass is best planted in spring or fall and may benefit from a layer of mulch or netting and periodic watering during establishment. Top dress dikes with 3-4 inches of topsoil prior to seeding. Hydroseeding or gel seeding can be used. Erosion control 'blankets', such as Curlex, have been successful in conjunction with grass planting. Choose non-weedy species for seeding dikes. Recommended examples include clovers, fescues, and perennial ryegrass. Mixtures of species in the seed mix are preferable to a single species. Fertilize and lime grasses as needed during establishment.

Consider protective measures to prevent animal damage to newly constructed dikes.

Chain-link or galvanized wire fencing (chicken wire) may be laid out on the dike surface prior to seeding or sodding to prevent muskrats or other pest animals from burrowing into the dike.

Maintain dikes at designed shape and height.

Initial height should be at least 5% higher than the desired working height to allow for settling (see previous page).

All efforts should be made to avoid the formation of deep tire channels on the top of the dike.

Maintenance should include periodic removal of any woody vegetation that becomes established on the embankment as roots of these species can destabilize the dike.

Embankments should be mowed as needed to prevent the spread of seeds onto the bogs and to facilitate removal of berries during flood harvest.

For more information:

Dike standard. 1980. Natural Resources Conservation Service Conservation Practice Standard #356. NRCS-NHCP. Amherst, MA.

Structure for water control standard. 1977. Natural Resources Conservation Service Conservation Practice Standard #587. NRCS-NHCP. Amherst, MA.

Erosion and Sediment Control and **Water Resource Protection and Enhancement** BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

Water Control Structures Checklist

✓ Flumes should be installed and maintained to minimize erosion.

✓ Consider aquatic life when planning water control structures.

✓ Seek expert planning assistance when adding a dike within a bog area.

✓ Stabilize dikes to prevent erosion.

Water Resource Protection and Enhancement

Cranberry growers manage water on bogs to ensure sufficient moisture and adequate drainage for optimum plant growth. Water management practices on cranberry bogs differ from those used for other forms of agriculture because of the variety of ways that water is used in cranberry culture. Water is used for disease and insect control, frost and heat protection, sanding, harvesting, and protection from winter desiccation and cold injury. Because of the periodic need for sizable amounts of water, impoundment of water adjacent to the bogs is a normal farming practice in cranberry production. In addition to storage ponds and sumps, components of a typical water management system for a cranberry bog include irrigation systems, wells, flood gates and flumes, lift pumps, and drainage ditches and pipes.

Water can be used and re-used within a cranberry bog because its irrigation system and water storage reservoir are often interconnected. In some instances, water can also be recycled among growers. Therefore, water uses on cranberry bogs are not always consumptive. Newly established bogs, however, do require more irrigation to satisfy the needs of growing vines. Because cranberry culture typically is carried out in moist areas such as wetlands and marshes, irrigation needs are limited and comparatively small (averaging between 0.4 and 1.5 inches per week from rainfall and irrigation combined, during the growing season).

Important environmental considerations directly related to water management include:
1) conservation of fresh water supplies;
2) prevention of contamination of surface and groundwater by pesticides, fertilizers, or sediments; and
3) optimizing plant growth, yield, and resistance to pests and diseases.

Recommended Practices

Make sure that your water supply is adequate for cranberry production needs.

Generally, older bogs will require as much as 10 acre feet of water per acre per season to meet all production, harvesting, and flooding needs. The actual figure will vary depending on the rate of recharge of your water supply and your ability to recapture and reuse water. With the implementation of appropriate BMPs, water needs may be reduced substantially.

Use tailwater recovery and holding ponds to conserve water.

Install tailwater recovery 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 only in 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 the 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.

Implement all feasible water conservation measures.

Laser-level new and renovated beds to minimize the volume of water needed for flooding.

However, beds should be slightly crested to promote drainage.

Implement efficient irrigation designs with maximized uniformity. This will minimize that volume required to achieve the optimum 0.1 inch/ hour dispersal rate at the poorest head. Refer to the Irrigation BMP and NRCS specifications for design suggestions.

Water control structures and dikes should be adequate to maintain floods. These structures should be well-maintained to avoid seepage losses and catastrophic failures. Flume boards should be tight to facilitate required water impounding following pesticide applications.

Cranberry bogs should be designed with a perched water table. This creates a barrier between the bed and ground water which serves to protect ground water resources, allow for flood retention in the bog, and facilitate efficient irrigation management. See the Mineral Soil Bog Construction and Irrigation BMPs for further information on designing and managing a perched water table.

Monitor soil moisture. Apply irrigation only when required based on plant needs and soil moisture status. Moisture may be monitored using tensiometers or water level floats. See the Irrigation BMP for information on the use of these devices.

In closed bog systems, where water can be held for extended periods of time, make sure that water control structures (i.e. flumes, bulkheads, etc.) are water-tight.

Water-tight flumes are essential to prevent the escape of ditch water containing fertilizer or pesticide residues and suspended sediment, and to prevent loss of flood water during harvest. Worn or damaged flume or bulkhead boards should be replaced regularly. Keep the boards free of debris and consider the use of rubber gasket strips on the channel guides or a tension activated tiedown system to decrease leakage. Information on suppliers and detailed construction drawings are available from the Cape Cod Cranberry Growers Association.

Application of sawdust to ditch water on the upgradient side of the ditch can sometimes be effective in reducing water flow through worn or imperfectly-fitted flume boards. A locking mechanism to prevent unwarranted tampering with the flume boards should be considered in areas prone to vandalism.

In flow-through bog systems, those containing a permanently flowing stream or constant water discharge, consider some strategy or method to segregate or isolate the stream flow from ditch water and protect external water bodies.

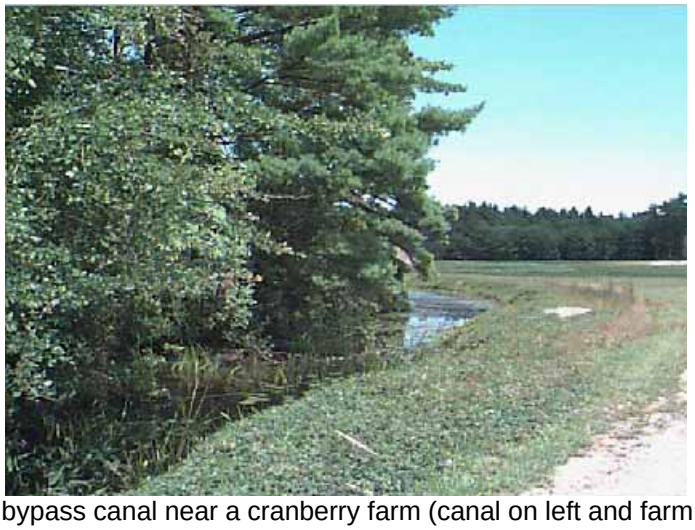
Prior to initiating these practices, seek technical assistance. You should, at minimum, have an NRCS Conservation Farm Plan in hand.

Installation of auxiliary flumes at the intersection of perimeter ditches and interior ditches is one way of segregating the stream from the bog ditches. Installation of perforated drainage pipe in the interior ditches and backfilling of interior ditches with gravel may be an alternative solution.

Construction of a by-pass canal to reroute water during fertilizer or pesticide applications may be an additional option. Alternatively, tailwater recovery systems may be used. Activated carbon filters have been shown to be an effective method of discharge water filtration under certain conditions. Carbon loading rates and filter efficacy are dependent on water flow rates.

If bogs have adequate soil drainage, consider leaving some actively growing aquatic vegetation in the ditches during the growing season. The vegetation can be effective in

removing nutrients and residues from the water. Take full advantage of aquatic vegetation's potential for nutrient removal by delaying cleaning or removal until later in the growing season, preferably after harvest.



Example of a bypass canal near a cranberry farm (canal on left and farm in back right)

Studies of constructed wetlands have shown them to be effective in filtering water flowing from agricultural land. Experience with constructed wetlands in cranberry systems is limited. It should be noted that a constructed wetland may be subject to the same regulations that pertain to natural wetlands.

Reduce the level of water in ditches as much as possible before application of fertilizers and pesticides. Take steps to minimize direct input of fertilizers and pesticides into surface water.

Minimizing direct application of fertilizers and pesticides to streams and ditch water is the single most important step in reducing the potential for off-site movement of these potential contaminants.

Lowering the water level in ditches dries out the soil and reduces the amount of water runoff that occurs. Also, lowering the water level in ditches before a fertilizer or pesticide application will allow for adsorption of nutrients and pesticides onto sediment and vegetation in the ditches and increases the water holding time even in flow-through bog systems. However, monitor soil moisture to avoid drought stress during this practice.

Based on research studies, other practices that may reduce deposition of materials in ditch water include:

- Installation of sprinkler guards - wire mesh was shown to be more effective than plastic mesh;
- Use of part-circle ('half-head') sprinkler heads (most effective when used with sprinkler guards);
- Move heads in from ditch edges;
- Irrigation system shutoffs;
- Substituting subsurface drainage for interior ditches;
- Covering internal ditches.

Hold harvest water to allow sediment to settle prior to release from the bog system.

During harvest, sediments are suspended into the flood water. Discharge of sediment into wetlands and waterways is not permitted. Sediments should be allowed to settle and flood

water should be discharged over the top flume boards gradually to avoid sediment discharge to surface water.

A novel practice of holding the harvest flood for up to 4 weeks is under investigation by scientists at the Cranberry Station and a team of growers. This practice may have additional benefits in pest and weed control. Refer to the Harvest and Postharvest Management BMP.

Hold water after pesticide applications for as long as practical and no less than the required holding time indicated on pesticide labels.

Impounding water is a key means to reduce the potential for adverse environmental impacts and is required for certain materials (see labels). If you have the capacity, hold water longer than the required label specified holding time to further reduce the likelihood of adverse environmental impact.

Incorporate weather forecasts into your water management plan.

Rainfall, especially downpours from severe thunderstorms, can wash fertilizer nitrogen and pesticides off the target area into nearby water bodies. Follow weather forecasts and postpone fertilizer and pesticide applications when rainstorms are forecast.

Heavy rainfalls during water impoundment periods may lead to bog flooding. Monitor bogs carefully during such periods. A short summer flood can have adverse effects on fruit quality; longer floods may kill blossoms or newly formed fruit by suffocation.

When feasible, take additional steps to protect surface water bodies.

Use of part-circle ('half-head') sprinklers and sprinkler guards can be effective in keeping pesticides out of surface water and off dikes and travel lanes. Research has shown that wire mesh guards are more effective than plastic mesh guards.

Consider installing secondary containment for liquid fuels stored adjacent to open water. Consult local and state fire marshall regulations for specifications.

Impound water for at least 7 days following barge sanding.
Follow the BMPs for Pesticide Storage and Pesticide Mixing and Loading.

Protect public drinking water supplies.

Growers should be aware of and strictly comply with all state regulations for the protection of public drinking water supplies, including wellheads and surface water supplies. These rules are designed to prevent contamination of these supplies and their recharge areas. Public water supplies are any sources that provide water to 25 or more people for 60 or more days per year.

