

2024

2024-2026 Chart Book

Hilary A. Sandler

University of Massachusetts - Amherst, hsandler@umass.edu

Anne Averill

University of Massachusetts - Amherst, aaverill@ent.umass.edu

Martha Sylvia

UMass Cranberry Station, martys@umass.edu

Katherine Ghantous

UMass Amherst, kghantou@umass.edu

Peter Jeranyama

UMass Cranberry Station, peterj@umass.edu

See next page for additional authors

Follow this and additional works at: <https://scholarworks.umass.edu/cranchart>



Part of the [Agriculture Commons](#)

Sandler, Hilary A.; Averill, Anne; Sylvia, Martha; Ghantous, Katherine; Jeranyama, Peter; Uppala, Sai Sree; and Mupambi, Giverson, "2024-2026 Chart Book" (2024). *Cranberry Chart Book - Management Guide*. 276. Retrieved from <https://scholarworks.umass.edu/cranchart/276>

This Teaching is brought to you for free and open access by the Cranberry Station Outreach and Public Service Activities at ScholarWorks@UMass Amherst. It has been accepted for inclusion in Cranberry Chart Book - Management Guide by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.

Authors

Hilary A. Sandler, Anne Averill, Martha Sylvia, Katherine Ghantous, Peter Jeranyama, Sai Sree Uppala, and Giverson Mupambi

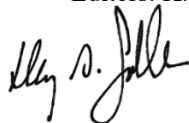
CRANBERRY CHART BOOK 2024 - 2026
MANAGEMENT GUIDE FOR MASSACHUSETTS

University of Massachusetts Amherst, Cranberry Station
1 State Bog Rd, East Wareham, MA 02538
(508) 295-2212

<http://www.ag.umass.edu/cranberry>

CAUTIONS.....	2
RESISTANCE MANAGEMENT.....	9
Martha M. Sylvia and Katherine M. Ghantous	
DISEASE MANAGEMENT.....	13
Leela S. Uppala and Martha M. Sylvia	
INSECT MANAGEMENT.....	26
Anne L. Averill and Martha M. Sylvia	
WEED MANAGEMENT.....	45
Hilary A. Sandler and Katherine M. Ghantous	
NUTRITION MANAGEMENT.....	76
Carolyn J. DeMoranville, K.M. Ghantous, and P. Jeranyama	
FRUIT QUALITY MANAGEMENT.....	91
Giverson Mupambi	
IRRIGATION WATER MANAGEMENT.....	93
Peter Jeranyama	
LATE WATER.....	97
Leela S. Uppala, H.A. Sandler, and A.L. Averill	
WINTER MANAGEMENT.....	101
Peter Jeranyama and Carolyn J. DeMoranville	
GROUNDWATER PROTECTION REGULATIONS AND ZONE II.....	104
Martha M. Sylvia	
USING ADJUVANTS WITH CRANBERRY PESTICIDES.....	107
Martha M. Sylvia and Katherine M. Ghantous	
MEASURES AND CONVERSIONS.....	109
Hilary A. Sandler	
PESTICIDE STORAGE.....	110
Hilary A. Sandler	

Editors: K.M. Ghantous, M.M. Sylvia, and D. Gauvin



Hilary Sandler, Director
UMass Extension Mailing Signoff

Revised March 2024

NOTICE: The Cranberry Station and its staff do not assume any responsibility for personal injury or property damage. All pesticides mentioned in this publication are registered and cleared for the suggested uses according to general registrations and state laws in effect on the date of this publication. The label is the law. Pesticides other than those listed have been registered for use on cranberry but are, for one reason or another, not currently recommended. When trade names are used for identification, no product endorsement is implied, nor is discrimination intended against similar materials.

A product of the Cranberry Station, College of Natural Sciences, University of Massachusetts Amherst, and UMass Extension. This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, and Massachusetts Agricultural Experiment Station. The University of Massachusetts is an Affirmative Action/Equal Opportunity Institution.

2 CAUTIONS

CAUTIONS

Fungicide Products	Max per acre per year	Preharvest interval (PHI)	Restricted entry interval (REI)	Max # apps	Min. App. Interval (days)
CHLOROTHALONILS (**RESTRICTED USE)					
Bravo Ultrex	18 lb	50 days	12 hrs		
Bravo Weather Stik	20 pt	50 days	12 hrs		
Chlorothalonil 720, Echo 720	20 pt	50 days	12 hrs		
Chlorothalonil Zn	28.3 pt	50 days	12 hrs	All 3	All 10
Equus 720 SST, Initiate 720	20 pt	50 days	12 hrs		
Echo 90DF	17.25 lb	50 days	12 hrs		
Initiate ZN, Echo Zn	29 pt	50 days	12 hrs		
COPPERS (copper hydroxide, copper oxychloride, copper sulfate)					
Badge X2	45 lb	No PHI	48 hrs	3	7
Badge SC	44.4 pt	No PHI	48 hrs	3	7
Champ Dry Prill	33.6 lb	No PHI	48 hrs	5	7
Champ Formula 2 Flowable	34.7 pt	No PHI	48 hrs	5	10
Cuprofix Ultra 40 Disperss	15 lb	No PHI	48 hrs	3	7
Kocide 2000	36 lb	No PHI	48 hrs	5	7
Kocide 3000	42 lb	No PHI	48 hrs	5	7
Mastercop	9 pt	No PHI	48 hrs	3	10
Nu-Cop HB, Nu-Cop 50 DF	12.6 lb	No PHI	48 hrs	3	7
EBDC's (Mancozeb + Ferbam)					
Dithane F-45 Rainshield	14.4 qt	30 days	24 hrs		
Dithane M-45, Koverall	18 lb	30 days	24 hrs		
ManKocide	21 lb	30 days	48 hrs		
Manzate Max	14.4 qt	30 days	24 hrs	All 3	All 7
Manzate Pro-Stick	18 lb	30 days	24 hrs		
Penncozeb 75DF or 80WP	18 lb	30 days	24 hrs		
Roper DF Rainshield	18 lb	30 days	24 hrs		
Ferbam Granuflo (ferbam)	30 lb	50 days	24 hrs	5	14
OTHER PRODUCTS (FRAC Groups 3, 11, and 19)					
Abound, AFrame, Satori (azoxystrobin)	92.3 fl oz	3 days	4 hrs	6	7
Aftershock, Evito (fluoxastrobin)	22.8 fl oz	1 day	12 hrs	4	14
Indar 2F (fenbuconazole)	48 fl oz	30 days	12 hrs	4	10
Oso (polyoxin D zinc salt)	78 fl oz	No PHI	4 hrs	6	7
Ph-D (polyoxin D zinc salt)	18.6 oz	No PHI	4 hrs	3	7
Proline (prothioconazole)	10 fl oz	45 days	12 hrs	2	7
QuadrisTop (difenoconazole/azoxystrobin)	42 fl oz	30 days	12 hrs	3	7
PHENYLAMIDES FUNGICIDES					
Metastar 2EC, Xyler (metalaxyl)	21 pt	45 days	48 hrs	3	
Ridomil Gold GR (mefenoxam)	105 lb	45 days	48 hrs	3	90
Ridomil Gold SL (mefenoxam)	5.25 pt	45 days	48 hrs	3	90
Ultra Flourish (mefenoxam)	10.5 pt	45 days	48 hrs	3	

Fungicide Products (cont.)	Max per acre per year	Preharvest interval (PHI)	Restricted entry interval (REI)	Max # apps	Min. App. Interval (days)
PHOSPHONATES FUNGICIDES					
Aliette WDG (fosetyl-al)	20 lb	3 days	12 hrs	4	30
Phostrol (phosphites)	24 pt	3 days	4 hrs	4	14
ProPhyt (phosphites)	12 pt	No PHI	4 hrs	3	
Alude, Confine Extra (phosphites)	N/A	No PHI	4 hrs	N/A	
Fosphite, Fungi-phite (phosphites)	N/A	No PHI	4 hrs	N/A	
K-Phite, Phiticide (phosphites)	N/A	No PHI	4 hrs	N/A	
Oxiphos, Rampart (phosphites)	N/A	No PHI	4 hrs	N/A	
Reliant, Reveille (phosphites)	N/A	No PHI	4 hrs	4, N/A	

Insecticide Products	Max a.i. per acre per year	Preharvest interval (PHI)	Restricted entry interval (REI)	Max # apps	Min. App. Interval (days)
Actara (thiamethoxam)**	0.188 lb	30 days	12 hrs	12 oz/A***	7
Admire and others (imidacloprid)	0.5 lb	30 days	12 hrs	0.5 lb ai/A***	
Altacor (chlorantraniliprole)	0.2 lb	1 day	4 hrs	2 or 3	7
Assail, Anarchy (acetamiprid)	0.26 lb	1 day	12 hrs	2	7
Avaunt (indoxacarb)	0.44 lb	30 days	12 hrs	24 oz/A***	7
<i>B.t.</i> based products	N/A	No PHI	4 hrs	-	7
Closer (sulfoxaflor)	0.266 lb	1 day	12 hrs	4	7
Confirm (tebufenozide)	1 lb	30 days	4 hrs	4	7
Cormoran (novaluron/acetamiprid)	0.23 lb/0.26 lb	1 day	12 hrs	35 fl oz/A***	7
Delegate (spinetoram)	0.305 lb	21 days	4 hrs	6	7
Diazinon*	9 lb	7 days	5 days	3	14
Entrust (spinosad)	0.45 lb	21 days	4 hrs	6	7
Exirel (cyantraniliprole)	0.4 lb	14 days	12 hrs	61.5 fl oz/A***	7
Fanfare (bifenthrin)*	0.3 lb	* varies by handler restriction	12 hrs	* varies by handler restriction	7
Imidan (phosmet)	10.92 lb	14 days	3 days	15.6 lb/A***	10
Intrepid (methoxyfenozide)**	1 lb	14 days	4 hrs	64 fl oz/A***	10
Movento (spirotetamat)	0.47 lb	7 days	24 hrs	30 fl oz/A***	7
Nematodes	-	No PHI	none	-	
Nexter (pyridaben)	10.67 oz	21 days	12 hrs	2	30
Oberon (spiromefesin)	0.75 lb	3 days	12 hrs	3	7
Orthene (acephate)	1 lb	90/75 days	24 hrs	1	
Pyganic (pyrethrins)	0.05 lb	No PHI	12 hrs	-	
Rimon (novaluron)	0.23 lb	1 day	12 hrs	36 fl oz/A***	7
Scorpion/Venom (dinotefuran)**	0.36 lb	7 day	12 hrs	2	14
Sevin, Carbaryl (carbaryl)	10 lb	7 days	12 hrs	5	7
Verdepryn (cyclaniliprole)	0.22 lb	1 day	4 hrs	3	5

* = restricted use pesticide, requires a pesticide certification to buy and apply.

** = Zone II restricted and restricted use, requires a pesticide license to buy and apply.

*** = No specific application limitations except the total amount formulated allowed per acre.

4 CAUTIONS

Herbicide Products	Max per acre per year	Preharvest interval (PHI)	Restricted entry interval (REI)	Max # apps	Min. App. Interval (days)
Aim (carfentrazone)	6.1 fl oz	0 days	12 hrs	N/A	14
Callisto, Explorer, Sotrion, etc. (mesotrione)	16 fl oz	45 days	12 hrs	2	14
Casoron 4G (dichlobenil)	100 lb	N/A	12 hrs	N/A	N/A
Devrinol DF-XT (napropamide)	18 lb	N/A	24 hrs	1	N/A
Devrinol 2XT (napropamide)	18 qt	N/A	24 hrs	1	N/A
Evital 5G (norflurazon)	160 lb	N/A	12 hrs	1	N/A
Poast (sethoxydim)	5 pt	60 days	12 hrs	N/A	14
QuinStar 4L (quinclorac)	16.8 fl oz	60 days	12 hrs	2	30
Roundup Weather Max (glyphosate)	N/A	30 days	4 hrs	N/A	14
Intensity	32 fl oz	30 days	24 hrs	N/A	14
Select Max, Intensity One (clethodim)	64 fl oz	30 days	24 hrs	N/A	14
Simazine (simazine)**	4 qt	N/A	12 hrs	1	N/A
Spartan/Zeus (sulfentrazone)**	12 fl oz	N/A	12 hrs	1	N/A
Stinger (clopyralid)	16 fl oz	50 days	12 hrs	2	N/A
Weedar 64 (2,4-D)*	N/A	30 days	48 hrs	1	N/A

* = restricted use pesticide, requires a pesticide certification to buy and apply.