Specific regulations exist for the protection of public drinking supplies and require specific management restrictions in Zone II and Zone B and C areas. Zone II wellhead protection areas are defined as the area of an aquifer which contributes water to a public water supply well under the most severe recharge and pumping conditions. Zones B and C are areas that feed surface water sources used as public drinking supplies. Zone B is the half mile area abutting the surface water source and Zone C is the area in the watershed that feeds the source. Zone II, B, and C areas are delineated by the MADEP. Maps showing the delineated areas are available from Mass GIS (State Executive Office of Environmental Affairs). Information can be ordered or downloaded via their web page at www.state.ma.us/mgis/massgis.htm.

Any grower whose bogs lie within a Zone II, B, or C should have a Farm Conservation Plan. If you do not have such a plan, contact the Plymouth County Conservation District. They are part of a partnership with NRCS and the Cape Cod Cranberry Growers Association formed to provide funding and resources for cranberry farm planning.

For additional information, the Cape Cod Cranberry Growers Association assists its members in defining the locations of Zone II, B, and C areas in relation to their farms.

Protect private wellheads.

When siting a non-public well on your farm, certain precautions should be taken. Wells should be located away from areas subject to uncontrolled surface runoff or flooding. If a well is in such a location, measures should be taken to protect the well. Construction of a protective berm or landscaping and contouring of the site so that water flow is diverted away from the well should be sufficient to protect the wellhead. Wellheads should be covered and the soil around the casing tightly packed to prevent surface water and shallow groundwater from entering the well. Wells should be sited at least 400 feet away from potential sources of contamination such as storage and preparation areas for fertilizers, pesticides, and petroleum products. It is recommended that wells should be sited at least 150 feet from bog edges.

Make sure the bog has adequate drainage. Maintain proper ditch drainage function.

Proper soil drainage results in healthy vines that reduce the incidence of diseases such as root rot.

For more information:

Sandler, H.A. and C.J. DeMoranville. 2008. **Cranberry production: a guide for Massachusetts**, CP-08. UMass Extension Publ.

Water Control Structures and **Flood management** BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

UMass Extension

Water Resource Protection and Enhancement Checklist

✓ Make sure your water supply is adequate for cranberry production needs.

✓ Use tailwater recovery and holding ponds to conserve water.

✓ Reduce water level in ditches as much as possible prior to application of fertilizers and pesticides.

✓ Hold harvest water to allow sediments to settle prior to release.

UMass Extension

PESTICIDE BMPs

Chemigation

In addition to providing water to the cranberry vines, many cranberry growers use their irrigation system to deliver many of their pesticides and fertilizers. When an irrigation system is used to dispense chemicals, every effort should be made to maximize the performance of the system. Review the Irrigation, Mixing and Loading, Pesticide Application, and Pesticide Storage BMPs for additional information on pesticide use.

It is a violation of Federal law to introduce pesticides into an irrigation system through the suction side of the pump.

All pesticide applications must be made on the discharge side of the pump regardless of whether the water is from a well or surface water source. Only fertilizer applications can be made from the suction side of the pump.

WORKER PROTECTION STANDARDS (WPS) REGULATIONS REQUIRE:
All workers involved in any aspect of handling, mixing and/or loading pesticides must be trained as a HANDLER or have a pesticide license.

MA LAW REQUIRES THAT ALL PERSONS APPLYING PESTICIDES IN A COMMERCIAL CAPACITY MUST HAVE A VALID PESTICIDE LICENSE.

Several types of licenses are available:

Applicator License. If you intend to do pesticide work using general use (non-restricted) pesticide for hire, you must obtain an applicator license.

Private Certification. If you intend to do pesticide work using restricted use pesticides on property owned or rented by you or your employer for the purpose of raising agricultural commodities, you must obtain a private certification. This is the license usually obtained by individuals working as farmers.

Commercial Certification. If you intend to do pesticide work using restricted use pesticides for hire or not for hire (barter/volunteer) on someone else's property, you must obtain a commercial certification.

System Requirements

To be in compliance, all irrigation systems that are used for chemigation applications must contain the following components:

Requirements for the irrigation system used for chemigation:
- Vacuum relief valve located at the highest point of the pipe system.
- Interlocking pressure switch hookup.
- Chemigation injection port positioned at least 6" lower than the bottom of the pipe (discharge pipe) on which the vacuum relief valve is located (i.e., the highest point of the pipe

system).

- 2’ minimum elevation *differential* between the top of the highest sprinkler head and bottom of the discharge pipe. If the irrigation system does not meet the 2’ requirement, the irrigation system must be equipped with a chemigation check valve, which includes a vacuum breaker and a low-pressure drain (and an injection port).
- Positive displacement pump (non-impeller; e.g. a diaphragm or roller-type) or Venturi.
- Interlocking pressure switch to shut down the chemigation pump at low pressure (if using displacement pump).
- Back-flow prevention device (e.g., check valve or main line loop).
- Pump interlock, flow sensor and flow interrupter (if using positive displacement pump). Interlocks are not needed with Venturis.

System Recommendations

Chemical injection ports should be located at least 10 pipe diameters upstream from a ‘T’ fitting to insure proper mixing.

For example, if the pipe diameter is 6”, then the injection port should be at least 60” from the “T” fitting. Without sufficient travel distance before a ‘T’ fitting, proper mixing will not occur and the material will be applied nonuniformly across the treated area.

Install and orient injection port to permit proper water drainage and to minimize the risk of freezing (and damaging) the port.

Rinse out the injection port after chemigation to remove chemicals to prevent corrosion of the mechanism.

Injection port must extend halfway into the diameter of the pipe.

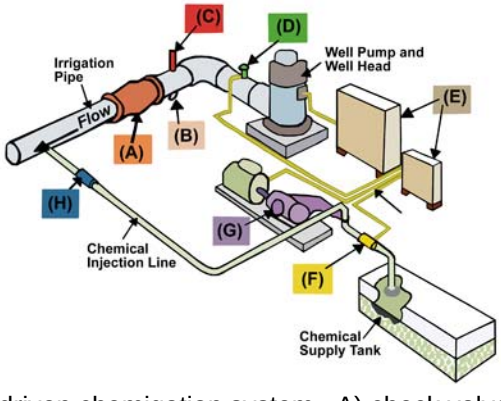


Fig. 1. Typical electrically driven chemigation system. A) check valve, B) low pressure drain, C) air/vacuum relief valve, D) pressure switch, E) interlocking system controls, F) solenoid operated valve, G) chemical injection pump, H) chemical line check valve (Harrison 2006). Some of these components may not be necessary depending on pump elevation.

Recommended Practices

Timing your system.

Timing your irrigation system is extremely important. It directly affects the level of pest control you can obtain by chemigation. Establishing a rinse time can be done by running a

concentrated dye solution through your system. Dye tests should be run every 1-3 years. You should certainly run a dye test anytime significant modifications are made to your irrigation system. In general, the shorter the wash-off time (the time from first to last head), the better. You should target wash-off times to be 5 minutes or less. The efficacy of certain products (such as the Bts) will be higher with wash-off times around 2-3 minutes. Excessive wash-off times will adversely affect pesticide performance.

The goal of a dye test is to:

- Determine how long to operate the chemigation application, and
- Observe mixing and application performance.

Running a dye test:

1) Locate the first head in the system that applies water.
2) Mix a concentrated solution of tracer dye (e.g., 1 oz. per acre in a gallon of solution). Novice timers may want to use a darker solution since it is easier to see as the dye moves through the system.
3) Place the gallon of mixture in the spray tank and inject it through your chemigation system. It will be necessary to circulate the mixture for a few minutes to fill the injection hose.
4) Using a stopwatch or a watch with a second hand, start timing as soon as you start to inject the solution. Do this as quickly as possible. Try to inject the dye solution in 15 to 30 seconds. This will give you the maximum time to observe your system as well as give you a dark solution. Clean up and rinse out equipment later. You will be wasting excellent observation time by cleaning at this point.
5) Note the time it takes for you to first see dye reach the first head *and* last head. The last-head time minus the first-head time is the wash-off time (see below). This is the amount of time the system will be 'washing off' the applied material.

***Several terms are used to evaluate this process*:**

Injection port to first head (travel time). This is the time needed for the material to actually reach the bog. This is primarily affected by pipe length, diameter of the main line, number of elbows or 'T' connectors, and operating pressure. If this time is inconveniently long, consider moving the injection port closer to the area of application.

Injection port to last head (rinse time). This refers to the time, measured from the end of the injection, that it takes a chemical to clear the last head in the system. This is the length of time you will run the irrigation system after the chemigation injection is completed.

First to last head (wash-off time or travel time on bed). This is the time that water (without any chemical) is being applied to the vines (traveling from first head to the last head). Long wash-off times will dilute and wash the material from the target area (leaves or fruit). You should try to get the wash-off time to be as short as possible (5 minutes or less).

Wash-off time = Rinse time – travel time

For most chemicals, you will want to have as short a rinse time and wash-off time as possible. However, there may be certain instances where the performance of a material will be improved with a slightly longer rinse time (assuming that your normal rinse time is fairly short). For instance, fungicide applications on bogs with very thick vines may benefit from an increased rinse time.

If you note differences in the dye concentration (i.e., some sprinklers are darker than others)

as it moves through your system, the chemicals may not be mixing enough before they reach certain lateral lines.

Injection Issues. Injection time is the amount of time needed to inject the material into the irrigation system. This affects the dilution of the product that you are injecting. Typically, pumps run at 70 gal/minute/acre. Most labels indicate that chemicals should be applied in 400-600 gallons of water per acre. Thus, a 6-8 minute injection should be your target injection time. Smaller pump systems should err towards 6 minutes; larger bogs should err towards 8 minutes. Extra-large pump systems (25+ acres) should allow an additional minute (9 minutes total).

Note that an injection time that is too short (less than 6 minutes) risks injury to the vines, particularly around the heads. Injections times that are too long for a given pump system risk losing efficacy of the product.

Optimize the Coefficient of Uniformity for your system.

Your irrigation system should be operating at its optimal Coefficient of Uniformity. Even distribution of pesticides is important for efficacy and food safety concerns. Refer to Irrigation BMP for methods to improve uniformity.

Minimize rinse time.

Minimal rinse time generally improves the efficacy of materials delivered through the irrigation system. Keep in mind the physical limitations of your particular irrigation system. Follow all pesticide label recommendations, especially for new materials, as efficacy may be directly related to rinse time.

General guidelines: For beds less than 3 acres, target a rinse time of 2-2.5 minutes. On large systems, try to limit rinse time to less than 10 minutes.

Suggestions for minimizing rinse times:

- Verify that pressure is good across the bog.
- Verify that the pump is appropriate for the job.
- Install satellite (lateral) shut-off valves.
- Install satellite ports (especially on larger systems) if rinse time is greater than 10 minutes. This assumes that overall performance is adequate for chemigation.
- As a last resort, consider significant re-design of the system.

Consider innovative high performance irrigation systems for new plantings or renovations.

While you may not be able to replace an existing system, install the best possible design in new plantings or renovations. Consult your local Natural Resource Conservation Service or a local irrigation system specialist for advice on system designs.

Consider alternatives to help shorten travel times.

Install satellite injection ports or shutoffs at each bed. You can inject chemical from a single injection port and shut off water to individual beds when the travel time to that bed is complete or you can install an injection port along the main at each bed and chemigate each bed separately. These options will increase your workload. However, the system will perform more efficiently and your production should be enhanced.

If possible, install the injection port so you have an unobstructed view of the application area.

This will allow you to view the area during the application to insure that the system is working

properly and that people have not inadvertently wandered into the application area. If the injection site is remote from the application area, consider stationing another person or vehicle near the application area.

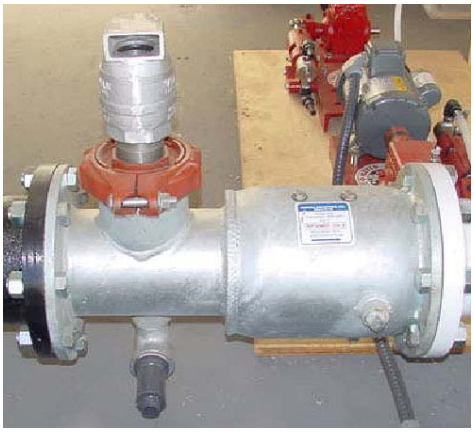


Fig. 2. (Top) Irrigation line check valve, vacuum relief valve, and low pressure drain. (Bottom) Pesticide metering pump. Diagram and photos courtesy http://www.cdpr.ca.gov/docs/emon/grndwtr/chem/chemdevices.htm.

The area around the injection port(s) should have secondary containment to facilitate containment and clean up of spills or leaks.

Consider having a bucket placed below the injection port to catch any spilled material. See Pesticide Storage and Mixing, and Loading BMPs.

It is preferable to calibrate your own system rather than rely on the manufacturer's specifications.

Output values of pumps are normally measured at the factory based on specific drive shaft speeds that may vary from the actual speed of your drive shaft. Calibrate with the irrigation system under normal conditions. Using a stopwatch with either a calibration tube or a tank with volume units printed or embossed on the side, measure the amount of solution removed from the supply tank. Make adjustments to the injection pump on 30-second or one-minute time checks.

Calibrate the Venturi or injection pump to insure that it can deliver the required chemical volume in the appropriate injection time.

Proper dilution and mixing of chemicals is important for efficient chemigation.

It is recommended to mix the ingredients in the following priority: 1) water, 2) pesticide, 3) adjuvants, 4) the rest of the water. However, if you are using a suspending agent, put it in the

water and agitate for 15 minutes prior to adding anything else. Check to make sure that the various chemicals are compatible.

Mixing Order for Liquids. Add 25-35% of total water first, and then add the pesticide. Add the rinse water from the containers. Add the rest of the water.

Mixing Order for Dry Formulations. Add 50% of the total water first, and then add the pesticide. Mix in the rest of the water.

Determining Your Total Mix. Generally, figure between 1-2 gallons per acre for liquids and 2-3 gallons per acre for dry formulations. For most liquids, the total amount of liquid (pesticide + water) needed will be a 1:1 mix. For example, if you applying 4 pt/A of Sevin to a 10-acre bog, you will need a total of 5 gallons of the pesticide. Therefore, mix it with 5 gallons of water.

Mix on site. Keep chemicals in original containers. DOT-approved containers are needed for over-the-road transport with containers that are not the originals.
Keep in mind the limitations of your injection system. It is important that your injection system have the capacity to provide the output needed for the size of the bog that is to be treated.

Be sure that the material you are applying is labeled for use through chemigation apparatus.

Even though many liquid formulations are labeled for chemigation, not all liquid formulations can be applied through the irrigation system. Read the pesticide label for each product thoroughly.

Nontarget application should be minimized with the use of screens and part-circle heads.

Sprinkler heads should not spray across open water unless water can be held for the appropriate holding time. Sprinklers should also not spray across dikes. The water stream should not contact areas where pedestrian or vehicular traffic might occur or contact open water. Make sure nozzles are sized to give matched precipitation when using part-circle heads. They should deliver one-half the water output of a full-circle head.

Late night through pre-dawn is the optimal time for chemigating.

Atmospheric conditions are typically most stable during this time period. Injury to pollinators and drift to nontarget areas is also minimized. In addition, it is less likely that someone will accidentally wander into the application area during these times. Early applications should be completed prior to dawn since research indicates that atmospheric conditions are usually most unstable at dawn and usually thereafter.

The timing of a particular application may also be chosen to maximize efficacy of control for a particular pest.

Avoid applications when wind speeds exceed 5 mph.

Excessive wind increases the likelihood of off-target and nonuniform applications. Bear in mind application during still conditions retards dissipation and increases the likelihood of drift of odorous compounds.

Periodically attend workshops on chemigation procedures whenever possible.

Additional Chemigation Guidelines

• Do a chemigation practice run with dye or water at the start of each season to insure all parts are working correctly.

- Prior to every application, make sure irrigation pump and injection pump (or Venturi) are operational before mixing pesticide solutions.
- Rinse out spray tank and pump after each application but do not include this rinse water in rinse time calculations. Avoid making up spray applications well ahead of time. Pesticide solutions may be corrosive and can cause pump components to fail prematurely. In addition, pesticide solutions may settle and form a sludge that may physically impede your machinery.
- Use secondary containment to capture all leakage from injection ports and consider using dry disconnect fittings on all chemical supply hoses. Secondary containment can be as simple as a 5-gallon bucket placed under the injection port or as sophisticated as a treated concrete pad with a berm.
- Rinse out injection ports on the irrigation water supply after each application. Concentrated residue left in the port may foul the mechanism.
- Make sure the chemical feed hose is depressurized before disconnecting from the injection port on injection systems utilizing positive displacement pumps. Failure to do so may result in you being sprayed with pesticide.
- Always use caution when working around the last head of any irrigation system as some pesticide residue may be present if rinse time was inadequate.
- New chemicals applied at low rate will most likely require short wash-off times.

Significant portions of this BMP were excerpted from:

Bicki, T. 1998. **Best management practices to optimize chemigation applications**. Environmental Bulletin Series, No. 5. Ocean Spray Cranberries, Inc., Lakeville-Middleboro, MA.

Cranberry Chart Book-Management Guide for Massachusetts, 2000. H.A. Sandler, C.J, DeMoranville, and D. Cannon, eds. UMass Ext. Publ., E. Wareham, MA. 51 pp.

For more information:

Harrison, K.A. 2006. Chemigation in Georgia. Univ. of Georgia Coop. Ext. Report No. B-1298.

UMass Extension

PESTICIDE APPLICATION CHECKLIST

IMPORTANT PHONE NUMBERS
Massachusetts Poison Control System. 1-800-682-9211 Chemtrec. 1-800-424-9300

Prior to the Application

Worker Protection:
Have all appropriate Personal Protection Equipment (PPE) ready to use. Have labels and MSDS on-hand Have decontamination kit stocked and ready for use.

Appropriate notification:
Neighbor relations. Sign-posting. WPS and REI notification.

Environmental concerns:
Address any public drinking water recharge area restrictions. Check to see that the planks are in place. Check the weather forecast.

Transport the pesticide in a legal manner. Applicator must have the appropriate license for application. Verify that all equipment is working properly. Observe pre-harvest intervals. Have your Emergency Action Plan on-site.

After the Application

Record keeping done? Containers rinsed and disposed of appropriately? Are excess pesticides properly stored? Clothes properly washed after application?

Equipment that may be helpful to have on hand:

- 5-gallon bucket
- Knife
- Measuring cup
- Duct tape
- Injection port rinse device
- Stopwatch
- Mixing stick
- Portable communication devices (e.g., cellular phones)
- Bungee cords (to hold hose, etc.)
- Assorted tools (pliers, screwdriver, wrench etc.)
- Clean water in jugs
- Pesticide clean-up kit (5 gallon is good)
- WPS decontamination kit

Prepared by Carolyn DeMoranville, Hilary Sandler, and Steve Ward, 2000.

Chemigation Checklist

✓ Never introduce pesticides into an irrigation system through the suction side of the pump.

✓ Obtain the appropriate license that you need to carry out applications on your farm.

✓ Run a dye test to properly time your system.

✓ Periodically attend workshops on chemigation procedures whenever possible.

Pesticide Applications

Pesticide use is typically recommended as part of an overall management plan for controlling pests that cause crop damage or loss. Pesticide applications in Massachusetts are generally made through chemigation systems, by aerial applications, or by ground rig. Be sure your application system complies with both state and federal laws. ***It is a violation of Federal law to introduce pesticides into an irrigation system through the suction side of the pump.***

Pesticides that may be used during the course of a growing season include herbicides, insecticides, miticides, and fungicides. Pesticides should be used within the context of an integrated pest management (IPM) program (refer to IPM BMP). Application of pesticides should always be conducted in a safe and legal manner.

WORKER PROTECTION STANDARDS (WPS) REGULATIONS REQUIRE:
All workers involved in any aspect of handling, mixing and/or loading pesticides must be trained as a HANDLER or have a pesticide license.

MA LAW REQUIRES THAT ALL PERSONS APPLYING PESTICIDES IN A COMMERCIAL CAPACITY MUST HAVE A VALID PESTICIDE LICENSE.

Several types of licenses are available:
Applicator License. If you intend to do pesticide work using general use (non-restricted) pesticide for hire, you must obtain an applicator license.

Private Certification. If you intend to do pesticide work using restricted use pesticides on property owned or rented by you or your employer for the purpose of raising agricultural commodities, you must obtain a private certification. This is the license usually obtained by individuals working as farmers.

Commercial Certification. If you intend to do pesticide work using restricted use pesticides for hire or not for hire (barter/volunteer) on someone else's property, you must obtain a commercial certification.

Recommended Practices

Worker Safety and Notification

Read and follow all pesticide label instructions.
The pesticide label is based on extensive scientific studies required by the Environmental Protection Agency (EPA) prior to registration in order to protect human health and the environment.

Pesticide labels are continually revised, so thoroughly read and follow all label directions each season. Growers are required to comply with all federal and state laws regulating pesticides. ***The label is the law.***

Keep current material safety data sheets (MSDS) accessible.
An MSDS, compiled for each pesticide product, contains important health and safety information. Availability of MSDS sheets is required by the Massachusetts Right-To-Know law.

A new MSDS should be obtained each time a pesticide product is purchased. Pesticide applicators, coworkers, and family members should be familiar with all information contained in the MSDS.

Follow all Worker Protection Standards (WPS) requirements.

New WPS require growers to train and notify all employees (family members excluded) about proper pesticide handling and sanitation practices. Carefully read the 'Agricultural Use Requirements' section and comply with all EPA requirements regarding WPS on the pesticide label.

Observe restricted entry intervals (REI) and wear the appropriate personal protection equipment (PPE).

Detailed information is available from the EPA 'How to Comply' manual and video formats. WPS materials and information booklets can be obtained through local suppliers and mail-order businesses.

Keep detailed pesticide application records.

Receiving stations and packing houses may require pesticide application reporting forms prior to delivery of fruit. Check with your handler to determine any specific requirements.

Massachusetts Department of Food and Agriculture (DFA) has specific record keeping requirements. Check with the DFA to insure that you are in compliance with their regulations.

Develop a plan to follow in case of pesticide emergencies.

Pesticide applicators should develop an emergency plan that lists actions to take and persons to contact in case of a pesticide poisoning, spill, fire, or other accident.

Comply with all application notification requirements.