** = Zone II restricted and restricted use, requires a pesticide license to buy and apply.

Recommended water-holding times: (Check the label on the product you are using to verify)

At least 1 day: Avaunt

At least 3 days: Chlorothalonil products (e.g., Bravo), Diazinon, Fanfare, and Nexter

At least 5 days: Actara

At least 14 days: Abound, AFrame, Satori and QuadrisTop

All chlorothalonil products (Bravo, etc.), Diazinon, Fanfare, Imidan, Nexter and QuadrisTop are extremely toxic to fish and can cause fish kills. Abound, Avaunt, copper fungicides, Indar, mancozeb, and Sevin are also toxic to fish.

To avoid contamination, do not clean equipment or dispose of waste near open water. Drift, runoff, or release of contaminated ditch water from treated areas may be hazardous to fish or other aquatic organisms in adjacent aquatic sites. Following any pesticide applications, hold water as long as possible.

Time Needed for Certain Pesticides to be Rainfast

Callisto	4 hr
Confirm	6 hr
Intrepid	6 hr
Nexter	5 hr
Poast	1 hr
QuinStar 4L	6 hr
Roundup	6 hr
Roundup WeatherMax	1-2 hr
Select Max	1 hr
Stinger	5 hr

Warnings

Pesticides are poisonous. Read and follow all directions and safety precautions on labels. Handle carefully and keep original labeled containers in locked storage areas. Do not contaminate forage, streams, or ponds. Dispose of empty containers in a legal manner.

Repeated exposure to organophosphate (such as Diazinon and Imidan) insecticides may, without symptoms, increase susceptibility to phosphate poisoning. All pesticide treated bogs must not be entered until restricted entry times have elapsed (see label). Workers should be notified prior to treatment. Tell family and co-workers. Make certain your doctor understands. After an accident, there may not be time.

If symptoms of acute pesticide poisoning occur, immediately take victim and appropriate pesticide label or container to the nearest hospital emergency room. For information and advice 24 hours a day, call the Massachusetts poison control system **1-800-222-1222**.

Restricted Use Compounds

Restricted Use Compounds require a **PRIVATE APPLICATOR CERTIFICATION** to buy, handle, and apply. This certification is available through the Massachusetts Department of Agricultural Resources (MDAR): www.mass.gov/pesticide-examination-and-licensing

Restricted Use Compounds:

State restricted because of groundwater concerns (and all products with same active ingredients)

- ACTARA (*thiamethoxam*)
- BRAVO, ECHO and others (*chlorothalonil*)
- INTREPID, INVERTID and others (*methoxyfenozide*)
- SCORPION, VENOM (*dinotefuran*)
- SIMAZINE (*simazine*)
- ZEUS, SPARTAN (*sulfentrazone*)

State restricted because of health concerns

- WEEDAR 64 (and all other products containing 2,4-D \geq 20%)

Federally restricted because of avian and aquatic toxicity concerns

- DANITOL (*fenprothrin*)
- DIAZINON (*diazinon*)
- FANFARE (*bifenthrin*)

6 WARNINGS

Compounds Requiring a Respirator - specific to formulations and labels, not active ingredient. It will be specifically listed on a pesticide product label under personal protective equipment. Note that there are no “engineering controls” in cranberry applications and you must wear the personal protective equipment listed for mixer and loaders.

Compounds that require a dust/mist filtering respirator - dusts, powders, mists, and sprays

Use a NIOSH-approved dust/mist filtering respirator:

- (NIOSH/MSHA approval number prefix TC-21C or any N, R, P or HE filter)
 - Bravo Ultrex, Echo 720, Echo 90DF
 - Ferbam
 - Nexter
 - Sevin XLR Plus, Carbaryl 4L

Compounds that require a respirator with an organic-vapor removing cartridge - gases and vapors. Use a respirator with an organic-vapor removing cartridge with a prefilter approved for pesticides:

- (MSHA/NIOSH approval number prefix TC-23C) or a canister approved for pesticides
- (MSHA/NIOSH approval number prefix TC-14G) or a NIOSH-approved respirator with an organic vapor (OV) cartridge or canister with any R, P or HE prefilter
 - Diazinon 50W, Diazinon AG500
 - Echo 720, Echo Zn, Echo 90DF
 - Imidan 70-W

Compounds that require a powered air purifying canister-type respirator (gas mask) equipped with an organic vapor canister with incorporated HE filters:

- (MSHA/NIOSH approval number prefix TC-14G)
 - Diazinon AG 600 WBC

Compounds Requiring Mandatory Posting

Mandatory posting of no-entry signs is required for the most hazardous pesticides. The signs prohibit entry into pesticide-treated fields until residues decline to a safe level.

If REI is 48 hours or greater, sign posting is required.

- Badge, Champ, Cuprofix, Kocide, Mastercop, Nu-Cop (coppers)
- Diazinon 50 W, Diazinon AG500, Diazinon AG 600 WBC (diazinon)
- Imidan 70-W (phosmet)
- Metastar 2E, Ridomil, Ultra Flourish, Xyler (mefenoxams)
- Weedar 64 (2, 4-D compounds)

Danger compounds also require posting.

- Bravo Ultrex
- Echo 90 DF

Compounds Requiring Protective Eyewear for Application and Additional Decontamination Water for Handlers due to Eye Toxicity

Chlorothalonils

- Bravo Ultrex
- Chlorothalonil Zn
- Echo 720, Echo 90 DF
- Equus DF

Coppers

- Badge, Champ, Cuprofix
- Kocide, Mastercop, Nu-Cop

Diazinon AG500, Diaz AG600 WBC

Fanfare

Intensity, Intensity One, Select Max - clethodim

Metastar 2E – mefenoxams

Penncozeb 75DF

Phostrol, Rampart - phostrols

Pyramite/Nexter – pyridaben

Rimon – novaluron

Weedar 64

Fumigants

Basamid (dazomet) and Vapam (metam-sodium) are soil fumigants that can be used on cranberry beds. They can only be used if fruit will not be harvested and delivered for 12 months post-application. **DO NOT USE FUMIGANTS AS A SPOT-TREATMENT IF ANY VINES WITHIN A DIKED SECTION WILL BE HARVESTED.** If it is used on part of a section, no fruit can be harvested or delivered from the entire (contiguous) section. If you are renovating an entire section, a portion of that section can be spot-treated with a fumigant. More information on the use of fumigants may be found in the “Planting New Cranberry Beds” Fact Sheet (<http://ag.umass.edu/cranberry/fact-sheets>). Contact the Weed Specialist if you have any questions about using these chemicals.

You must complete EPA fumigant training before applying any fumigant. You must get certified/pass the module on EPA's web site. As required by updated soil fumigant product labels, certified applicators must successfully complete an EPA-approved training program covering the new soil fumigant provisions. Basamid is listed under the name “dazomet” on the EPA web site. Please go to the EPA’s web site for more information:

<https://www.epa.gov/soil-fumigants/soil-fumigant-training-certified-applicators>

You must take Modules 1-4 plus the module specific to your use; Basamid (dazomet) is discussed in Module 7. Vapam is metam sodium (Module 8). The certification process is NOT regulated by MDAR; it is totally a federal EPA requirement. This is a NEW regulation.

Note: There is a provision that if you are already certified in a soil fumigation (sub)category and your state is listed with additional training option and requirements, you can bypass the training. Massachusetts is NOT one of these states! So you must take and pass the modules.

CAUTIONS

1. Pesticide-treated bogs may need to be posted. Check labels. Workers and scouts should be notified prior to treatments, and informed about re-entry times. See CCCGA website for more current info on sign posting listed under pesticides:
<http://www.cranberries.org/growers/advisories.html>
2. **READ AND FOLLOW LABEL INSTRUCTIONS.** The label is the law! Current labels and MSDS can be found on the CDMS website: <https://www.cdms.net/Label-Database> . Do not use a pesticide for control of a pest not on the label unless a specific recommendation is made by a person authorized to do so.
3. Make all pesticide applications in a manner to prevent contamination of streams, ponds, and public ways, and impound water as long as possible after applying.
4. Be aware of and adhere to guidelines regarding distances from site of chemical application to protected areas. Consider addition of drift retardants.
5. Many insecticides are highly toxic to bees. Check label and choose options that are least toxic.
6. Stored pesticides may deteriorate. Avoid freezing of liquid formulations. It is usually not advisable to use heldover materials in opened containers. Follow regulations of the MDAR Pesticide Program when disposing of pesticides and their containers.
7. **CONCENTRATE SPRAYS** may injure new growth, bloom, and small berries, particularly in hot, humid weather or if the emulsifiable concentrate (EC) content nears 50% of mixture.

RESISTANCE MANAGEMENT 2024-2026

Prepared by Martha M. Sylvia and Katherine M. Ghantous

Pesticide resistance is **an inheritable** (genetic) characteristic of a pest that makes it less sensitive to a pesticide and can occur in **all** types of pests (weeds, insects, fungi, etc.). Repeated use of the same pesticide (or pesticides with the same mode of action) over time kills pests that are susceptible to the pesticide and leaves behind individuals that are less sensitive. These then reproduce and pass on the genes that let them survive pesticide exposure to their offspring. The goal in resistance management is to **not** repeatedly use compounds that fall within the same group. Resistance management may include alternating products with different modes of action or limiting the total number of applications per season.

International groups have been founded to foster a cooperative approach to resistance management. They have assigned group numbers to pesticides to help growers make decisions on how to rotate pesticides. They are based on mode of action – how and where the chemicals in the pesticide work on the target.

In an effort to manage resistance with our pesticides, most labels now come with a “group” number assigned to them. The group number is specific for each type of pesticide (e.g., Group 1 insecticides have no relation to Group 1 herbicides). The following 3 pages show the groupings for our cranberry pesticides. Some active ingredients are available under several different product names, and different active ingredients have the same mode of action. When rotating pesticides for resistance management, use the **group number** as your guide and **NOT** the product name or active ingredient.

The group number is located on the first page of the label, and is usually displayed similarly to this example:

GROUP	5	INSECTICIDE
-------	---	-------------

Insecticide Resistance Action Committee (IRAC) (<http://www.irc-online.org/>)

The Insecticide Resistance Action Committee (IRAC) has been formed to assemble the information for insecticides. For cranberry, organophosphates and neonicotinoids have the most compounds within their group. We are reliant on several compounds in these groupings. As long as growers remember to alternate between groupings and not repeat same mode-of-action compounds over and over, we should be able to keep newer compounds viable for decades. See Cranberry Insecticides by grouping on the next page.

Fungicide Resistance Action Committee (FRAC) (<http://www.frac.info/home>)

The group that advises for fungicide resistance is the Fungicide Resistance Action Committee (FRAC). Their goal is to prolong the effectiveness of fungicides that are likely to encounter resistance problems. For cranberry, Ridomil and Abound are fungicides that are at high risk for resistance development, while Indar and Proline are at medium risk. They should not be used repeatedly and should be carefully alternated with other fungicides from other groupings. See Cranberry Fungicides by grouping on following pages.

Herbicide Resistance Action Committee (HRAC) (<http://www.hracglobal.com/pages/Home.aspx>)

The Herbicide Resistance Action Committee and The Weed Science Society of America (WSSA) have developed a classification systems of herbicides. Previously the WSSA used numbers while HRAC used letters to designate the categories. As of March 2020, these two systems have been integrated and use numbers to represent groups by mode of action. One of the purposes of these classification systems is to make it easier for farmers and farm advisors to understand which herbicides share the same mode of action without having to actually know the biochemical basis.

A key step in resistance management is to minimize the continuous use of herbicides with the same mode of action through rotations and combinations of products. In cranberry, our biggest concern for developing resistance is our reliance on Callisto. Clethodim and other grass herbicides are also at risk. Be sure to rotate other compounds into your herbicide schedule. Do not treat the same bog with Callisto and/or clethodim year after year. See Cranberry Herbicides by grouping on following pages.