Regardless of application method, most pesticide applications require notification for the public and workers. Notification may need to be oral, written, (or both) as well as the posting of signs. Refer to Cape Cod Cranberry Growers' Association (CCCGA) bulletin for specifics on sign posting and WPS requirements for workers.

Consider neighborhood activities when scheduling pesticide applications.

Be cognizant of foot traffic when making an application. Do a final perimeter check, (inspecting for leaks, people, pets, malfunctioning sprinkler heads, proper sign posting, and planks) immediately prior to the application (refer to Neighbor to Neighbor BMP).

The use of spotters is recommended when the bog is not visible from the injection site or the pumping area. Spotters can help to quickly identify problems in the system (e.g. clogged heads, broken lines) as they occur or alert the applicator should anyone accidentally enter the area.

General Pesticide Application Information

For any application method, always verify chemical compatibility when applying more than one chemical in a single application.

Pesticide mixing and loading should occur in a secure containment area.

If the pesticide mixing and loading area is located on your property, make sure the site has a

containment area where the spray tanks are refilled. Repeated leakage of small amounts of pesticide residues during refilling can lead to soil and ground water contamination that may require costly remediation. See Mixing and Loading BMP and references at the end of the section.

Provide secure, safe storage for pesticide containers.

The floor of the storage area should be made of treated concrete or other chemically impervious material. Designate a specific area in the storage facility for each group of pesticides (e.g., herbicides, fungicides, insecticides, and miticides). Keep bags and containers off the ground. See Pesticide Storage BMP and the references at end of the section.

Triple-rinse all empty pesticide containers before disposal.

Federal law prohibits re-use of pesticide containers. Liquid containers should be triple rinsed, or preferably pressure rinsed. The rinsate should be added to the spray tank. The pesticide label and MSDS contain instructions for safe container disposal. Do not store empty containers in your pump house, even temporarily. Inquire if your pesticide supplier will recycle clean, empty containers. Additionally, any container used for any pesticide purpose must be labeled appropriately.

Avoid excessive overlap of pesticide applications when low gallonage is applied.

To minimize phytotoxicity, vine stress, or burning, avoid excessive overlap when applying low volume sprays of Lorsban, diazinon, Pyrenone, and other pesticides containing oil based carriers. These problems are associated with some boom applicators, mist blowers, and aerial applications.

Protecting Water Quality

Water control structures should be in place and free of leaks to allow ditch water containing pesticide to be held for the required time specified on the pesticide label.

Determine the groundwater contamination susceptibility of the bog.

The potential for contamination is influenced by soil characteristics, depth to bedrock and water table, type of bedrock, and characteristics of surface deposits. Pesticide users need to know the potential for site contamination and include the risks to water resources as a criterion of pest management decisions.

Drop the water level in your ditches prior to application.

This will allow you more time to hold water in ditches once the pesticide is applied.

Retain water containing pesticide residues for the required or recommended times.

Regardless of application method, every effort should be made to keep pesticides confined to the bog. It is considered a best management practice to hold water for as long as feasible following a pesticide application. All waters in contact with the bogs should be retained for the length of time as required by the label. As holding times vary for each pesticide be sure to check the label. If possible, retain water within the bog system even longer to allow maximum degradation of pesticide residues. Refer also to the Northeast US Cranberry Pesticide Chart or the UMass Chart Book.

Release water slowly after the retention period has expired.

Allow water to flow over the top flume board first and then slowly remove each of the remaining flume boards until the water is at the appropriate management level.

Activated carbon filter technology is available and may be appropriate for use in certain situations. It is recommended to consult with a professional prior to using carbon filters on your farm.

Avoid direct spraying of ditches and waterways and surrounding non-bog areas.
Aerial application of pesticides may result in non-target application to ditches and waterways.

Choose flight paths that minimize direct spraying of water with pesticides. Take extra effort to insure that flumes or bulkheads are water-tight and ditches are drained as much as possible before an application.

Consider the use of spray guards to minimize application to non-target areas. Refer to the Water Resource Protection and Enhancement BMP in this series.

Methods of Pesticide Application

Chemigation

It is a violation of Federal law to introduce pesticides into an irrigation system through the suction side of the pump. Only fertilizer applications can be made from the suction side of the pump.

Chemigation is the most common method of pesticide application for the Massachusetts cranberry industry. Refer to the Chemigation BMP, University of Wisconsin Chemigation Bulletin and the CCCGA/Ocean Spray poster on chemigation for required components and design options available to cranberry growers.

Optimize irrigation system performance before using chemigation as a pesticide application technique. Even distribution of pesticides is important for efficacy and food safety concerns. See Irrigation BMP for information on recommended system improvements to enhance coefficient of uniformity.

The use of spotters is recommended when the bog is not visible from the injection site or the pumping area. Spotters can help to quickly identify problems in the system (e.g. clogged heads, broken lines) as they occur or alert the applicator should anyone accidentally enter the area.

Aerial application

Make sure your property is properly posted prior to any aerial pesticide application.
Aerial applications of all pesticides within 500 feet of a sensitive area (e.g., residential, business, public way, school, park, playground, etc.) must be posted with the EPA Worker Protection sign. Post signs at conspicuous points no less than 200 feet away from one another and at every principal entrance fronting a public road.

Be sure that your property is clear of people and pets before starting the application.

Aerial application of pesticides on bogs adjacent to a public road must comply with certain regulations.
Aerial applications made within 150 feet of public way owned or maintained by a government entity must comply with 333 CMR 13.04. Please consult a current copy of these regulations for specific information.

Observe buffer zone recommendations.
Aerial applications of liquid materials must not take place within 150 feet of a protected area (e.g. roadway, school). A buffer zone of 50 feet is required for granular pesticides. (see 333 CMR 13.04)

Ground application (granular applicators, boom sprayers, mist blowers, hand-held sprayers, etc.)

Make sure application equipment is properly calibrated and operated.
Yearly calibration is advised to check for changes in output due to wear of equipment components. Since products may vary in particle size and/or density, calibrate the herbicide spreader every time a new material is used. Refer to Wisconsin reference and see example on page 6.

Limit non-target application when using boom or mist blowers.
Shut off boom and mist blowers when crossing waterways and ditches to minimize contamination in the bog system.

Do not operate these sprayers in windy conditions as small droplets are more prone to drift. Consider the use of drift reduction additives.

Inspect O-rings, seals, and nozzles on backpack and hand-held sprayers annually.
Since the backpack sprayer is in direct contact with your body during application, be certain that the sprayer is not leaking. Wear the appropriate PPE during application.

Use brass nozzles instead of plastic ones. Flat fan nozzles are recommended for general area spraying. Install a pressure gauge on all sprayers when possible.

Triple rinse the sprayer after application and rinse the hoses with clean water.

Calibrating granular herbicide spreaders.
If possible, use a device to collect herbicide from *each individual* output of the herbicide rig. You could use a sock or bag that attaches to the output. Be sure to weigh each device *prior* to calibrating the spreader. It is recommended to label each device to correspond to each output, so if there is a problem, you can easily tell which output is malfunctioning (see example below).

1. Run the spreader over a measured distance (e.g. 20-50 ft). Collect the output of herbicide from this measured area. If you are using a device for each output, weigh each device + herbicide. To determine the weight of the herbicide, subtract the weight of the device from this number.
If you are running the rig over a tarp, simply collect all of the material that falls onto the tarp and weigh it.
2. Calculate the area to which the herbicide was applied. Multiply the length of the swath you used in Step 1 by the width that the spreader covers. Calculate the acreage this represents by dividing this number by 43,560 (all measurements need to be in feet for this to be correct).
3. Next, multiply the rate in lb/A that you want to apply by the number you got (square feet/43,560) from Step 2. This is the amount in pounds that you should have collected in Step 1. If you determined the weights in a unit other than pounds, convert to pounds and then compare the numbers.
4. If you are off by an appreciable amount, total up the weights from the left and right sides separately (this can only be done if you used individual collection devices). Take half of the

swath area and determine the pounds delivered. If one side is off, look at the individual hose weights to determine which one(s) is off. Check for a clogged hose, etc.

If both sides are off, make an adjustment to the setting and repeat the process until you get the correct amount.

If you used the tarp method, you have no direct way to determine where the problem is when your numbers are off. Adjust the settings and repeat the process until you get the correct amount.

Example (all weights in grams to start).
Bag # Bag+herb bag herb Left side
- 1 88.3 52.0 36.3
- 2 87.5 51.3 36.2
- 3 83.9 50.2 33.7

4 87.2 51.5 35.7 Total weight for the left side = 141.9 g
Right side
- 5 86.0 52.6 33.4
- 6 80.4 52.8 27.6
- 7 82.0 53.8 28.2

8 79.0 50.7 28.3 Total weight for the right side = 117.5 g

Grand Total Weight = 258.7 g
Weight of herbicide collected in pounds = 258.7 x (1 lb/454g) = 0.57 lb.

Length of swath = 50 ft Herbicider width = 18 ft Area covered: 50 x 18 = 900 sq.ft Portion of an acre: 900/43,560 = 0.021 A

Desired rate of herbicide = 32 lb/A

Should have collected: 0.021A x 32 lb/A = 0.67 lb herbicide % difference: (0.67-0.57)/0.67 = 14.9%

The herbicider is putting out ~15% less than desired. Let's examine both sides to see if we can identify the source of the problem.

Half of the desired area rate: 0.67 lb/2 = 0.33 lb Left side: 141.9 g x (1 lb/454g) = 0.31 lb % difference: (0.33-0.31)/0.33 = -6.1%

Right side: 117.5 g x (1 lb/454g) = 0.26 lb % difference: (0.26-0.33)/0.33 = -21.2%
The right side seems to be the problem area. The weights of bags 6,7,and 8 appear to be low. Look for blockages in these hoses.

For more information:

Chemigation - key guidelines for best performance. Poster. Cape Cod Cranberry Growers Association (CCCGA) / Ocean Spray Cranberries, Inc.

Flashinski, R. and D. Wixted. 1993. **Pest management principles: chemigation**. Pesticide Applicator Training Bulletin, University of Wisconsin-Extension.

Kammel, D. W., R. T. Noyes, G. L. Riskowski, and V. L. Hofman. 1995. **Designing facilities for pesticide and fertilizer containment.** Bulletin. MidWest Plan Service, Agricultural and Biosystems Engineering Department, Iowa State University. MWPS-37, 120 p. (515) 294-4337.

Northeast United States Cranberry Pesticide Chart. Published annually by the Cranberry Institute, Wareham, MA.

On-farm agrichemical handling facilities. Bulletin. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. NRAES-78. (607) 255-7654.

Pesticides and groundwater: a guide for the pesticide user. 1995. Bulletin. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. NRAES-34. (607) 255-7654.

Sign posting. Bulletin issued annually by the CCCGA, Wareham, MA.

Worker Protection Standards information, Massachusetts Department of Food and Agriculture, Boston MA (617) 626-1700.

See **Chemigation BMP** in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

UMass Extension

Pesticide Applications Checklist

✓ IMPORTANT PHONE NUMBERS

Massachusetts Poison Control System. 1-800-682-9211 Chemtrec. 1-800-424-

Prior to the Application

✓ **Worker Protection:**

Have all appropriate Personal Protection Equipment (PPE) ready to use. Have labels and MSDS on-hand Have decontamination kit stocked and ready for use.

✓ **Appropriate notification:**

Neighbor relations. Sign-posting. WPS and REI notification.

✓ **Environmental concerns:**

Address any public drinking water recharge area restrictions. Check to see that the planks are in place. Check the weather forecast.

Transport the pesticide in a legal manner. Applicator must have the appropriate license for application. Verify that all equipment is working properly. Observe pre-harvest intervals. Have your Emergency Action Plan on-site.

✓ **After the Application Record keeping done? Containers rinsed and disposed of appropriately? Excess pesticides properly stored? Clothes properly washed after application?**

✓ **Equipment that may be helpful to have on hand:**

- 5-gallon bucket
- Knife
- Measuring cup
- Duct tape
- Injection port rinse device
- Stopwatch
- Mixing stick
- Portable communication devices (e.g., cellular phones)
- Bungee cords (to hold hose, etc.)
- Assorted tools (pliers, screwdriver, wrench, etc.)
- Clean water in jugs
- Pesticide clean-up kit (5 gallon is good)
- WPS decontamination kit

UMass Extension

Pesticide Mixing and Loading

Mixing and loading may be the most hazardous activities associated with normal pesticide use. Because of the concentrations and quantities of pesticides involved, accidental releases of pesticides at a mixing and loading site pose a high risk of ground and surface water contamination. Also, when you mix and load, you handle a pesticide in its most concentrated form and experience the greatest potential for exposure. To prevent pollution and safeguard human health, the mixing and loading of pesticide and the washing and rinsing of equipment should be conducted in a safe and environmentally responsible fashion.

WPS REGULATIONS REQUIRE:
All workers involved in any aspect of handling, mixing and/or loading pesticides must be trained as a HANDLER or have a pesticide license.

MA LAW REQUIRES THAT ALL PERSONS APPLYING PESTICIDES IN A COMMERCIAL CAPACITY MUST HAVE A VALID PESTICIDE LICENSE.

Several types of licenses are available:

Applicator License. If you intend to do pesticide work using general use (non-restricted) pesticide for hire, you must obtain an applicator license.

Private Certification. If you intend to do pesticide work using restricted use pesticides on property owned or rented by you or your employer for the purpose of raising agricultural commodities, you must obtain a private certification. This is the license usually obtained by individuals working as farmers.

Commercial Certification. If you intend to do pesticide work using restricted use pesticides for hire or not for hire (barter/volunteer) on someone else's property, you must obtain a commercial certification.

Recommended Practices

Protect water sources from contamination when mixing and loading pesticides and when rinsing equipment and pesticide containers.

Mixing and loading of pesticides should not occur within 400 feet of any private or public drinking water supply or within 200 feet of surface water (DFA recommendation).

No pesticide application equipment or mix tank should be filled directly from any source waters unless a back siphon prevention device is present.

A properly designed spill containment surface should be used for all mixing and loading activities.

Protect all resources from point pollution resulting from pesticide concentrates, mixtures, or wastes. Mix and load chemicals on a treated concrete pad or other impervious surface.

Avoid pesticide spills and prevent back-siphoning into wells or surface water impoundments.

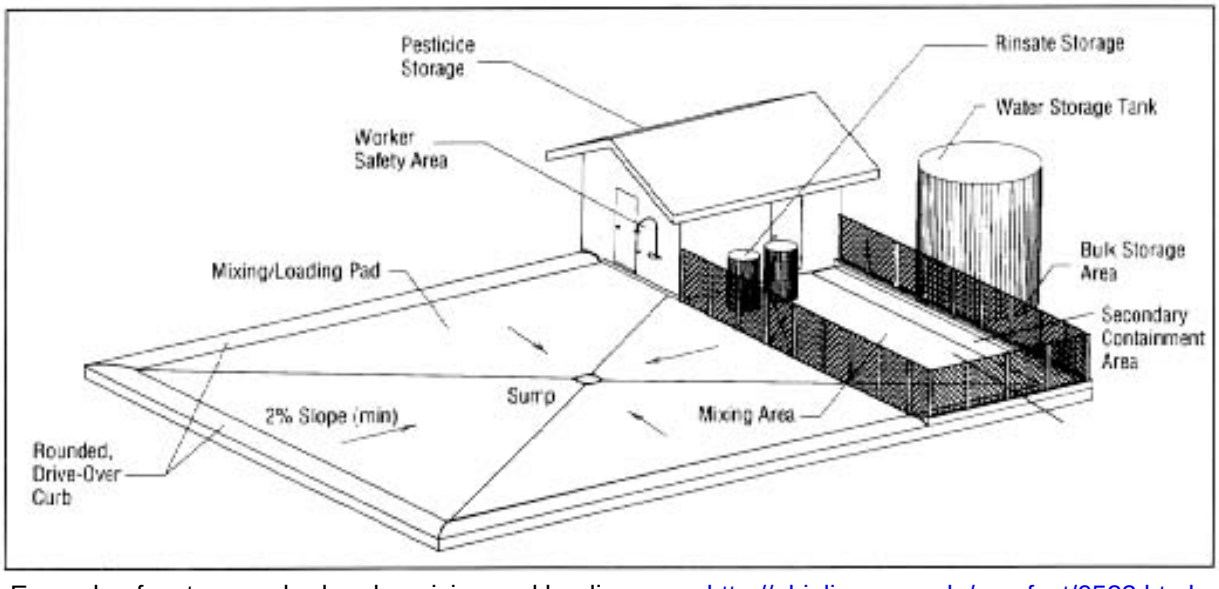
Be careful not to allow pesticides to leak from chemigation units when hoses are disconnected from injection ports.

Always exercise caution when adding water and pesticides.

Be extremely careful to avoid overflow when you add water to the equipment. Never leave the equipment unattended while it is being filled.

Open pesticide containers carefully. Use a knife (dedicated solely for pesticide use) to open paper products; never tear open. When you pour a liquid, keep the container below eye level to minimize exposure to your face. Use a pump to remove concentrate from a large container.

Close partially filled containers and return them immediately to storage. If you empty a container, rinse it with water and add the rinsate to the application tank.



Example of a storage shed and a mixing and loading area. http://ohioline.osu.edu/aex-fact/0522.html.

Personal Protection Equipment (PPE) is required for all workers involved in mixing and loading activities.

Respirators, chemically resistant (CR) gloves, CR footwear, coveralls with long sleeves, socks, protective eyewear (glasses, goggles, or faceshield), CR headgear, CR aprons, and a first-aid kit should be available immediately outside the storage area.

An eyewash station, capable of flushing the eyes for 15 minutes, should also be available. At minimum, a nozzle and a hose should be on hand.

Routine clean-up facilities, equipped with soap and water and single-use paper towels should also be available.

If no particular instructions exist, wear at least rubber gloves, a chemical-resistant apron, and protection eyewear. If mixing two or more chemicals, wear the PPE required for the most hazardous chemical involved. Wear PPE even if a product is packaged to reduce exposure (e.g., water-soluble packets, etc.).

Since pesticides are hazardous, it is best not to work alone.

If you splash or spill pesticides onto your clothes, stop work immediately and remove the contaminated clothing. Wash thoroughly with soap and water. Dispose of soiled clothes as pesticide waste. Know where the on-site emergency action plan is kept.

Develop an emergency response plan.

The plan should include:

- A list of the names and quantities of current pesticides used or kept in the storage area.
- A map with the location and directions to the work area.
- Names, addresses, and phone numbers of the owner and key employees.
- A plan of the facility should include pesticide locations, flammable materials, electrical service, water supply, fuel storage tanks, fire hydrants, storm drains and nearby wetlands, ponds, and streams. Put a copy of the emergency plan near the entrance to the facility and a second copy with your business records. Give copies to the local police and fire departments.
- Location of emergency equipment supplies such as breathing equipment and protective equipment.

If you employ non-English speaking persons, the emergency plan should also be available in their own language.

Choose an appropriately designed mixing/ loading pad.

The actual design of the pad will vary depending on the types of operations (e.g., number and types of pesticides used, etc.) that will be performed at the site. Many types of pads are available (e.g. portable rubber pads, tarps, or concrete pads). Choose the type that is most appropriate for your situation and needs.

Concrete Pad. The concrete pad should be constructed of an impervious material such as sealed concrete. Use a high quality cement (Recommended by DFA: 5-7% air entrainment; compressive strength of 4,000-4,500 psi; and a water-cement ratio of 0.40-0.45 for a stiff [1.5-3.0”] slump). The pad should stay intact during freezing conditions. Use a protective sealant (e.g., epoxies, urethanes, vinyls, polyureas, etc.) to help prevent the corrosive actions of pesticides and fertilizers on the concrete.

DFA recommends constructing walls and a roof to avoid the expense associated with the disposal of pesticide hazardous waste generated due to rainfall. A greenhouse frame covered with a durable plastic sheet can be a low-cost alternative to a roof.

Insure that the pad will properly contain any releases or discharges from mixing and loading activities.

The containment area should hold 125% of the volume of the largest container that will be filled. The pad should be curbed to contain spills, leaks or discharges and to prevent water from flowing onto or off the pad. The pad may be sloped (at least 2%) to a single liquid-tight sump (catch basin). Design the sump such that a pump can be easily placed in the basin or install a permanently mounted pump.

If mixing non-liquid pesticides, the containment surface may consist of a tarp made of non-absorbent materials of adequate thickness to withstand all foreseeable loading conditions.

Safety is of the utmost importance when mixing chemicals!

- Wear protective equipment.

- Work in pairs whenever possible (radio communication is a plus).
- Be sure pump is running before starting to mix.
- Mix in a well-ventilated area.
- Have good lighting available.
- Be on solid footing when mixing.
- When pouring, turn the jug on the side to minimize stuttered delivery.
- Pour pesticide down the interior side of the tank to minimize splashing.
- Do not submerge the water supply hose in the pesticide solution.
- Water supply hose must have check valve to prevent backflow (required by law!).
- Rinse jugs, measuring cups, and mixing stick into the tank so rinsate goes onto the bog.
- Wash your gloves BEFORE you take them off.

Dilution and mixing of chemicals may vary depending on the application method and the product formulations.

It is recommended to mix the ingredients in the following priority: 1) water 2) pesticide 3) adjuvants 4) rest of the water. However, if you are using a suspending agent, put it in the water and agitate for 15 minutes prior to adding anything else.

Mixing Order for Liquids. Add 25-35% of total water first, then add the pesticide. Add the rinse water from the containers. Add the rest of the water.
Mixing Order for Dry Formulations. Add 50% of the total water first, then add the pesticide. Mix in the rest of the water.

For aerial applications, the applicator is responsible for mixing and loading chemicals.

Do not inject liquid pesticides directly from the container into the irrigation system.

To insure uniform delivery of the pesticide to the irrigation system, maintain continuous agitation in the chemical tank. Agitation (i.e., stirring with a stick paddle) is particularly important for materials of low solubility, like chlorothalonil.

Triple-rinse all empty pesticide containers before disposal.

Federal law prohibits re-use of pesticide containers. Liquid containers should be triple rinsed or preferably, pressure rinsed. The rinsate should be added to the spray tank. The pesticide label and MSDS contain instructions for safe container disposal. Do not store empty containers in your pump house, even temporarily. Inquire if your pesticide supplier will recycle clean, empty containers. Additionally, any container used for any pesticide purpose must be labeled appropriately.