10 RESISTANCE MANAGEMENT

Insecticide Resistance Action Committee (IRAC) Grouping for Cranberry Insecticides

IRAC GROUP	TRADE NAME	ACTIVE INGREDIENT	MODE OF ACTION	CHEMICAL FAMILY
1	Diazinon	diazinon	Acetylcholine esterase inhibitor	Organophosphates and carbamates
	Imidan	phosmet		
	Orthene	acephate		
	Sevin	carbaryl		
3	Danitol	fenpropathrin	Sodium channel modulators	Pyrethrins
	Fanfare	bifenthrin		
	Pyganic	pyrethrin		
4A	Actara	thiamethoxam	Nicotinic acetylcholine receptor competitive modulators	Neonicotinoids
	Admire (+others)	imidacloprid		
	Assail	acetamiprid		
	Scorpion	dinotefuran		
4C	Closer	sulfoxaflor		Sulfoximines
5	Delegate	spinetoram	Nicotinic Acetylcholine receptor allosteric activators	Spinosyns
	Entrust	spinosad		
11	Dipel Xentari Biobit	<i>Bacillus thuringiensis</i>	Microbial disruptors of insect midgut membranes	<i>Bacillus thuringiensis</i>
15	Rimon	novaluron	Inhibitors of chitin biosynthesis	Benzoylureas
18	Confirm	tebufenozide	Ecdysone agonists / molting disruptors	Diacylhydrazines
	Intrepid	methoxyfenozide		
21	Nexter	pyridaben	Mitochondrial complex / electron transport inhibitor	Meti acaracides
22	Avaunt	indoxacarb	Voltage-dependent sodium channel blockers	Oxadiazines
23	Oberon	spiromesifen	Inhibitors of acetyl CoA carboxylase	Tetramic acid derivatives
	Movento	spirotetramat		
28	Altacor	chlorantraniliprole	Ryanodine receptor modulators	Diamides
	Exirel	cyantraniliprole		
	Verdepryn	cyclaniliprole		

Fungicide Resistance Action Committee (FRAC) Grouping for Cranberry Fungicides

FRAC GROUP	TRADE NAME	COMMON NAME	MODE OF ACTION	GROUP NAME	CHEMICAL GROUP	Resistance Development Risk
4	Ridomil	mefenoxam	A1: RNA polymerase I	PA – fungicides (PhenylAmides)	acylalanines	High Risk
	Ultra Flourish Metastar, Xyler	metalaxyl				
11	Abound AFrame	azoxystrobin	C3: cytochrome bc1 at Qo site	QoI- fungicides Strobilurins	methoxy- acrylates dihydro- dioxazines	High Risk (Single site fungicide)
	Aftershock, Evito	fluoxastrobin				
3 + 11	Quadris Top	azoxystrobin + difenoconazole	C3 + G1	QoI- + DMI- fungicides	methoxy- acrylates + triazoles	High/ Medium Risk
3	Indar	fenbuconazole	G1: c14- demethylase in sterol biosynthesis	DMI- fungicides (DeMethylation Inhibitors)	triazoles	Medium Risk (Single site fungicide)
	Proline	prothioconazole				
19	OSO Ph-D	Polyoxin D zinc salt	H4: chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	Medium Risk
33	Aliette Legion	fosetyl-Al aluminum-tris	Unknown	phosphonates	ethyl phosphonates	Low Risk Multi-site fungicide
	Alude, Confine Fosphite, Fungi-Phite, K-Phite, Oxiphos, Phiticide, Phostrol, ProPhyt, Rampart, Reliant, Reveille	phosphorous acids and salts				
M1	Badge, Champ, Kocide, Mastercop, Nordox, NuCop	copper (salts)	M1: Multi-site contact activity	inorganic	inorganic	Low Risk Multi-site fungicide
M3	Ferbam	ferbam	M3: Multi-site contact activity	dithiocarbamates EBDC's (Ethylene bis dithio carbamate)	dithiocarbamates	Low Risk Multi-site fungicide
	Dithane, Koverall Manzate, Penncozeb, Roper	mancozebs				
M5	Bravo, Chloronil, Echo, Equus, Initiate	chlorothalonil	M5: Multi-site contact activity	chloronitriles	chloronitriles	Low Risk Multi-site fungicide

12 RESISTANCE MANAGEMENT

Weed Science Society of America (WSSA) and Herbicide Resistance Action Committee (HRAC) Groupings for Cranberry Herbicides

WSSA/HRAC GROUP	TRADE NAME	ACTIVE INGREDIENT	MODE OF ACTION	CHEMICAL FAMILY
1	Select, Intensity Poast	clethodim sethoxydim	Inhibition of acetyl CoA carboxylase (ACCase)	Cyclohexanedione 'DIMs'
4	Quinstar 2,4-D, Weedar 64 Stinger	quinclorac 2,4-D clopyralid	Action like indole acetic acid (synthetic auxins)	Quinoline carboxylic acid Phenoxy-carboxylic acid Pyridine carboxylic acid
5	Simazine	simazine	Inhibition of photosynthesis at photosystem II	Triazine
9	Roundup	glyphosate	Inhibition of EPSP synthase	Glycines
12	Evital	norflurazon	Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)	N-Phenyl heterocycles
14	Zeus Spartan	sulfentrazone	Inhibition of Protoporphyrinogen Oxidase (PPO)	N-Phenyl-triazolinones
27	Callisto, Explorer, and others	mesotrione	Bleaching: Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	Triketone
29	Casoron	dichlobenil	Inhibition of cell wall (cellulose) synthesis	Nitrile
0	Devrinol	napropramide	Unknown	Acetamide

DISEASE MANAGEMENT 2024 - 2026

Prepared by Leela S. Uppala and Martha M. Sylvia

UPRIGHT DIEBACK

Causal Agent/Pathogen: Three different fungi have been associated with this disease.

1. *Phomopsis vaccinii* (primary).
2. *Fusicoccum putrefaciens* (often).
3. *Synchronoblastia crypta* (rarely).

Factors aggravating disease incidence and severity:

- Growing seasons with prolonged periods of drought or heat stress.
- Stress weakens the vines and makes them more susceptible to infection by fungal pathogens.

Critical Phases of Infection:

- Spores of the pathogen would be produced from overwintering cranberry tissue in April and May and the emerging buds are particularly susceptible to infection.
- Infection most probably occurs during or shortly after bud break when tissues are susceptible.
- Infection may also occur during the entire growing season.

Typical time to monitor for symptoms: Once infected, plants show symptoms (dead uprights and leaf drop) when weather-related stresses weaken the plants. There are three phases when symptoms likely appear.

1. Shortly after the winter flood has been withdrawn.
2. June and early July.
3. Late August and September.

Symptoms:

- Individual uprights that die back from the growing point toward the runner.
- Every upright may be infected on some runners, while other runners may only have one or a few infected uprights. In severe cases, the entire runner will be stressed or dying.
- Scattered uprights may be infected or whole patches of dieback may show up, particularly in newer beds.

Suspect upright dieback? Please get samples diagnosed by a plant pathology lab before applying fungicides.

Management:

- Avoid stress (by properly timing irrigation) on the plants especially through the hottest (and potentially the driest) portion of the growing season.
- Early season fungicide applications at bud break and/or early bud expansion (approximately around April 25 through May 15) are proven to give excellent control of the disease.
- Fungicides targeted for fruit rot control also provide a degree of protection against this disease during early and mid-season infection periods.

14 DISEASES

UPRIGHT DIEBACK FUNGICIDE RECOMMENDATIONS

PESTICIDE/FORMULATION	RATE (amt/A/app)	COMMENTS/RESTRICTIONS
<u>COPPER FORMULATIONS</u>		
Champ DP Dry Prill	5.3 lb	Must be applied pre-bloom. 48-hour restricted entry interval.
Champ Formula 2 Flowable	5.33 pt	
<u>CHLOROTHALONIL FORMULATIONS</u>		
Bravo Ultrex	3.8 – 6 lb	One pre-bloom application should be applied after the terminal bud has broken dormancy (begun to swell or has begun new growth). The exact timing will depend on whether the variety is early or late-season. 12-hour restricted entry interval.
Bravo Weather Stik	4 – 6.5 pt	
Chlorothalonil 720, Equus 720 SST	4 – 6.5 pt	
Chlorothalonil Zn	5.66 – 9.25 pt	
Echo 720	4 – 7 pt	
Echo 90DF	3.25 – 5.75 lb	
Initiate ZN	5.75 – 9.25 pt	

For all above chlorothalonil formulations: Hold water for 3 days after application. In beds subject to Zone II regulations, growers must follow the required process (See Zone II section) to determine if these products may be used. As per the label, the maximum allowable number of chlorothalonil applications in a growing season is 3. **If one chlorothalonil application is used for upright dieback, only 2 applications are allowed for fruit rot.**

PHYTOPHTHORA ROOT ROT

Causal agent: *Phytophthora spp.*

Factors aggravating disease incidence and severity:

- It just takes a few infected roots (and runners) to initiate and spread the disease to a new location. However, symptoms of infection develop in only a small percentage of the exposed acreage, due to the excellent drainage and low pH values (3.0–4.5) of cranberry soils in most beds.
- Poor drainage or water-logged areas are the first places *Phytophthora* infections occur.
- High temperatures (>50 °F) facilitate the reproduction and spread of the pathogen.

Symptoms:

- Infected root systems are poorly developed, have few feeder roots, are reduced in mass and show necrosis.
- Infected roots cannot uptake water and nutrients, resulting in stunting, dieback of plants and reduced drought tolerance. Other symptoms include runners rot, fewer (mostly off color) leaves per plant which may turn red prematurely in the late summer, or may be delayed in turning green in the spring. If the outer layer of the underground runner is scraped off, the internal tissue will be discolored olive green to dark brown.

Suspect *Phytophthora*?

- Symptoms of *Phytophthora* are similar to those of related root disorders such as damage by root-feeding insects and nematodes, other fungal diseases such as fairy ring, or simply “wet feet.”
- Because management of each of these problems differs, it is extremely important to get an accurate diagnosis before undertaking any control measures.
- If you suspect *Phytophthora* infection, please get samples diagnosed by a plant pathology lab before applying fungicides.

Management: Adequate control can be achieved only through several integrated strategies.

- Drainage: Improve drainage (through tiles, stones, underdrains or new ditches) in low areas of the bed. Existing ditches should be maintained to the proper depth. Following rain, irrigation, or frost protection event, examine the soil surface for standing water. Problems arise where soil drainage is highly variable, and it is not possible to irrigate sufficiently in well-drained areas without over-irrigating poorly drained areas.
- Irrigation Uniformity: Examine the distribution of sprinkler heads and the total capacity of irrigation system to make sure they are irrigating the bog uniformly. For irregular beds, sprinkler heads placed closer than specified in the design should be outfitted with reduced-volume nozzles. Repeated cycles of wetting and drying, especially extreme cycles, are conducive to root rot. Schedule irrigation timing to consistently maintain soil moisture near the optimum level, rather than leaving long intervals between irrigation events.
- Sanding: Apply a uniform layer of sand to the areas of dieback to get those areas up to grade with the remainder of the bed.
- Fungicides: After the drainage is improved, the ideal time to apply fungicides (foliar application of phosphonates or soil application of phenylamides) is when soil temperatures are conducive for root development and pathogen multiplication (May, June, July and August).
 - Spring applications (if a diagnosis is confirmed and drainage is improved) could slow down the infection.
 - If summer application cannot be done, a fall application can be considered before winter hardiness. However, fall application is only effective in early harvested beds or if there is a warm, extended fall season.
 - Multiple applications per season may be needed until vine recovery is visible. These applications can revitalize the canopy by encouraging root growth and help the plant uptake water and nutrients.

Additional notes for new beds:

- Creating uniform drainage should be a high priority on new beds. Before planting, examine the bed for low points or poorly drained areas that may be vulnerable to Phytophthora development. Implementing a drainage plan during new bed construction may avoid problems down the road.
- Irrigation systems should be carefully laid out so that sprinkler heads are placed according to design specifications.
- Basamid fumigation prior to planting has been recommended for renovations that had a history of Phytophthora infestation in the soil. EPA regulations require EPA fumigant training to use this chemical. See “Fumigants” on page 7.
- Newly planted vines may not be able to absorb the phosphonate fungicides until sufficient shoot growth has occurred, whereas Phenylamide fungicides with a.i. mefanoxam (Ridomil Gold SL, Ultra Flourish) applied through chemigation could offer excellent root uptake.