Significant portions of this BMP were excerpted from:

Kennedy, G. 1999. **Storage, mixing and loading of pesticide guidelines.** MA Dept. of Food and Agriculture Pesticide Bureau.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

UMass Extension

Pesticide Mixing and Loading Checklist

✓ IMPORTANT PHONE NUMBERS
Massachusetts Poison Control System. 1-800-682-9211 Chemtrec. 1-800-424-9300

Prior to the Application

✓ **Worker Protection:**
Have all appropriate Personal Protection Equipment (PPE) ready to use. Have labels and MSDS on-hand Have decontamination kit stocked and ready for use.

✓ **Appropriate notification:**
Neighbor relations. Sign-posting. WPS and REI notification.

✓ **Environmental concerns:**
Address any public drinking water recharge area restrictions. Check to see that the planks are in place. Check the weather forecast.

Transport the pesticide in a legal manner. Applicator must have the appropriate license for application. Verify that all equipment is working properly. Observe pre-harvest intervals. Have your Emergency Action Plan on-site.

✓ **After the Application Record keeping done? Containers rinsed and disposed of appropriately? Excess pesticides properly stored? Clothes properly washed after application?**

✓ **Equipment that may be helpful to have on hand:**

- 5-gallon bucket
- Knife
- Measuring cup
- Duct tape
- Injection port rinse device
- Stopwatch
- Mixing stick
- Portable communication devices (e.g., cellular phones)
- Bungee cords (to hold hose, etc.)
- Assorted tools (pliers, screwdriver, wrench, etc.)
- Clean water in jugs
- Pesticide clean-up kit (5-gallon is good)
- WPS decontamination kit

Pesticide Storage

Recommended Practices

Provide secure, safe storage for pesticide containers.

Pesticides should be stored in a secure storage building or area. The floor of the storage area should be made of treated concrete or other chemically impervious material. Protective coatings are available that help prevent the corrosive actions of pesticides and fertilizers on concrete.

Consider the risk of environmental contamination when locating and securing pesticide storage areas.

Post signs that clearly indicate that you store pesticides in the building. See references at the end of this BMP.

Do not store pesticides with food, feed, seed, fertilizers or personal protection equipment (PPE).

Designate a specific area within the storage facility for each group of pesticides (e.g., herbicides, fungicides, insecticides, and fumigants). Flammable products should be separated from nonflammable products. Access to the containers should be unimpeded. Keep bags and containers off the ground.

Containers should not be filled beyond 95% of their capacity to allow for thermal expansion.

Example of an agrichemical storage building

Two building options exist: Build a permanent structure or a portable hazardous material storage building.

Portable structures are commercially available and may be appropriate for the storage of small quantities (range from four to fifty 55 gallon drums). They should have self-closing doors that can be locked. These facilities can be moved and relocated with a fork lift.

Preparation for construction of a new building should include consultation with a licensed contractor familiar with state code building requirements. The facility should provide adequate within-building spill containment. The building should be accessible from all sides for emergency and fire fighting equipment. The distance the building should be ‘set back’ from other buildings depends on the thickness of the fire wall.

Choose an appropriate location and design.

Consider locating the building downwind and downhill from sensitive areas such as houses, play areas and livestock facilities (DFA recommends 2000 ft from sensitive areas). Preferably, the area should be located at least 400 feet down-gradient from any drinking water supplies and 200 feet down-gradient from surface water (DFA recommendations).

Choose a site that will not flood nor be likely to allow surface water to become contaminated if there is a fire or spill. The site should not lie within a Zone II delineation. If you have a multi-story building, locate the storage facility on the ground level. Pesticides should not be stored underground or in basements due to increase difficulty in monitoring leaks and other potential dangers to ground water.

Keep the area well-ventilated so that fumes do not accumulate. Fans that provide 3 to 6 air exchanges per hour are recommended. The lights and fans should operate off the same switch. The air inlet should be located within 12 inches of the floor to facilitate the escape of heavier vapors.

Install lights such that the building is well-lit, both inside and outside. A sealed cement floor and a drainage system that collects run-off will help protect the environment in case of a spill. Make all efforts to protect containers and labels from damage. Keep a shovel and absorbent material in the area to use in case of spills.

Containers may be placed on pallets or shelves to help prevent water damage or corrosion. Plastic or metal shelves are easier to clean than wooden shelves. It is recommended not to store dry products on shelves below liquids.

Do not store personal protective equipment within the pesticide storage facility.

For example, respirators can absorb pesticides during storage and may lose some of their effectiveness.

Mark each container with its date of purchase and date opened.

Use oldest products first. Whenever possible, do not buy more pesticide than you can use in any one season. This minimizes storage problems as well as expenses related to storage and disposal.

Store opened products in their original container.

Keep the labels intact and visible. Placing pesticides in soda bottles, jars, or other food containers is not recommended. Dry materials tend to cake when humid, so put opened or damaged bags in resealable plastic bags or containers.

Utilize safe methods for pesticide container disposal.

Pesticide residues leaking from used containers can cause significant pollution. Liquid containers should be triple rinsed or, preferably, pressure rinsed. The rinsate should be added to the spray tank. The pesticide label and MSDS contain instructions for safe container disposal.

Keep empty containers in a secured area until you are ready to dispose of them. Inquire to determine if a local distributor or company will recycle the containers. If needed, dispose of unusable materials through community programs.

Develop a plan to follow in case of pesticide emergencies.

Pesticide applicators should develop an emergency plan that lists actions to take and persons

to contact in case of a pesticide poisoning, spill, fire, or other accident.

Significant portions of this BMP were excerpted from:

Kennedy, G. 1999. **Storage, mixing and loading of pesticide guidelines.** MA Dept. of Food and Agriculture Pesticide Bureau.

Training manual for the private pesticide applicator, 4th ed., January 1998. Published by the University of Wisconsin-Extension, Pesticide Applicator Training Program, Madison, WI. (contact: Roger Flashinski).

For more information:

Conference Proceedings. 1992. **National symposium on pesticide and fertilizer containment-design and management.** MWPS-C1. MidWest Plan Service, Iowa State University, Ames, IA.

Dean, T.W. and R.A. Bucklin. 1996. **Permanently sited pesticide storage facilities in Florida.** Florida Cooperative Extension Service.

Kammel, D.W., R.T. Noyes, G.L. Riskowski, and V.L. Hoffman. 1995. **Designing facilities for pesticide and fertilizer containment.** Bulletin. MidWest Plan Service, Agricultural and Biosystems Engineering Department, Iowa State University. MWPS-37, 120 p. 515-294-4337.

Ross, D.S. and J.W. Bartok. 1995. **On-farm agrichemical handling facilities.** Bulletin. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. NRAES-78. 607-255-7654.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

UMass Extension

Pesticide Storage Checklist

IMPORTANT PHONE NUMBERS
Massachusetts Poison Control System. 1-800-682-9211 Chemtrec. 1-800-424-9300

Prior to the Application

✓ **Worker Protection:**
Have all appropriate Personal Protection Equipment (PPE) ready to use. Have labels and MSDS on-hand Have decontamination kit stocked and ready for use.

✓ **Appropriate notification:**
Neighbor relations. Sign-posting. WPS and REI notification.

✓ **Environmental concerns:**
Address any public drinking water recharge area restrictions. Check to see that the planks are in place. Check the weather forecast.

✓ **Transport the pesticide in a legal manner. Applicator must have the appropriate license for application. Verify that all equipment is working properly. Observe pre-harvest intervals. Have your Emergency Action Plan on-site.**

✓ **After the Application Record keeping done? Containers rinsed and disposed of appropriately? Excess pesticides properly stored? Clothes properly washed after application?**

✓ **Equipment that may be helpful to have on hand:**

- 5-gallon bucket
- Knife
- Measuring cup
- Duct tape
- Injection port rinse device
- Stopwatch
- Mixing stick
- Portable communication devices (e.g., cellular phones)
- Bungee cords (to hold hose, etc.)
- Assorted tools (pliers, screwdriver, wrench, etc.)
- Clean water in jugs
- Pesticide clean-up kit (5 gallon is good)
- WPS decontamination kit

Preventing and Responding to a Fuel or Oil Spill

The best way to reduce the possibility of a fuel or oil spill is to take preventative steps to minimize the chance that a spill will occur. Preventative steps include: (1) use of food grade oil; (2) proper storage and handling of fuel and oils and; (3) regular maintenance and inspection of equipment. In spite of taking these steps to minimize spills, accidents do occur.

Even though most spills tend to happen during harvest, you should be prepared to handle a fuel or oil spill at any time during the year. Should an accidental spill occur, be prepared to respond quickly. Clean-up preparedness requires: (1) prior training in clean-up procedures; (2) immediate availability of clean-up (spill kit) materials and; (3) prompt notification to the handler. Following the recommended practices will insure food safety and reduced environmental risk.

Despite the fact that the FDA tolerance, the legal allowable amount of food grade lubricant residue that can occur on cranberries, is 10 ppm, the goal of every grower should be to deliver fruit with no food-grade oil residue.

Remember that there is no tolerance for non-food grade oil or fuel on cranberries.

Recommended Practices

Equipment Maintenance and Preventative Measures

Employ preventative measures and maintain equipment.

Always use food-grade lubricants (except crankcase oil) approved by the U. S. Food and Drug Administration and designated as H-1 in all equipment**.** Food grade oil has an FDA tolerance of 10 ppm. *Non-food grade oil has zero tolerance.*

Machinery subjected to high use should have annual replacement of hoses, fittings, seals, and hydraulic lines. Machinery subjected to low annual use should have components changed every 3 years. Pay particular attention to proper installation of seals, fittings, etc. Consult an equipment/parts supplier to determine the appropriate maintenance schedule for your equipment use.

Routinely inspect all fuel, oil, or fluid-containing fittings, hoses and seals during machinery operation to detect leaks. Inspect harvesting equipment as well as other machinery such as dike mowers and hydraulically or PTO-activated machinery operated on or near open water.

Inspect all fruit delivery trucks for fuel, oil, and fluid leaks before they enter the bog or harvest area. Chock or block the wheels of harvest elevators, harvest pump trucks, and other equipment operated near the bog to prevent them from rolling into water.

Consider using a portable containment pad or constructing a temporary earthen dike around portable equipment that hold large volumes of diesel fuel, gasoline, or oil near open water. If an engine or pump tips over or leaks, the fuel or oil is retained inside the containment area and clean up is easier.

Place reusable containment booms in the water between harvesting equipment and the corralled fruit. Each boom should extend from the entrance of the elevator conveyor to the

dike. In the event of a fluid leak, the contaminated water will be isolated from the corralled fruit.

Install ballcock-type shutoffs on hoses connecting the hydraulic fluid tank and pump. In the event of a hose rupture, deployment of the shutoffs will stop flow of fluid to the pump, significantly reducing the amount of fluid leakage.

Use of double-walled hydraulic fluid tanks will lessen the likelihood of leaks due to tank rupture.
Locate fuel and oil containing equipment such as auxiliary pumps and conveyor engines as far from open water as possible. Do not operate auxiliary pumps or engines on the edge of dikes. Keep them a safe distance away from open water to avoid an oil or fuel spill or leak into the water.