Precautions to prevent the spread of the pathogen from infected areas/beds to healthy areas/beds:

- Machinery, equipment, footwear, etc., should be sterilized using steam, bleach (freshly prepared 10% bleach solution), or 70% alcohol. If possible, the sequence of flooding the beds during water harvest should be adjusted to flood heavily infected beds last.
- Exercise caution when purchasing/moving plant material or soil from other bogs. Be certain that materials are not coming from infected beds.

PHYTOPHTHORA ROOT ROT FUNGICIDE RECOMMENDATIONS

	PESTICIDE/FORMULATION	RATE (amt/A)	COMMENTS/RESTRICTIONS
	Aliette WDG	5 lb	Rates are for chemigation application!
Foliar Applications (Phosphonate fungicides)	Fungi-Phite	2-4 pt	Read the label for each product to determine application interval, re-entry period, and the number of applications per season. Read label, some do not tank mix!
	ProPhyt, Reveille	4 pt	
	Reliant	2-6 pt	
	Confine Extra, K-Phite, Rampart	4-8 pt	
	Alude, Phiticide, Phostrol	5-6 pt	
	Oxiphos	5-10 pt	
Soil Applications (Phenylamide fungicides)*	Metastar 2EC	4-7 pt	Ground or chemigation only. No aerial application!
	Ridomil Gold SL	1-1.75 pt	
	Ultra Flourish	2-3.5 pt	Ground or air only. No chemigation!
	Ridomil Gold GR	20-35 lb	

***Soil applications** must be watered in after application. Run the sprinklers for 3 hours after application to water the fungicide into the root zone. Too much water, however, may push the chemical past the root zone. Therefore, do not apply if more than 0.5 inches of rainfall is forecasted or if sprinklers will run for more than 5 hours during the first few days after the application.

FRUIT ROT

This is the most prevalent disease problem that cranberry growers face from season to season. The disease is generally divided into two distinct categories: field rot and storage rot. The field rot phase is expressed pre-harvest and constitutes a major component of direct crop loss. Storage rots cause a reduction in the quality and shelf life of fresh, refrigerated fruit.

Causal agent:

- Fruit rot is a disease complex associated with more than 12 fungal pathogens. The most common isolated in MA are *Allantophomopsis lycopodina*, *A. cystisporea*, *Botryosphaeria vaccinii*, *Coleophoma empetri*, *Colletotrichum gloeosporioides*, *C. acutatum*, *Fusicoccum putrefaciens*, *Phomopsis vaccinii*, *Phyllosticta vaccinii* and *Physalospora vaccinii*.

Factors aggravating disease incidence and severity:

- The degree of fruit rot in different beds in a given season is dependent on many factors (e.g., weather, cultural practices, fruit rot fungal inoculum). Not all factors are completely understood.
- Bog microclimatic factors: Factors that leave the cranberry vine wet for long periods of time (e.g., rain, fog, dew or irrigation) provide optimal conditions for fungal growth and increases the risk of fruit rot incidence and severity. Other factors include dense vine growth, poor air circulation, high humidity, slow drying-out of dew, and poor drainage.
- Cultural Practices: Any practice that promotes excessive vine growth such as excessive N fertilizer, frequent late water, holding water high in ditches, too frequent irrigation, and not cleaning the bog of berries/detached plant tissues (they could serve as sources of overwintering inoculum) from the previous cropping season could favor fruit rot development.

- Bogs planted with susceptible cultivars and with high fruit rot levels in the previous season.
- Rot develops rapidly only after the berries are detached and floating on the flood surface. Thus, the time the berries are left in the harvest floods is an important factor too.
- Not following bog sanitation: Cranberry leaves, stems, and fruit left behind after harvest (trash) are colonized by several fungi that cause field and storage rot.
- Improper timing and frequency of fungicide applications: The fungicides should target the most susceptible stages of infection (bloom and early fruit set). Applying fungicides after this period will not be of use. The frequency of fungicides should be decided based on the history of fruit rot infection in the previous growing season.

Critical phases of infection:

- Flowering and fruit development are the susceptible phases of infection. Spores of the fruit rot fungi germinate from overwintering sources of inoculum and spread by wind or wind-driven rain to bloom or developing fruit. If there is a suitable layer of moisture present for 6 to 8 hours and the cultivar is susceptible, the fungi will infect these tissues.

Symptoms:

- In general, after the infection, although the fungal pathogens are multiplying with developing fruit, the fruit rot symptoms (break down of berry tissue and rot) are not apparent (latent infection) until later in the growing season or until the berries have been harvested and held in storage.

Management: Adequate control can be achieved only through several integrated strategies.

- Canopy Management: Practices that increase air circulation such as pruning will reduce disease pressure. Sanding can also reduce disease pressure by burying excess runners and improving airflow, as well as burying sources of disease inoculum.
- Late Water: Holding late water (flooding from mid-April to mid-May) once in three years will improve berry quality by disrupting the life cycles of fruit rot fungi and increase fungicide application efficacy by synchronizing bloom. In the year late water is used and in the following year, the number of fungicide applications can be reduced in beds with a history of low fruit rot pressure. The fungicides should not be eliminated completely, or vine diseases may be a problem the following growing season. Fungicide regimes should be brought back to normal in the second year after late water.
- Trash Removal: Remove trash from water-harvested beds during harvest, or as soon after as possible. If the bed was dry-harvested, trash should be removed from the bed with a postharvest flood in the fall or from the winter flood before it is withdrawn. Trash piles should not be left next to the bed and should be deposited at least a quarter mile from the bed if possible. Self-pollinated seeds in berries left behind on the bog may germinate in the soil and possibly produce plants that are the typical "mongrels". These genotypes may produce much vegetation but few berries, and in worst-case scenarios, may take over the productive vines in the bed.
- Irrigation: When irrigation is necessary, sprinkler systems should be run in the early morning, and not in the early evening. Morning watering allows vines to be watered with minimal evaporation, and the surface of the vines can then dry out in the sun's heat. When watering is done in the early evening, the vines are kept wet for an extended period, thus creating favorable conditions for infection by the fruit rot fungi. On days with excessive temperatures (>100°F on the bed), particularly in newly planted or recently sanded beds, sprinklers should be run in the late morning or early afternoon to cool the vines and berries and may prevent injury. Sprinklers should be run to prevent scalding of the fruit when all of the following conditions persist: (1) dewpoints of 55°F or less during midday and afternoon hours, (2) high temperatures of 80°F or more, (3) clear or

18 DISEASES

scattered sky conditions during the day, (4) bed soil moisture is low, (5) wind speeds average greater than 11 mph, and (6) no rainfall has occurred during the last 48 hours (2 days). This "forecast" is based on research performed in New Jersey. Scalded berries are typically browned on one side, with a clear demarcation between the brown area and the green (usually) area of the fruit. The rotted area in a berry affected with fruit rot typically has an area of anthocyanin production (reddish border) adjacent to the affected area. After 7 days, a scalded berry will be hard to discern from a rotted berry, particularly since fungi will colonize the stressed scalded berry.

- **Resistant Varieties:** When replanting bogs or planting new bogs, varying levels of disease resistance against fruit rot among varieties should be considered. A summary chart with some of the most common cultivars and their relative field rot resistance (highest-moderate-low) is presented below.

Highest field rot resistance	Moderate field rot resistance	Lowest field rot resistance
Mullica Queen, Howes, Black Veil	Stevens, Crimson Queen, Early Black, Scarlet Knight, Haines	Ben Lear, Demoranville

- **Fungicides:** For adequate control, fungicide applications should have good coverage and take place before fungi infect plant tissues. Most fruit rot infections occur during the bloom period and early fruit set before berries start to size up. Applications typically should begin during early bloom (mid-June, before 50% of flowers have opened). Once the fruit has set and begun to increase in size (mid-late July), fungicides are no longer necessary or effective. Fungicide decisions such as the choice, frequency and interval between fungicide applications are dependent on the individual bed, its history of fruit rot severity, products allowed by respective fruit handlers and Keeping Quality Forecast (KQF) found on the Cranberry Station's website. If the KQF forecast is good to excellent, consider fewer applications and/or longer application intervals. Cranberry beds prone to fruit rot may need up to 4 fungicide applications. One or two fungicide applications may be adequate for a bed with very little fruit rot in previous growing seasons. Storage rot is usually not a concern for berries that are water harvested, as these berries will immediately be frozen in most cases. If in doubt, call the Extension Plant Pathologist.
- **Note for newly planted beds:** One or two fungicide applications during the first two years after planting will help reduce fungal inoculum and may reduce fruit rot in subsequent years.

FUNGICIDE RESISTANCE MANAGEMENT FOR FRUIT ROT

Fungicide resistance, defined as reduced fungicide sensitivity in fungal populations, is a real and serious threat to the cranberry industry. It could severely impact the efficacy of fungicides used against fruit rot pathogens. The Fungicide Resistance Action Committee (FRAC) developed a code of numbers and letters that can be used to distinguish the different fungicide groups based on their mode of action. Repeated and ineffective use of fungicides from the same FRAC group can accelerate the development of resistant pathogen populations and once this occurs, fungicide applications will provide very little or no disease control.

Two key groups of fungicides employed in fruit rot management (Mancozeb/EDBCs used since 1960; Chlorothalonils used since 1985) have no Maximum Residue Limits (MRLs) in key international export markets such as the European Union. Many handlers restrict the use of these fungicides for export markets, and growers are increasingly relying on the newer, single-site mode of action fungicides from

FRAC Group 3 and 11. These newer fungicides (eg., Abound, Indar, Proline and Quadris Top) can be equally effective in controlling fruit rot fungi and are perceived to be less harmful to human and environmental health when compared to the older, multi-site mode of action chemicals (chlorothalonil and EBDCs/Mancozebs). However, newer fungicides are at higher risk of selecting for fungicide-resistant pathogens than older fungicides. To preserve the effectiveness and durability of the few effective registered fungicides we have available, it is **CRITICAL** to incorporate the fungicide resistance management strategies listed below:

- Follow ALL label instructions, including application interval and recommended rate. Never use less than the lowest recommended rate on the label.
- Alternate or mix fungicides with different modes of action.
 - Use FRAC codes on labels to determine the mode of action. The same FRAC codes indicate that fungicides have the same mode of action. For example, Indar and Proline have different trade names and active ingredients, but they have the SAME mode of action and FRAC code (3).
- For best control and fungicide resistance management, mix Abound with Indar or Proline, or use Quadris Top.

FRUIT ROT FUNGICIDE RECOMMENDATIONS

TIMING – Begin early to mid-bloom (10-50%), then at 7-14 day intervals.

Read the label for each product to determine application interval, re-entry period, and number of applications per season.

NEWER CHEMISTRIES

RATE (amount/A)

Abound AFrame Satori <i>azoxystrobin</i>	FRAC Group 11	6.0-15.5 fl oz	No more than 2 sequential apps. To achieve best fruit rot control and reduce the risk of fungicide resistance, don't use these products as standalone fungicides. Instead, use these in combination with Group 3 (eg. Proline, Indar) fungicides. See Resistance Management notes below and in Resistance Management chapter. Avoid drift if the bed is next to a McIntosh apple orchard, as the fungicide is highly phytotoxic to this cultivar. Must hold water for 14 days after application.
Indar 2F <i>fenbuconazole</i>	FRAC Group 3	6.0-12 fl oz	No more than 2 apps due to resistance concerns. Do not use prior to bloom. 30-day PHI.
Proline 480SC <i>prothioconazole</i>		5 fl oz	No more than 2 apps. 45-day PHI.
Quadris Top <i>difenoconazole</i> and <i>azoxystrobin</i>	FRAC Group 3+11	10-14 fl oz	No more than 2 sequential apps due to resistance concerns. Do not use prior to bloom. 30-day PHI. 14-day water holding.

POLYOXIN-D ZINC SALT

Oso	FRAC Group 19	3.75-13 fl oz	No more than 6 apps of Oso or 3 apps of Ph-D when using maximum rate. Limited research on efficacy. For best results alternate or incorporate into a program with other fungicides for fruit rot.
Ph-D		6.2 oz	

20 DISEASES

FRUIT ROT FUNGICIDE RECOMMENDATIONS

TIMING – Begin early to mid-bloom (10-50%), then at 7 - 10 day intervals

CHLOROTHALONIL FORMULATIONS*

Bravo Ultrex		3.8-6.0 lb	Restricted use!! Check with handler for restrictions before using!
Bravo Weather Stik		4-6.5 pt	
Chloronil 720, Initiate 720		4-6.5 pt	Use the maximum rate in beds with high rot incidence on a 10-day schedule. Zone II restricted.
Chlorothalonil 720 SC	All FRAC Group M5	4-6.5 pt	Check label for max lbs/a.i./A/yr! 12-hr REI (6.5-day eye irritant). Hold water for 3 days after application.
Echo 720		4-7 pt	
Echo 90DF		3.25-5.75 lb	
Equus 720 SST		4-6.5 pt	
Initiate ZN		5.75-9.25 pt	50-day PHI

* For all chlorothalonil formulations: Before use on beds subject to Zone II regulations, growers must follow the required process to determine if these products may be used. See Zone II Section. Do not mix with Dipel.

Ferbam Granuflo	FRAC Group M3	6 lb	Do not apply more than 5 times. Apply at 14-day intervals. 50-day PHI, 24-hr REI.
-----------------	------------------	------	---

MANCOZEBS

Dithane F-45 Rainshield		2.4-4.8 qt	Restricted use!! Check with handler for restrictions before using!
Dithane M-45		3-6 lb	
Penncozeb 75DF		3-6 lb	The addition of spray adjuvants will improve distribution and deposition for all of the mancozeb compounds.
Penncozeb 80WP		3-6 lb	
Koverall	All FRAC Group M3	3-6 lb	May delay color development in some varieties!
Roper DF Rainshield		3-6 lb	
ManKocide		7 lb	30-day PHI.
Manzate Flowable		2.4-4.8 qt	
Manzate Max		2.4-4.8 qt	All 24-hr REI, except ManKocide 48-hr REI.
Manzate Pro-Stick		3-6 lb	

TIMING- Begin at late-bloom (>50%), then at 7-14 day intervalsCOPPERS (See page 2 for full list of copper products)

Mastercop	FRAC Group M1	3 pt	Make first application in late bloom. Apply one or two additional applications at 10-14 day intervals or as needed depending on disease severity.
Badge X2		3.5 lbs	
Kocide 3000		3.5 lbs	Make first application in late bloom. Apply one or two additional applications at 7-14 day intervals or as needed depending on disease severity.
Champ		4.2 lbs	

Do not mix copper fungicides with insecticides. Do not tank mix with Aliette or phosphites unless spray solution has been buffered first. Call Extension specialist for information on buffering.

BIOLOGICAL PRODUCTS

Howler (<i>Pseudomonas chlororaphis</i> strain AFS009)	BM02	5 lbs	Apply with non-ionic surfactant (NIS) at 0.25% v/v. Repeat at 7 to 21day intervals as needed. For best activity, apply Howler later in the bloom period as part of the fungicide regime with other fungicides applied at early and mid-bloom. 0-day PHI.
---	------	-------	--

22 DISEASES

FRUIT ROT FUNGICIDE ADDITIONAL NOTES

Fungicides	Trade Names	Resistance Risk	Comments
Chlorothalonils	Bravo, Echo, Equus, etc.	Low	Check with handlers for market restrictions.
Mancozebs	Dithane, Manzate, Penncozeb, etc.	Low	Check with handlers for market restrictions. Anecdotally believed to have a negative effect on fruit color. In 2019 trials, we did not observe any negative effects on color in Stevens.
Coppers	Mastercop Badge X2 Champ Kocide 3000, etc.	Low	Limited research data available. Coppers could serve as resistant management tools while efficiently managing fruit rot if used as part of a fungicide program with other fungicides. More effective if used later in the season (late bloom).
Difenoconazole + Azoxystrobin	Quadris Top	Medium	
Prothioconazole Fenbuconazole	Proline Indar	Medium	For best results and resistance management, use during bloom and combine with azoxystrobin.
Azoxystrobin	Abound, AFrame, Satori	High	For best results combine with prothioconazole or fenbuconazole.
Polyoxin-D zinc salt	Oso, Ph-D	Medium	Limited research data available. For best results alternate or incorporate into a program with other fungicides for fruit rot.
SDHI, plant extracts	Kenja, Regalia, etc.		Limited research data available.

FAIRY RING

This disease is sporadic in occurrence and the severity of symptoms varies from year to year.

Causal Agent/Pathogen:

- Some fungi such as *Psilocybe agrariella* var. *vaccinii*, *Helicobasidium* sp. (anamorph *Thanatophytum* sp.), *Rhizoctonia*-like fungi, *Pezicula*, *Dermea*, *Crytosporiopsis* and *Neofabrea* have been associated with this disease. However, the role of these fungi in fairy ring disease is not completely characterized.

Factors aggravating disease incidence and severity:

- Damage caused by this disease is usually worse during growing seasons with limited rainfall (drought) and hotter than normal temperatures. Excessively dry soils could promote this disease.
- Stevens, Ben Lear and Howes are highly susceptible, while Early Black is less susceptible but not resistant.

Symptoms:

- Initially, a small area of weak or dead vines occurs, usually in higher spots in the bog or near the ditches.
- When environmental conditions are favorable for disease spread, the area of dead vines expands outward in all directions and opens the canopy for weed invasion.
- The outside edge of the necrotic zone is sometimes bordered by a ring of cranberry vine overgrowth which are unproductive. In heavily infested beds, numerous rings will be present and they may overlap or combine, resulting in whole sections that are devastated by the disease.
- Reduces yield 50-60%. Increases fruit rot incidence.
- Increases the need for replanting.

Precautions to prevent the spread of fairy ring from infested areas/beds to healthy areas/beds:

- The mechanism of dissemination of this disease is unknown. It is possible that movement of vines, during harvest or any other means, could spread the disease from infested areas to healthy areas of bog or even among various bogs.

Management:

- Control strategies for this disease have still not been worked out thoroughly.
- During those summers with low rainfall, plants should be properly irrigated.
- Sprinklers should be run for several hours in the early morning hours, when there is little evaporation, to ensure that the root systems are properly watered.
- Raising the water level in the ditches can help in this regard. This can be a problem, however, if there are low areas in the same bed where *Phytophthora* root rot may also be present. Beds should be properly graded.

FAIRY RING FUNGICIDE RECOMMENDATIONS

TIMING	PESTICIDE/ FORMULATION	RATE (amt/A)	COMMENTS/RESTRICTIONS
MAY	Abound/AFrame and Indar	15.5 fl oz/30-100 gal <hr/> 12 fl oz/30-100 gal	Make the first app at budbreak. Irrigate for 1-2 hours before and following application. Repeat 2-4 weeks later if necessary. Make sure to have Indar supplemental label. <i>See below for drench instructions.*</i>
JUNE - JULY	Ferbam Granuflo	9 lb/100 gal	Apply 1 gal of this mixture to 1 sq ft area. Treat the area 3 feet beyond the advancing line of dying vines and 2 feet within the line. Do not apply after July 31. Only 1 app!
MID-AUGUST THROUGH OCTOBER	Sul-Po-Mag or K-Mag 0-0-22	4000 lb/A or 1.5 oz/sq. ft.	Follow-up applications may be necessary. This may help vines out-compete the fungus.

* Indar and Abound soil drench. Using a drench method, one can treat up to a tenth of each acre while remaining within the label restrictions (one-tenth of an acre is approximately 4,300 ft²).

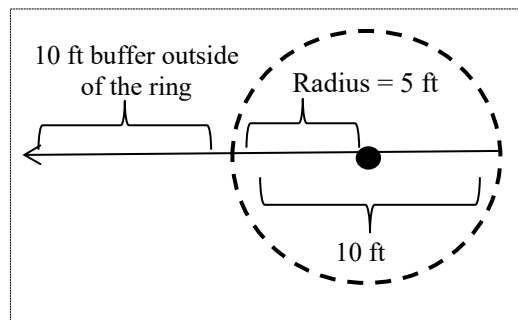
A. Estimate the area to be treated:

1. Measure across the center of the fairy ring (this gives you the diameter).
2. Divide by 2 to get the radius.
3. Add 10 ft to the radius to include a buffer around the fairy ring.
4. Use the formula

$$\text{Area} = r^2 \times \pi. \text{ (r is radius, } \pi \text{ is } \sim 3.14)$$

The fairy ring in this example has a 5 ft radius + 10 ft buffer = 15 ft.

$$\text{Area to be treated} = 15 \times 15 \times 3.14 = 706.5 \text{ ft}^2$$



B. Calculate the rates of Indar and Abound for your fungicide mix.

The rate for Indar will be equal to the fairy ring area (ft²) multiplied by 0.0028 fl oz.

The rate for Abound is equal to the fairy ring area (ft²) multiplied by 0.004 fl oz.

For every ft² to be treated, use 0.1 to 0.2 gallons of water. Apply the tank mix evenly over the affected area (entire ring area plus the 10 ft outer margin). If you need assistance in managing the fairy ring or calculating fungicide rates or if the area is larger than one-tenth of each acre, please contact the Extension Plant Pathologist at the Cranberry Station.

DISEASE MANAGEMENT NOTES

1. Read and follow label instructions. Always check the label for variations in restricted entry intervals and worker protection standards.
2. Ensure that all pesticide applications are made in a manner that prevents contamination of streams, ponds, and public areas. Impound water (as per label) for as long as possible after applying.
3. **THREAT FOR DEVELOPMENT OF RESISTANCE** to Abound, Indar, Proline, and Quadris Top by the fruit rot fungi is very real and serious. Applications of the fungicide should be made pre-infection rather than post-infection to minimize resistance development. See Resistance Management section.

These products are most effective when applied during early to mid-bloom (20-50%) and it is highly recommended to not use Group 11 products (e.g., Abound, Satori) as standalone products; instead mix them with Group 3 products (e.g., Indar or Proline). The number of fungicide applications should be based on the label instructions and the Keeping Quality Forecast.

4. When applying half-rates, the maximum number of applications (not material applied) must not be exceeded. It is not recommended to use a rate below the lowest recommended rate on the label.
5. Use Abound very carefully and avoid drift if the bed is next to a McIntosh apple orchard, as the fungicide is highly phytotoxic to this cultivar. See Resistance Management section.
6. **PRE-MIX** fungicides with a small amount of water until a smooth suspension is obtained before final dilution. Use immediately. Blossom injury may occur with concentrate sprays especially when sprayed by air when the temperature on the bog is above 85 °F. Do not combine any copper fungicide with an insecticide. Do not tank mix copper compounds with Aliette or any of the phosphites for Phytophthora unless appropriate precautions have been taken to buffer the spray solution or severe phytotoxicity will result. Call plant pathologist for information on buffering.
7. Consider delaying harvest to obtain acceptable color in thick vines or when mancozeb is used.
8. **SANDING** and **FERTILIZING**. Regular and uniform sanding most likely helps to reduce inoculum of the fungi that cause fruit rot. Sanding and late water flooding should not be done during the same year.
9. **SPREADER STICKERS** are contained in most fungicides. The addition of wetting agents or spreader stickers to Bravo, Echo, or Equus may cause phytotoxicity damage. Please check the fungicide label. **NOTE:** the addition of spray adjuvants will improve the distribution and deposition of all mancozeb chemicals.
10. **STORED PESTICIDES** may deteriorate. Avoid freezing liquid formulations. It is not advisable to use old materials in opened containers. Follow Pesticide Bureau regulations for disposing of pesticides and their containers.
11. Review the Disease Management BMP in the UMass Best Management Practices Guide: ag.umass.edu/cranberry/publications-resources/best-management-practices
12. **Organic Options**. Some fungicides are certified organic for disease management in cranberry. They include many of the coppers, but check with OMRI (www.omri.org) or your certifier for approved products.

INSECT MANAGEMENT 2024 - 2026

Prepared by Anne L. Averill and Martha M. Sylvia

Essential Points!

Start scouting bogs early May. Black-headed fireworm, green spanworm and winter moth larvae may be active early but larvae are difficult to see until mid-May. Always gauge levels of pest caterpillars in their early stages! As the caterpillars of many species grow larger, they cling more tightly to the vine or hide in daytime and are harder to pick up in daytime sweep netting.