Small engines and pumps should be retro-fitted with a catch pan or basin to collect fuel or oil in the event of a leak or spill. The basin should be sized to contain at least 110% of the fluid storage capacity.

Consider converting gasoline powered engines on bog buggies, reeling machines and other equipment to propane fuel.

Spill Clean up Materials and Supplies

A supply of fuel/oil clean-up materials should be readily available <u>at all times</u>.
A well-stocked kit contains: 1) BOOMS to contain or corral the spill; 2) ABSORBENT MATERIALS to clean up the fuel or oil; 3) a CONTAINER to store soiled materials prior to disposal; 4) ADDITIONAL SUPPLIES to aid in the clean-up process and; 5) an ACTION PLAN. Please refer to list of suppliers.

Booms. The booms you purchase should be long enough to completely surround a leaking piece of equipment and contain the fuel or oil leak. Dispose of **contaminated absorbent booms** after use and purchase a new clean absorbent boom for your spill kit. **Reusable containment booms** must be thoroughly washed with soap and hot water before reuse.

Harvest booms can be used to contain a spill until proper spill supplies can be obtained. If the spill is food grade oil, the harvest booms should be removed away from the bog and cleaned with soap and water. If the spill is non-food grade oil, discard the booms.

Absorbent materials. Have a sufficient quantity of absorbent materials on hand to absorb the entire fuel or oil volume contained in the fuel tank or oil lines. The absorbent material must come in direct contact with the oil or fuel, so placement of the absorbent material is critical. Hydrophobic absorbent materials are best for fuel or oil spills because they absorb only fuel or oil, not water.

A well-stocked spill kit should have several forms of absorbent material: pillows, pads, loose pulp, and granular material. Loose granular or particulate absorbents work faster than pillows or pads. Select absorbents that float indefinitely. Purchase materials that will absorb food-grade oil. Promptly remove soiled clean-up materials regardless of buoyancy characteristics.

Containers. Spill kit containers can be rigid plastic barrels or buckets or soft duffel bags. The container serves both for storage of clean materials and for disposal of soiled materials. If you use the duffel bag, include a supply of plastic bags for disposal of soiled materials. Regardless

of the type of container you choose, make sure the spill kit container is properly marked. Complete kits can be purchased from local cranberry equipment suppliers or you can assemble your own kit. Refer to CCCGA Suppliers list.

Additional supplies. If you use loose pulp or granular absorbent materials, a skimmer to remove the soiled materials from the water should be a component of your spill kit. Disposable rubber gloves will prevent additional contamination. Wear safety eye glasses during containment and spill clean-up. Consider also: a supply of wood dowels with varying sized tapers (to be used as plugs in ruptured hoses), a small mallet, duct tape to wrap hoses, and a 150 ft. coil of rope for securing and moving booms.

Action Plan. Develop a written action plan of what you will do in the event of a spill. Review your plan with your family and employees and add copies of the plan to each of your spill kits. Train all employees in proper emergency response to contain and clean up an oil or fuel spill.

Spill Clean-up Preparedness

For large land- or water-based spills, especially fuel spills, you may want to contract with a private company that specializes in quick response environmental remediation.

Keep their telephone number handy in the event that a spill occurs. See list of emergency response teams located in CCCGA handout.

Spills on land. Keep an supply of dry absorbent materials such as Speedi-Dry or cat litter available at all times. Do not use for spills on water. Absorbent fabric pads or pillows can also be used to clean up land-based spills.

For extensive land-based spills, immediate excavation and disposal of the contaminated soil is the most prudent approach. Delays in clean up may result in more extensive and costly excavation and ground or surface water remediation at a later date.

Spills in water. Notify the appropriate state and federal authorities in the event of a spill (see phone numbers at end).

Keep a fuel/oil spill kit for water-based spills easily accessible at all times, especially at harvest.

Post the location(s) of your spill kit(s) on your WPS Bulletin Board. Examine the kit at least annually, but especially prior to harvest to make sure it contains the full complement of materials and that the materials are in good usable condition.

When a spill occurs during harvest, stop operations immediately to minimize the contamination and begin the containment and clean up procedures. Notify your handler immediately.

Segregate and isolate contaminated fruit from unaffected fruit. Do not mix these fruit to minimize the overall oil residue. A small amount of oil may render the entire load unusable.

Do not add liquid or powdered soaps or detergents to an oil or fuel spill. These cause the oil or fuel to disperse and/or sink, making containment and clean up more difficult.

Store a supply of absorbent materials on each beating or reeling machine and on harvest

elevators and large pumps. This will reduce response time in the event of a leak.

Thoroughly clean equipment, machinery or vehicles that contact the oil or fuel with hot water and soap. Move all equipment away from the bog and open water and thoroughly wash with soap and hot water.

If a spill occurs, do not use or transfer the contaminated water to another bog. Once clean up is complete, the water may be released to a stream, river, or reservoir. Place an absorbent boom and clean blankets or pillows near the outlet to the flume. Slowly release water by lifting flume boards from the bottom of the flume.

Dispose of soiled materials as soon as possible in compliance with local, state and federal laws.

For more information:

List of suppliers and emergency response teams from CCCGA.

Proper storage, handling, and spill clean-up of fuels and oils. Ocean Spray Cranberries, Inc., Environmental Bulletin Series.

Federal National Response Center 1-800-424-8802.

State of Massachusetts Department of Environmental Protection 1-508-946-2850 or 617-292-5500 (after 4:30 PM).

Prepared by Carolyn DeMoranville, Hilary Sandler, and Tom Bicki, 1996.

Preventing and Responding to a Fuel or Oil Spill Checklist

✓ Employ preventative measures and maintain equipment.

✓ Have a supply of fuel/oil clean-up materials readily available at all times.

RENOVATION AND CONSTRUCTION BMPs

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.

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

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 ***BUT this method is not recommended*.** 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:

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

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.

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 More 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 recovery 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 more 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 more 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 more information:

Cranberry chart book - Management guide for Massachusetts. University of Massachusetts Cranberry Station http://scholarworks.umass.edu/cranchart/.

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.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000. .

Mineral Soil Bog Construction Checklist

- ✓ When constructing a bog in mineral soils, water table modifications are required.
- ✓ Site selection and evaluation prior to the start of a project is very important.
- ✓ A site should have access to ample supplies of fresh water.
- ✓ Consult an engineer to assist in planning and preparation activities.

Renovating Producing Cranberry Acreage

Over the course of time, conditions may arise on the bog (e.g., weed infestations, invasion by nonproductive mongrel vines, etc.) that may become severe enough to necessitate renovation of the bog. Renovation is a costly procedure in both time and money. Thoroughly consider the implementation of all other available remedial activities before initiating renovation of the bog. If positive outcomes are not obtained within a reasonable time frame, then consider renovation.

Recommended Practices

Take the opportunity to improve water management when renovating a bog.

If the entire system is to be upgraded, consider modifying irrigation pipe lateral spacing to 40' x 50'. Closer lateral spacing requires more sprinkler heads per acre, but water use efficiency improves since less water may be needed to achieve proper uniformity. Research has shown that high uniformity nozzles and 18" risers on existing systems with wider spacing can improve irrigation uniformity. For best performance, risers should extend above the vines and should be secured (staked) to a 90° angle to the bog. System modifications may affect wetted diameter. For example, use of riser heights of less than 30" will significantly reduce wetted diameter from that reported in irrigation manufacturers' design manuals.

Make modifications that minimize rinse time as many existing and new pest control products work most effectively when applied with short rinse times. Installation of multiple satellite injection ports will facilitate effective pesticide application. Refer to the Chemigation BMP for more details.

If the bog is severely out of grade, consider subdividing the bog by adding interior dikes. This practice will make the individual sections more uniform (less out of grade) and flooding depth can be reduced. Utilize available technologies, such as ground penetrating radar (GPR), to properly site ditches in stable areas on the farm.

It is recommended to consult with an irrigation specialist to determine the most appropriate design (spacing) for your system. Consider consulting with the USDA Natural Resources Conservation Service (NRCS) for dike suitability assessments if needed.

Conserve and re-use organic material removed from the bog during renovation.

Organic debris, including material scalped from the bog surface during renovation, can be screened and re-used as organic liners on new bogs. Depending on the organic matter content of the debris, this material may need to be supplemented with additional organic matter. Before re-using organic material, decide if any weed, disease, or insect concerns associated with that organic material outweighs its utility as lining material.

If you are stockpiling sand or organic material, refer to the Erosion and Sediment BMP for information on managing these resources.

When spot-renovating or filling in bare spots, choose your plant material carefully.

Cuttings require significant amounts of water during establishment. If you plant cuttings in a bare spot surrounded by established vines, you may have to over water the established plants to insure survival of the cuttings. If this is the case, consider planting rooted cuttings instead. If the area to be planted is along a ditch edge, it may be possible to protect cuttings by raising the water level in the ditch. You may be able to install shut-off valves between old and new plantings. It may also be possible to water ditch-edge cuttings with a portable pump and

temporary sprinklers drawing water from the ditch.

Horticultural Recommendations

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

The root zone should consist of about 6 inches of coarse sand (approximately 70% of the sand should fall within 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.

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.

Obtain vines from a known reputable source.

It is highly recommended to visit the bog from which the vines will be pruned. However, if that is not possible, buy from a reputable grower or handler. If able to make a site visit, assess the uniformity of the cultivar and the relevant histories of infestations of diseases, insects, and weeds. Obtain production records whenever possible. Find out the date that the vines were cut and how they have been stored. All of these factors will affect how well the vines will establish on your bog.

If you are unable to make a site visit, be sure to ask questions about production and fertilizer histories and request records from the seller. Inquire about any particular pest management problems associated with the source bog.

If using your own vines, cut the vines as close to the date of planting as possible. Growers report better rooting from vines that have been recently cut. Keep in mind that you will lose two years' worth of berries when mowing to harvest vines.

Some cultivar identities can be verified by DNA fingerprinting. The Blueberry and Cranberry Research Center, Rutgers University (609-7261590), provides this service for a fee.

If vines cannot be planted immediately, store them appropriately.

If the volume of vines is small, they can be stored in the water in the ditches. Larger volumes of vines can be stored in reservoirs or holding ponds. They may be stored this way for 5-6 weeks, providing they are rotated periodically to aerate the vines.

Vines can also be transported in tight bales. Upon arrival, the bales should be loosened and kept moist, and periodically turned.

Check vines for viability prior to planting.

This is especially important if the vines have been stored for a while. Snap several uprights and runners to verify that the tissues are still alive. If the vines are in a pile, it is not unusual for exposed vines to be less viable (dried out). When testing for viability, collect vines from the interior portion of the pile.

Consider planting varieties that show resistance to fruit rot.

Several varieties that have shown good field rot resistance in experimental plots include: Black Veil, Foxboro Howes, Howes, Matthews, Shaw's Success, Stevens, and Wilcox.

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.

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 prior to planting to kill weed seeds and roots. ***These materials should be used with caution***, see the Weed Management BMP for more 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 two years as they may retard stand establishment.

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. Soil should be moist, but not saturated. Manage irrigation schedules such that puddles are minimized. Using shut-off valves on risers where puddling occurs may also be helpful. After the plants are rooted, less frequent but longer irrigation periods (up to four hours) are preferred to encourage deeper rooting.