Immature cranberry **black bug** and blunt nosed leafhopper appear as tiny green/yellow nymphs in mid May. These must be discerned from harmless springtails (Collembola). Be aware that most pests can be very patchy or in coves or edges, particularly scale, black bug, cranberry weevil, spongy (gypsy) moth, black-headed fireworm, and brown spanworm. Thorough assessment of total acreage is essential.

Vaccinium scale can be detected in spring by walking the bog and looking for off color or weak areas. Carefully look for live scales on the oldest parts of the uprights.

Keep an eye on Cranberry Fruitworm. Management with Altacor has reduced populations, but there may be pressure. Cultivars with the earliest fruit sizing up may be hard hit with egg-laying. Be aware that there may be two peaks of fruitworm egg-laying: a large one in late June, early July with a second smaller peak towards the end of July.

Be careful with advanced growth. Be aware that the new growth and early flower buds on newer cultivars, sanded areas, and renovations may be magnets for pest insects. Cranberry weevil, in particular, can move to beds with advanced vine development. Feeding on new growth and egg-laying is of concern. All insect activity could be moved 2 weeks forward.

Sweep netting. Using a 12" net and 180° sweeps into the vine, sweep netting should be conducted at least once a week. A sweep set consists of 25 sweeps across the bog. The insects in the net should be properly identified, counted, and recorded. Conduct 1 set of 25 sweeps for each acre. For larger pieces (more than 20 acres), at least 1 sweep set/2 acres is advisable. In multiple-acre pieces, calculate the average number of each insect in all of your sweep sets. Treat only after the average numbers of each insect in your series of sweep sets exceeds these values, and after other external concerns have been considered including cost of application, expected returns, weather, etc.

Action Thresholds for Common Cranberry Pests
Based on Average Numbers of Insects in Sets of 25 Sweeps

	AVERAGE #		AVERAGE #
ADD UP: blossomworm, false armyworm, other cutworms, and spongy (gypsy) moth	4.5	black-headed fireworm	1 to 2
flea beetle	15	<i>Sparganothis</i> fruitworm	1 to 2
brown and green spanworm, winter moth	18	cranberry weevil	4.5 in spring 9 in summer

In sweep net sampling, the average numbers of a pest that we use to trigger a management measure is only a guide. It serves as an indication that an insect pest is being sampled at numbers that we consider high and worthy of attention. Significant pressure by cranberry weevil and particularly by black-headed fireworm and *Sparganothis* fruitworm should be attended to in the spring; infestations are harder to manage in the summer.

Reducing inputs to cut production costs. Key insect management practices should be the last ones eliminated to save money. It is seldom advisable to skip the first cranberry fruitworm spray (initial spray in IPM-based programs when most pinheads have set and berries have begun to size up) unless late water has been held. This first spray targets the largest portion of the population. Sweep netting in early to mid-May is important to detect spongy (gypsy) moth and black-headed fireworm. Finally, walk the bog both early and late in the season to inspect for injury from scale and fireworms to detect pests that have long term impacts.

Pheromone traps. Traps can be used for timing management of black-headed fireworm and *Sparganothis* fruitworm and should be up by June 1. Use 1 trap/10 acres. Place on upwind side of bog. Check and clean traps weekly, recording number of moths captured. Change bait every 3 weeks.

Based on pheromone trap catches...

For black-headed fireworm: treat summer generation with Altacor or Intrepid and apply 2 weeks after **onset** of moth flight (~6/20), and again 10 days later. For *Sparganothis* fruitworm: if treating with Altacor or Intrepid, apply 3 weeks after the moth flight **begins** (~late June), and again 10-14 days later. If using Delegate, apply 10-14 days after **peak** moth captures, (~mid-to-late July); vines wet with Delegate spray pose high risk to bees, time the spray to allow drying by morning. Dried residues are considered safe.

For *Sparganothis* fruitworm: if treating with Altacor or Intrepid, apply 3 weeks after the moth flight **begins** (~late June), and again 10-14 days later. If using Delegate, apply 10-14 days after **peak** moth captures, (~mid-to-late July). Vines wet with Delegate pose a risk to honey bees. Dry residues are considered safe. Time spray to allow for drying by morning.

BEES!!! Most insecticides are toxic to bees, especially direct applications. Do not apply or allow to drift to cranberries in bloom or nearby blooming plants/weeds if bees are foraging. Bumble bees may be equally vulnerable to sprays applied at bloom; populations will dwindle over time if they are not protected.

Bee protection is complicated:

If possible:

- Leaving some beds of untreated flowers allows dilution of pesticide concentration experienced by bees. Even for pesticides considered bee-safe (fungicides, Altacor, Intrepid), unbroken areas of treated mass bloom may result in risk for colonies.
- Expanding the number of days pre-bloom that many insecticides are applied may reduce residues in pollen. Bee-toxic Sevin, Diazinon, and Actara are absorbed by the plant and move systemically into developing flowers and contaminate the pollen.
- Research in other crops has shown that the combined effect of some insecticides/fungicides (tank mixes of Altacor/Indar, Altacor/Proline, and Altacor/QuadrisTop) impact honey bee colony health.

INSECTICIDE TOXICITY TO HONEY BEES

Admire/Alias	imidacloprid	
Actara	thiamethoxam	
Delegate	spinetoram	super
Entrust	spinosad	toxic
Fanfare	bifenthrin	
Nexter	pyridaben	
Scorpion	dinotefuran	
Avaunt	indoxacarb	
Closer	sulfoxaflor	
Diazinon	diazinon	highly
Exirel	cyantraniliprole	toxic
Imidan	phosmet	
Orthene	acephate	
Sevin	carbaryl	
Verdepryn	cyclaniliprole	
Altacor	chlorantraniliprole	practically
Intrepid	methoxyfenozide	non-toxic
Confirm	tebufenozide	

Cranberry Insect Pests Commonly Encountered in Massachusetts

Insect Life Histories: Insects undergo change as they grow in a process called metamorphosis. In *complete metamorphosis*, there are four stages: egg, larva, pupa, and adult (see Figure 1). The larva bears no resemblance to the adult. The pupa is an inactive stage where adult structures are formed. Adults no longer molt or grow but they mate and reproduce. Many cranberry insects, including black-headed fireworm and cranberry weevil undergo complete metamorphosis.

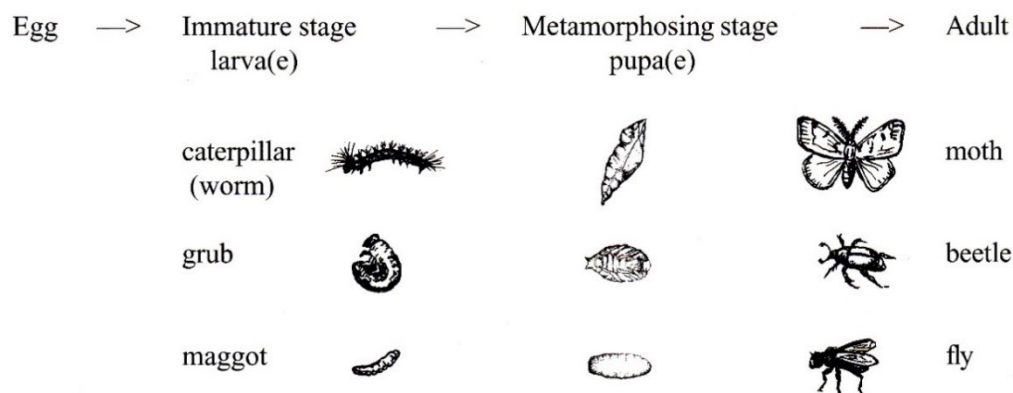
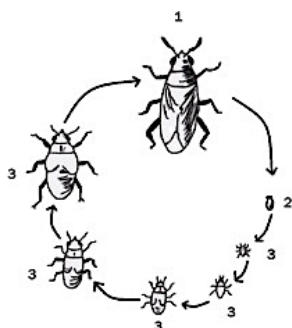


Figure 1. Life stages for insects undergoing complete metamorphosis (Illustration: Albright and Garnett)



In *gradual metamorphosis*, there are only three stages: egg, nymph and adult (see Figure 2). Nymphs are the growth stage and their wings gradually develop. Several pest species, including cranberry black bug and blunt-nosed leafhopper undergo gradual metamorphosis.

Figure 2. Gradual metamorphosis, with number: 1) adult; 2) egg; 3) nymphs (immatures with developing wings). Image: M.A. Ayieko

SPRING AND EARLY SEASON PESTS

Vaccinium SCALE (*Diaspidiotus* sp.) (and Dearness Scale, Latania Scale, etc.).

Vaccinium scale populations should be assessed in the spring. There are two generations, one in spring, another in summer. Treatment should only occur when the crawlers have been released (mid-June, mid-August) but care must be taken when bees are present.

Sevin XLR Plus Carbaryl 4L	1.5-2 qt	FIFRA 2(ee) recommendation. Do not apply when bed is in bloom. 5 apps/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict with much longer PHI.
Diazinon 50 W Diazinon AG 500	4-6 lb 2-3 qt	FIFRA 2(ee). Hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, and 14-day spray interval. Do not apply when bees are present.
Fanfare EC, 2EC, ES <i>bifenthrin</i>	6.4 fl oz	FIFRA 2(ee). RESTRICTED USE due to aquatic toxicity. Handler restrictions! Check with your handler. 12-hr REI. Do not apply to flow through bogs. Before applying, drop ditch water, place flume boards, check the weather for rain, and hold water for 3 days at least and longer if possible. 2EC and ES formulations are phasing out at the end of 2024.
Late Water	Holding late water for 4 weeks in the spring causes mortality in scale populations and those that survive do not reproduce, effectively suppressing the population. This is an excellent IPM option. See Late Water section for advice on holding the late water flood.	

CRANBERRY WEEVIL (*Anthonomus musculus*)

Bolded selections are the best choices for management. All rates are per acre.

Actara <i>thiamethoxam</i>	2-4 oz	Effective against both spring and summer adult populations. Be aware that when used in spring this neonicotinoid moves into pollen and nectar. Lower rates are effective. <u>Restricted Use and Zone II restricted</u> . Do not apply by air or to flow-through bogs. Highly toxic to bees – do not apply within 5 days of bee arrival. Hold water 5 days.
Avaunt Avaunt eVo <i>indoxacarb</i>	6 oz	Many populations show resistance to this compound. Effective against spring weevil populations only. Do not use after bloom against weevil in summer. Only 2 apps allowed targeting weevil in spring, prior to bloom. 7 days between applications. No flow-through bogs, hold water 1 day. Toxic to bees.
Exirel <i>cyantranilprole</i>	10-20.5 fl oz	FIFRA 2(ee) recommendation. Limited in-field efficacy trials, but an option to manage weevil populations.
Fanfare EC, 2EC, ES <i>bifenthrin</i>	6.4 fl oz	FIFRA 2(ee) recommendation. RESTRICTED USE due to very high aquatic toxicity. Handler restrictions! Check with your handler. 12 hr REI. Do not apply to flow through bogs. Before applying, drop ditch water, place flume boards, check the weather for rain, and hold water for 3 days at least and longer if possible. Labels for 2EC and ES expire Dec 2024.

Weevil Management: Cranberry weevil has developed sequential resistance to compounds over time. Use Avaunt (indoxacarb) if it still shows efficacy on your bogs; in the event of Avaunt failures, switch to Actara (thiamethoxam); in the event of Actara failures, switch to Fanfare (bifenthrin). For resistance management, if you have success with more than one compound, rotate them.

Action threshold is an average of 4.5 weevils in 25 sweeps for spring population, and 9 weevils in summer. Summer feeding is not as damaging as spring feeding and egg-laying. Adult weevils are found throughout the growing season. Sweep-net for weevil when warm, sunny, and calm. Let net contents settle: weevils "play dead" when disturbed. Do not count non-pest gray weevils. Spring weevils move in from the woods and blueberry outside the bog; consult sweep records from previous years to determine invasion pattern. Even if threshold is exceeded, sometimes it is advisable to wait 1-2 weeks in spring to treat. Weevil numbers may continue to rise as more weevils move in. However, waiting too long becomes risky if blossom buds have appeared and eggs are being laid. Late water is not effective against weevil. Early developing new hybrid cultivars may be infested by weevil earlier than heritage cultivars. Sanded and new plantings are magnets for earliest weevil activity.

Blunt nosed LEAFHOPPER (*Limotettix vaccinii*)

This insect appears as a nymph (tiny green bug) in May and may be managed then. This insect vectors false blossom disease. Adults appear in July, and this timing could be a second window for treatment. Any broad-spectrum applications should keep populations in check.

Diazinon 50 W	4-6 lb	FIFRA 2(ee) recommendation. Hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, and 14-day spray interval. Do not apply when bees are present.
Diazinon AG 500	2-3 qt	
Diazinon AG 600	51-76.5 fl oz	
Sevin XLR Plus Carbaryl 4L	1.5-2 qt	FIFRA 2(ee) recommendation. Do not apply when bed is in bloom. 5 apps/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict with much longer PHI.
Fanfare EC, 2EC, ES bifenthrin	6.4 fl oz	FIFRA 2(ee) recommendation. RESTRICTED USE due to extreme aquatic toxicity. Handler restrictions! Check with your handler. 12 hr REI. Do not apply to flow-through bogs. Before applying, drop ditch water, place flume boards, check the weather for rain, and hold water for 3 days at least and longer if possible. 2EC and ES formulations are phasing out at the end of 2024.
Actara, Assail, and Cormoran were found to be effective in NJ screening trials. FIFRA 2(ee) recommendation based on efficacy in NJ.		

Cranberry BLACK BUG (*Plagiognathus repetitus*)

This insect appears as a nymph (tiny green bug) in May and should be managed then to avoid that year's crop loss. Adults appear in July, and this timing and could be a second window for treatment. Any broad-spectrum application should keep populations in check.

Sevin XLR Plus Carbaryl 4L	1.5-2 qt	FIFRA 2(ee) recommendation. Do not apply when bed is in bloom. 5 apps/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict with much longer PHI.
Diazinon 50 W	4-6 lb	FIFRA 2(ee) recommendation. Hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, and 14-day spray interval. Do not apply when bees are present.
Diazinon AG 500	2-3 qt	
Diazinon AG 600	51-76.5 fl oz	
Fanfare EC, 2EC, ES bifenthrin	6.4 fl oz	FIFRA 2(ee) recommendation. RESTRICTED USE due to extreme aquatic toxicity. Handler restrictions! Check with your handler. 12 hr REI. Do not apply to flow through bogs. Before applying, drop ditch water, place flume boards, check the weather for rain, and hold water for 3 days at least and longer if possible. 2EC and ES formulations are phasing out at the end of 2024.

**CUTWORMS (BLOSSOMWORM, FALSE ARMYWORM),
HUMPED GREEN FRUITWORM AND SPONGY (Gypsy) MOTH**

Bolded selections are the best choices for management. All rates are per acre.

Assail 30 SG, Anarchy <i>acetamiprid</i>	4.0-6.9 oz	7 days between apps, 2 apps maximum. Do not flood for 60 days.
Avaunt, Avaunt eVo <i>indoxacarb</i>	6 oz	FIFRA 2(ee) recommendation. 7 days between applications, do not use on flow-through bogs, hold water 1 day.
Dipel ES Biobit, Xentari, Dipel DF, Crymax	1-4 pt 0.5-2 lb	<u><i>Bacillus thuringiensis (B.t.)</i></u> products. Multiple applications, addition of an adjuvant, and good coverage in low gallonage are essential.
Delegate WG <i>spinetoram</i>	3-6 oz	Do not exceed 19.5 oz/season. 7 days between apps. Only use lower rates if rinse time is 4 minutes or less.
Diazinon 50 W Diazinon AG 500 DiazinonAG 600	4-6 lb 2-3 qt 51-76.5 fl oz	FIFRA 2(ee) recommendation. Hold water for at least 3 days. 5 day REI!! 3 apps/season, 7-day PHI, 14-day spray interval.
Intrepid 2F Invertid 2F <i>methoxyfenozide</i> Confirm 2F <i>tebufenozide</i>	10-16 fl oz 16 fl oz	Insect growth regulator products, these compounds need to be eaten. Note methoxyfenozide is restricted use and Zone II restricted. Safe for pollinators and natural enemies. Confirm is being phased out.
Orthene 97, Acephate 97 UP Acephate 90 WSP, 90 WDG Acephate 90 Prill <i>acephate</i>	1 lb 1.1 lb	Do not apply within 10 days of start of bloom until all berries set due to bee repellancy concerns. 1 app/season. Observe 90-day PHI, except 75-day PHI with some Acephate 90, 97, 97UP only – check label.
Sevin XLR Plus, Carbaryl 4L <i>carbaryl</i>	1.5-2 qt	5 applications/season, 7-day spray interval, 7-day PHI.

The action threshold for cutworms is an average of 4.5 larvae per 25 sweeps. Count all cutworms and spongy (gypsy) moths together. Very young false armyworm caterpillars are whitish with black spots, each with a black spine. These caterpillars tend to loop like spanworms but gradually drop this movement. Early detection is important because they consume the terminal buds before new growth starts. As cutworms get older, they will not be picked up in day sweeps.

For spongy (gypsy) moth, check for patchy infestations and spot treat, i.e., along edges facing uplands with infested trees. Larvae balloon in from trees. Check previously infested areas - eggs can overwinter on flooded bogs.

SPANWORMS
(GREEN SPANWORM, BROWN SPANWORM, BIG CRANBERRY SPANWORM, WINTER MOTH)

Bolded selections are the best choices for management. All rates are per acre.

Avaunt Avaunt eVo <i>indoxacarb</i>	6 oz	7 days between apps, no flow-through bogs, hold water 1 day.
Dipel ES Biobit, Xentari, Dipel DF, Crymax	1-4 pt 0.5-2 lb	<i>Bacillus thuringiensis (B.t.)</i> products. Multiple applications, addition of an adjuvant, and good coverage in low gallonage are essential. Target small caterpillars.
Delegate WG <i>spinetoram</i>	3-6 oz	Do not exceed 19.5 oz/season. 7 days between applications. Only use lower rates if rinse time is 4 minutes or less. If infestation appears during bloom, remember this compound is highly toxic to bees, but dried residues are considered safe; sprays must go on at night and dry by morning.
Imidan 70W <i>phosmet</i>	1.33-4 lb	REI of 3 days, 10-day spray interval, 14-day PHI.
Intrepid 2F Invertid 2F <i>methoxyfenozide</i> Confirm 2F <i>tebufenozide</i>	10-16 fl oz 16 fl oz	These are insect growth regulator products and need to be eaten, applied multiple times in low gallonage, and target small caterpillars. Methoxyfenozide is restricted use and Zone II restricted. Safe for pollinators and natural enemies. Confirm is being phased out.
Orthene 97, Acephate 97 UP Acephate 90 WSP, 90 WDG Acephate 90 Prill <i>acephate</i>	1 lb 1.1 lb	Do not apply within 10 days of start of bloom til all berries set due to bee repellancy concerns. 1 app/season. Observe 90-day PHI, except 75-day PHI with some Acephate 90, 97, 97UP only – check label.
Pyganic EC 1.4 Pyganic EC 5.0	16-64 fl oz 4.5-18 fl oz	Spot treating using low gallonage may be helpful for patchy infestations. Beware bee toxicity. Do not apply when bees are present.
Sevin XLR Plus, Carbaryl 4L <i>carbaryl</i>	1.5-2 qt	FIFRA 2(ee) recommendation for winter moth. Limit 5 apps/season, 7day spray interval, 7-day PHI.

Green spanworm caterpillars start to appear in early season sweeps. They pupate at the end of May and white/yellow moths can be seen flying close to the vines in June. The action threshold for spanworm is an average of 18 small larvae in 25 sweeps. Threshold may be lowered for large larvae.

Brown spanworm larvae occur later but have been rare in recent years.

Scout for winter moth much earlier than for other spanworms, as early as May 1. If you have a history of winter moth infestation, you may need to apply a prophylactic spray early in the season. Larvae balloon in from infested trees. Injury may be done to the developing buds before populations can be detected and impact yield.

BLACK-HEADED FIREWORM (*Rhopobota naevana*)**Bolded selections are the best choices for management. All rates are per acre.**

Altacor Altacor eVo <i>Chlorantraniliprole</i> Exirel <i>cyantraniliprole</i> Verdepryn <i>cyclaniliprole</i>	3-4.5 oz 1.5-2.2 oz 10-20.5 fl oz 8.2-11 fl oz	Low rinse time required for efficacy. Must target eggs or tiny larvae. 7 days between applications (Altacor and Exirel), 5 days (Verdepryn). Exirel and Verdepryn cannot be applied during bloom. 12-hr REI (Exirel), 4-hr REI (Altacor and Verdepryn).
Avaunt Avaunt eVo <i>indoxacarb</i>	6 oz	7 days between applications. 30-day PHI. Do not use on flow-through bogs, hold water 1 day.
Delegate WG <i>spinetoram</i>	3-6 oz	Max 19.5 oz/season. 7 days between apps. Only use lower rates if rinse time is 4 minutes or fewer. If using during bloom, sprays must go on at night and dry by morning. This compound is highly toxic to bees, but dried residues are considered safe.
Diazinon 50 W Diazinon AG 500 Diazinon AG 600	4 lb 2 qt 51 fl oz	It is advisable to hold water for at least 3 days. 5-day REI!! 3 apps/season, 7-day PHI, and 14-day spray interval. Do not apply during bloom.
Imidan 70W <i>phosmet</i>	1.33-4 lb	REI 3 days, 10-day spray interval, 14-day PHI.
Intrepid 2F Invertid 2F <i>methoxyfenozide</i> Confirm 2F <i>tebufenozide</i>	10-16 fl oz 16 fl oz	These are insect growth regulator products and need to be eaten, applied multiple times in low gallonage, and target small caterpillars. Methoxyfenozide is restricted use and Zone II restricted. Safe for pollinators and natural enemies. Confirm is being phased out.
Orthene 97, Acephate 97UP Acephate 90 WSP, 90 WDG Acephate 90 Prill <i>acephate</i>	1 lb 1.1 lb	Do not apply within 10 days of start of bloom until all berries set due to bee repellancy concerns. 1 app/season. Observe 90-day PHI, except 75-day PHI with some Acephate 90, 97, 97UP only – check label.
Sevin XLR Plus, Carbaryl 4L <i>carbaryl</i>	1.5-2 qt	5 applications/season, 7-day spray interval, 7-day PHI. Bee toxic, do not spray during bloom.
Spring Flood		A 48-hour flood in May was historically used to impact black-headed fireworm and yellow-headed fireworm. Care must be observed. These floods must be completed before roughneck stage. A flood too late could increase fruit rot and reduce the crop.

Watch out: Fireworm can be a very serious problem! *Start inspecting in early spring.* This pest is easy to manage if infestation is detected early. Larvae hatch in mid-May; even earlier in warm springs. Small larvae are hard to pick up and see in sweep net. Larvae do not grow bigger than 1/3 inch.

Second generation is active during bloom. Use pheromone traps to time management of second generation. Black-headed fireworm moths are only 1/4" long and are black and gray; exclude larger, non-pest moth caught in traps. For summer generation with Intrepid or Altacor, timing is 2 weeks after **onset** of moth flight (~6/20), and again 10 days later. Do not use Diazinon, Orthene or Sevin during bloom; it is illegal and will interfere with pollination.

Infestations move rapidly! Spring generation is a much easier target than the second generation (occurs during bloom).

YELLOW-HEADED FIREWORM (*Acleris minutum*)

Orthene, Sevin, and spinosyn products (**Delegate** and Entrust) can be used as specified for black-headed fireworm (see previous page). **Intrepid** and **Diazinon**, FIFRA 2(ee) recommendations, can be used as specified for black-headed fireworm.

Yellow-headed fireworm may appear on beds that are not completely flooded in the winter. Eggs are laid in April and hatch in May. Caterpillars are all yellow and are impossible to distinguish from Sparganothis. The yellow-headed fireworm pupa has a knob at its top, while Sparganothis pupae do not. The overwintering moths are slate grey and the summer generation moths are bright yellow.