Frequently check soil moisture to make sure the vines do not lack for water (refer to Irrigation BMP). This is particularly crucial is the weather is warm and sunny right after planting.

Pest management activities should be conducted on a new planting.

Scout bogs for signs of incoming insect, disease and weed infestations. As vines start to fill in, you can use a sweep net to monitor insect populations as on an established planting. Removing weeds before or as they become established (making room for the vines to fill in) will minimize many future weed problems.

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. Sanding on ice is currently the industry standard, however, new methods are constantly being developed. Sand may be applied by hand when small areas need an application. Refer to the Sanding BMP.

Exercise caution when using machinery on new plantings to apply sand. Ensure that the bed is stable and able to handle the machinery. Improper use of machines may cause rutting and other damage in a new planting.

Protect new vines from cold injury in their first spring.

When vines are planted in early spring (April-May), protect new vines for a frost tolerance of 29.5°F. New growing tips can be easily injured during periods of cold temperatures and establishment will be inhibited.

In the second year, consider protecting only when temperature drops below 15°F. Mild frost events injure floral initials permitting more resources to go into vegetative growth. This practice will minimize the second year's crop.

Stabilize ditches until plants have vined in.

It is important to minimize erosion on new plantings. Many types of materials (e.g., wooden cribs, curlex blankets) are available to serve this purpose. Refer to the Erosion BMP.

Some growers have reported that flooding a newly planted bog prior to or during torrential downpours disperses the energy of the water and helps to prevent large-scale washouts.

For more information:

Bog construction and renovation manual. 1998. UMass Ext. Publ., UMass Cranberry Station, E. Wareham, MA.

Cranberry chart book - Management guide for Massachusetts. UMass Cranberry Station. http://scholarworks.umass.edu/cranchart/.

Dike standard. 1980. Natural Resources Conservation Service Practice Standard #356. NRCS-NHCP. 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.

Rutgers University Blueberry and Cranberry Research and Extension Center. 125 Lake Oswego Road, Chatsworth, NJ 08019. (609) 7261590.

Water Management Act. Information sheet. CCCGA.

Weed Management and **Water Management** BMPs in this series.

Prepared by Carolyn DeMoranville and Hilary Sandler, 2000.

Renovating Producing Cranberry Acreage Checklist

- ✓ Improve water management when renovating a bog.
- ✓ Obtain vines from a known reputable source.
- ✓ Conduct all necessary pest management activities on a new planting.
- ✓ Stabilize ditches until plants vine-in.

COMMUNITY BMPs

Neighbor to Neighbor Relations

U. S. Census data indicate that people are leaving the urban population centers for suburban and rural areas. People may move to rural areas with an expectation that their new home will be located in a quiet, peaceful, rustic, and isolated setting. The consequence of this population migration is that more and more people, with little or no understanding of cranberry production, are moving into homes in close proximity to cranberry bogs. Late evening or early morning bog inspections and frost protecting, as well as helicopter activity, can be quite disconcerting to your neighbors. The management practices outlined below can be helpful for developing and maintaining congenial neighbor-to-neighbor relations.

Recommended Practices

Communication is the key to good neighbor relations.

Know your neighbors. Effective communication with abutting property owners, whether sympathetic or adverse to cranberry production, is the most effective way to prevent and resolve problems. Talk to your neighbors about all aspects of cranberry production. In most instances, an informed neighbor will be a better neighbor. Maintain limited communication with adversarial neighbors in an effort to anticipate and resolve problems as they arise.

Invite neighbors over to observe the harvest or other production activities. Make a special effort to talk to neighborhood children about paying attention to signs and postings.

Send neighbors a copy of the pamphlet, 'Neighbor to Neighbor-An Information Guide. What to expect when living near a cranberry bog', published by the CCCGA (http://www.cranberries.org/cranberries/neighbor2neighbor.html). The guide provides an easy-to-understand description of the various management practices that take place during each season of the year.

Keep in mind that neighbors who are allowed limited access to your property are less likely to cause vandalism and be antagonistic. Neighbors are often great allies and also take pride in helping to monitor the cranberry bog for suspicious activities.

Pesticide applications are typically the greatest concern for neighbors around a cranberry bog. Educate your neighbors about why, when, and how you use pesticides.

Explain that all pesticides must be tested and registered for use with the Environmental Protection Agency and the Commonwealth of Massachusetts and that certified and licensed applicators must complete yearly training requirements to maintain their license or certification.

Describe the philosophies and practices associated with integrated pest management (IPM) to your neighbors. Many people are unaware of what IPM is, but are very receptive to the idea once they understand the basic principles.

Explain that most pesticide applications take place at times of low wind, typically in the early

morning or late evening hours. These off-time applications are not an attempt to ‘sneak in’ a pesticide application.

Be selective in the pesticides you use. When choosing a pesticide, evaluate and consider both human and environmental risks.

If you apply through the irrigation system, use high efficiency nozzles, screens, and half-heads when appropriate in sensitive areas. If applications are made by helicopter, work with pilots to insure drift is minimized and that applications reach the target areas. Refer to the Pesticide Application BMP for more details.

Explain the importance of adhering to pesticide notices and sign postings. Be sure your neighbors understand what the pesticide signs mean. Inform them about the mandated restricted entry intervals.

Allowing neighbors the use of your private property as ‘open green space’ for fishing, hunting, walking, and other leisure activities can be both an asset and a liability. Educate your neighbors about the proper procedures to follow prior, during, and after pesticide applications and about the importance of restricted entry times. Explain to your neighbors what the various signs mean.

Drive the entire perimeter of your bog before any pesticide application to insure that the area is free of people and pets.

Inform your neighbors about upcoming pesticide applications.

If you plan to apply an early morning pesticide application, consider notifying your neighbors the evening before.

Consider using a telephone tree information system to notify neighbors about upcoming pesticide applications. The information tree works by notifying a few designated neighbors who then each call two neighbors who in turn call two neighbors until all interested parties have been notified.

You may want to consider employing local phone services which offer automated options of providing your recorded message to your neighbors.

Be sensitive to the concerns and well-being of your neighbors.

Some chemicals or their carriers have strong odors which some people may find offensive. Application of a strong-smelling pesticide when the humidity is high and the air is very still may increase the chances of neighbor complaints. A very light wind, 1-2 mph, can be effective in quickly dissipating the pesticide and reducing concerns from neighbors about pesticide odors.

Advise neighbors to turn off their air conditioning systems to reduce the likelihood that odors will be drawn into their homes.

Anticipate your neighbors’ reactions when you undertake an activity that abuts their properties.

Consider night-time delivery of bee hives. Place them as far away from abutters’ houses and pathways when possible.

Operate machinery or application equipment to minimize noise and dust.

Maintain adequate mufflers on the exhausts of machinery and pumps. Where possible,

minimize exhaust noise by directing the exhaust away from residential housing.

Whenever possible, minimize movement of large trucks and harvest vehicles in early morning or late evening hours. If a work area is particularly dusty, consider wetting down the area prior to truck or equipment activity to minimize drift of dust.

If you use aerial applications, advise pilots to use the least sensitive routes when entering and leaving the property.

Keep your bogs and adjoining property clean and free of debris.

A clean and well managed cranberry operation demonstrates pride of ownership and portrays a high level of professionalism to outsiders, whether it be residential neighbors or regulatory agency personnel. If you must maintain a stockpile of pipe, culverts, and equipment parts, try to keep the materials orderly and out of the view of your neighbors.

If your bogs are situated in a remote area, make sure access roads are secured with a locked gate to minimize illegal dumping of refuse.

Properly post your property as required.

Post your property with the appropriate sign(s) prior to a pesticide application. Be sure to remove sign postings within the legal time limit.

Sign posting requirements change periodically. Consult the Cape Cod Cranberry Growers' Association (http://www.cranberries.org/growers/advisories.html) for current requirements.

Notify your neighbors of aerial fertilizer applications. Even though posting is not mandated, consider posting an 'aerial fertilizer application' sign.

Be cautious, but courteous, to adversarial neighbors.

Some neighbors can become very distressed when it comes to pesticide use. It may be best to avoid confrontations when emotions, rather than reason, take over. Always be courteous and keep your distance. If the problem becomes unmanageable, contact the Cape Cod Cranberry Growers' Association for resolution suggestions.

If a neighbor decides to sell their home that is near your cranberry bog, it has become a common habit for the potential new homeowners to actually contact the bog owner. Typically the interested homeowners want to meet the cranberry bog owner, ask general questions about farming practices. Most often, this type of communication prevents future issues.

For more information:

Neighbor to Neighbor-An Information Guide. What to expect when living near a cranberry bog. (http://www.cranberries.org/cranberries/neighbor2neighbor.html).

Sign posting. Cape Cod Cranberry Growers' Association, http://www.cranberries.org/growers/advisories.html

Updated by Hilary Sandler, Dawn Gates, and CCCGA Environmental Committee. 2010.

Neighbor-to-Neighbor Relations Checklist

✓ Maintain good communications with your neighbors.

✓ Explain what your common farming practices are and be sensitive to the concerns of your neighbors.

✓ Properly post your property as required.

RESOURCES

Massachusetts Department of Agricultural Resources (MDAR), http://www.Mass.gov/agr.
251 Causeway Street, Suite 500
Boston, MA 02114-2151
Phone: (617) 626-1700
Fax: (617) 626-1850

Massachusetts Farm Bureau Federation Inc., http://www.mfbf.net/
466 Chestnut Street.
Ashland, MA 01721
Phone: (508) 881-4766
Fax: (508) 881-4768

UMass Cranberry Research and Extension Team, http://www.umass.edu/cranberry
Insects:
Anne Averill, ext 20, aaverill@psis.umass.edu
Diseases:
Frank Caruso, ext 18, fcaruso@umext.umass.edu
IPM/Weeds:
Hilary Sandler, ext. 21, hsandler@umext.umass.edu
Nutrition:
Carolyn DeMoranville, ext 25, carolynd@umext.umass.edu
Physiology:
Peter Jeranyama, ext 29, peterj@umext.umass.edu

USDA-Natural Resource Conservation Service (NRCS) http://www.ma.nrcs.usda.gov.
451 West Street, Amherst, MA 01002
Phone: (413) 253-4350

Worker Protections Standards http://www.epa.gov/oecaagct/htc.html.

Massachusetts Department of Environmental Protection (Mass DEP)
1 Winter Street, Boston, MA 02108
Phone: (617) 292-5500
Fax: (617)556-1049
http://www.mass.gov/dep

Massachusetts Division of Fisheries and Wildlife http://www.mass.gov/masswildlife.
251 Causeway St., Suite 400, Boston, MA 02114
Phone: (617) 626-1590

Massachusetts Department of Agriculture Energy Program
http://www.mass.gov/agr/programs/energy/index.htm

University of Massachusetts Soil & Tissue Testing Laboratory
West Experiment Station, 682 North Pleasant St. UMass, Amherst, MA 01003
Phone: (413) 545-2311. http://www.umass.edu/plsoils/soiltest/

Cape Cod Cranberry Growers' Association
http://www.cranberries.org

Crop Data Management Systems, Inc. http://www.cdms.net.
Pesticide labels and MSDS.