SPARGANOTHIS FRUITWORM (*Sparganothis sulfureana*)

Bolded selections are the best choices for management. All rates are per acre.

Altacor	3-4.5 oz	Low rinse time required for efficacy. Must target eggs or tiny larvae. 7 days between applications (Altacor and Exirel), 5 days (Verdepryn). Exirel and Verdepryn cannot be applied during bloom. 12-hr REI (Exirel), 4-hr REI (Altacor and Verdepryn).
Altacor eVo	1.5-2.2 oz	
<i>Chlorantraniliprole</i>		
Exirel	10-20.5 fl oz	
<i>cyantraniliprole</i>		
Verdepryn	8.2-11 fl oz	
<i>cyclaniliprole</i>		
Assail 30SG, Anarchy <i>acetamiprid</i>	4.0-6.9 oz	7 days between apps, 2 apps. Wait 60 days before flooding. Toxic to bees.
Delegate WG <i>spinetoram</i>	3-6 oz	Max 19.5 oz/season. 7 days between apps. Only use lower rates if rinse time is 4 minutes or fewer. If using during bloom, sprays must go on at night and dry by morning. This compound is highly toxic to bees, but dried residues are considered safe.
Intrepid 2F Invertid 2F <i>methoxyfenozide</i>	10-16 fl oz	These are insect growth regulator products and need to be eaten, applied multiple times in low gallonage, and target small caterpillars. Methoxyfenozide is restricted use and Zone II restricted. Safe for pollinators and natural enemies. Confirm is being phased out.
Confirm 2F <i>tebufenozide</i>	16 fl oz	

Small Sparganothis caterpillars are picked up in the sweep net in mid-May. Check for caterpillars in yellow loosestrife tips that have rolled leaves; this will give you an idea of the larva's appearance so you can ID them in the net. The 2nd generation in July feeds on both fruit and foliage. **With both generations, always target the small caterpillars.** Keep an eye on large-fruited cultivars, which tend to be hardest hit; Howes the least. The 2nd generation caterpillars are difficult to manage because they feed inside large fruit.

Beginning in June, use pheromone traps to determine moth flight. When managing 2nd generation population, you want to target caterpillars as they are hatching, not the adult moths. If treating with growth regulator (Intrepid) or Altacor, apply insecticide 3 weeks after the moth flight begins, (~late June), and make at least one more application 10-14 days later. When treating with Delegate, apply 10-14 days after peak moth captures (~mid-to-late July).

Sparganothis populations are resistant to the organophosphates, including Diazinon and Orthene. Intrepid and Delegate are excellent alternatives. Late water has not been shown to be effective against this insect, but it does synchronize moth emergence.

CRANBERRY FRUITWORM (*Acrobasis vaccinii*)

Moths fly in June. Females hold off laying eggs until pinheads have started to size up. Large-fruited cultivars are hard hit with early egg laying. Management of Howes should be later than all other varieties as berries are later to size up. A second peak of egg laying may occur at the end of July.

Bolded selections are the best choices for management. All rates are per acre.

Late Water	Holding late water in the spring is an excellent cultural practice that severely reduces fruitworm when held for the full duration of 4 weeks. It is possible that sprays can be eliminated.
-------------------	--

Early fruitworm spray options, when bloom is present (~6/20-7/10):

Altacor	3-4.5 oz	<u>Highly recommended</u> for first fruitworm at 50% out of bloom and when pinheads have started to size up for all varieties, except on Howes (wait 7 days). Targets the eggs as they hatch. Timing is end of June, early July. 2 apps at least 7 days apart are allowed. Spacing at 10-14 days apart is recommended due to a very long residual. Low rinse time required for efficacy.
Altacor eVo <i>chlorantraniliprole</i>	1.5-2.2 oz	
Intrepid 2F Invertid 2F <i>methoxyfenozide</i>	10-16 fl oz	Some larvae make it through to enter fruit, so control is not complete. Restricted use and Zone II restricted. Low gallonage only. 4 applications allowed at the 16 oz rate. Moderate residual. Safe for bees and natural enemies
Delegate WG <i>spinetoram</i>	3-6 oz	Best choice for later applications after Altacor is used. Moderate residual. 3 applications allowed at the 6 oz rate. Do not exceed 19.5 oz/season. <u>Caution:</u> highly toxic to bees. Thoroughly dried residues are considered safe. Thus, sprays must go on at night and dry by morning if sprayed during bloom.

Later fruitworm options once bloom is complete: all of these choices are toxic or highly toxic to bees and should not be applied to beds with bloom. Exception is Delegate (see caution above).

Assail 30 SG, Anarchy <i>acetamiprid</i>	4.0-6.9 oz	7 days between applications, 2 apps maximum, 1 day PHI. Short-lived residual.
Delegate WG <i>spinetoram</i>	3-6 oz	Good choice for late fruitworm applications. Medium-lived residual. See caution above.
Diazinon 50 W Diazinon AG 500 Diazinon AG 600 WBC <i>diazinon</i>	4-6 lb 2-3 qt 51-76.5 oz	It is advisable to hold water for at least 3 days. 5-day REI. 3 apps/season, 7-day PHI, and 14 days between sprays, except AG500, which has a 7-day minimum. Short-lived residual.
Exirel <i>Cyantraniliprole</i>	10-20.5 fl oz	Low rinse time required for efficacy. Must target eggs or tiny larvae. 7 days between applications (Exirel), 5 days (Verdepryn). Handler restrictions – check with your handler! 12-hr REI for Exirel, 4-hr REI for Verdepryn.
Verdepryn <i>cyclaniliprole</i>	8.2-11 fl oz	
Imidan 70W <i>phosmet</i>	1.33-4 lb	Efficacy results have been variable, use higher rate. REI of 3 days, 10-day spray interval, 14-day PHI.
Sevin XLR Plus Carbaryl 4L <i>carbaryl</i>	1.5-2 qt	Short-lived residual. Limit of 5 applications/season. 7-day spray interval, 7-day PHI. Beware, most handlers restrict with much longer PHI.

Important general considerations for **cranberry fruitworm management**:

1. Target only eggs. They are inside the berry calyx. Early larvae in fruit cover entrance with white silk.
2. Do not treat in attempt to control caterpillars in the fruit or expect that you can manage them as they move between fruit. Research shows that sprays made after caterpillars have entered fruit are wasteful and minimally effective.
3. Red berries indicate a missed treatment; caterpillars are protected now and feeding inside the berry.
4. Today, fruitworm populations may be very low on bogs that have had well-timed Altacor sprays; thus, the need for a series of three sprays like the old days may not be cost effective. (See Option 2 below where presence of an infestation is used to trigger a spray).
5. To truly estimate how big a cranberry fruitworm infestation is on a bog, sampling of berries must be random (close your eyes when your reach for a berry). Collect berries across the whole bog.
6. Use magnification when assessing eggs. Look at eggs carefully to be sure they are alive. As you move into the season, many eggs are dead or parasitized. Do not count these.
7. Be careful that you do not count newly settled Vaccinium scale; crawlers like to settle inside of the berry calyx and form a waxy cover that can be mistaken for a fruitworm egg.
8. Consider two possible approaches to managing fruitworm, 1) a prophylactic option based on plant development where you spray and assume there is fruitworm pressure present, or 2) a sampling program searching for eggs in berry calyx to determine if or when treatments are triggered.

OPTION 1: USING PLANT DEVELOPMENT TO TIME EARLY FRUITWORM MANAGEMENT

1st treatment

Calculate % out of bloom (*% flowers that have lost petals or become pinheads/fruits*)

To properly time your first spray, calculate the % out-of-bloom every few days as pinheads start to form, usually around the end of June. You are trying to accurately assess when 50% OOB occurs and to estimate the onset of berry development. For each acre of bog, randomly collect 10 uprights and record the number of flower buds, flowers, pinheads, and fruit.

Calculate using the following:

$$\% \text{ out-of-bloom} = \left(\frac{\text{total number of pinheads and fruit}}{\text{Total number flower buds, flowers, pinheads, and fruit}} \right) \times 100$$

For Early Blacks, Ben Lears, Stevens and large-fruited hybrids -- Apply 1st treatment 0-7 days after 50% out-of-bloom. For Howes -- Apply 1st treatment 7-9 days after 50% out-of-bloom.

2nd treatment

Apply about 10 days after 1st treatment.

3rd treatment

Sample berries and check for eggs to trigger this spray. Keep in mind that we may see a second peak of activity in late July.

One week after your 2nd treatment, inspect 50 randomly picked berries/A (with a minimum of 200 berries per piece, no matter how small piece is) for viable eggs. Follow guidelines in table below to determine necessity of additional sprays. If egg numbers trigger a spray, spray ASAP. If no egg is found, repeat berry inspection process every 3-4 days until Aug. 15 or longer if eggs are still being detected.

OPTION 2: SCOUTING FOR FRUITWORM EGGS TO DETERMINE NEED FOR TREATMENT

Starting after 50% out-of-bloom when berries have enlarged, inspect 50 randomly picked berries/A (with a minimum of 200 berries per piece, no matter how small piece is) for viable eggs. Follow guidelines in table below to determine necessity of sprays to avoid a projected 3% infestation of fruit. If egg numbers trigger a spray, spray ASAP. If no egg is found, repeat berry inspection process every 3-4 days until Aug. 15 or longer if eggs are still being detected.

TABLE USED (for all practices) TO DETERMINE NECESSITY OF MAKING A SPRAY

Number of acres	Number of berries checked	Number of viable eggs needed to trigger spray
0-5	200-250	1
5-7	251-350	2
7-9	351-450	3
9-11	451-550	4
11-13	551-650	5
13-15	651-750	6
for each additional 2 acres	add 100 berries	add 1 egg

CRANBERRY FLEA BEETLE (*Systema frontalis*)

Bolded selections are the best choices for management. All rates are per acre.

Actara <i>thiamethoxam</i>	2-4 oz	May only provide suppression of flea beetle. Restricted Use and Zone II. Do not apply by air or to flow-through bogs. Post-bloom only. Hold water 5 days!
Delegate WG <i>spinetoram</i>	3-6 oz	FIFRA 2(ee) recommendation. Delegate may only provide suppression of flea beetle. Do not exceed 19.5 oz/season. 7 days between applications.
Diazinon 50 W Diazinon AG 500 Diazinon AG 600	4-6 lb 2-3 qt 51-76.5 fl oz	FIFRA 2(ee) recommendation. Hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, and 14-day spray interval.
Imidan 70W <i>phosmet</i>	1.33-4 lb	FIFRA 2(ee) recommendation. Efficacy may be reduced at pHs found in bog water (pH 6-7). REI of 3 days, 10-day spray interval, 14-day PHI.
Scorpion Venom <i>Dinotefuran</i>	3.5-7 fl oz 2-4 oz	Check Handler Restrictions! Limited efficacy, likely only suppression, but an option for management. No chemigation. 30-day PHI.
Sevin XLR Plus Carbaryl 4L <i>carbaryl</i>	1.5-2 qt	5 applications/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict use after bloom.

Adult flea beetles are active in late July through September. Beetles and their feeding injury are very patchy, often in areas of lush vine. High levels of beetle feeding can impact bud development for the following year. Firm thresholds have not been quantified, but sweep net counts of 15 per 25 sweeps on average over all acreage is the trigger to consider management.

GOLDEN CASEBEARER (*Triachus vacuus*)

A tiny new beetle appeared in the last decade that causes feeding injury in June and July, showing as discrete brown areas and bloom damage. If beetles can be detected before bloom, a spray could be applied to manage them. Larvae feed on detritus on the bog floor and cannot be targeted.

Sevin XLR Plus Carbaryl 4L	1.5-2 qt	FIFRA 2(ee) recommendation. Do not apply when bed is in bloom. 5 apps/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict with much longer PHI.
Diazinon 50 W	4-6 lb	FIFRA 2(ee) recommendation. Hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, and 14-day spray interval. Do not apply when bees are present.
Diazinon AG 500	2-3 qt	
Diazinon AG 600	51-76.5 fl oz	
Fanfare EC, 2EC, ES <i>bifenthrin</i>	6.4 fl oz	FIFRA 2(ee) recommendation. RESTRICTED USE due to extreme aquatic toxicity. Handler restrictions! Check with your handler. 12 hr REI. Do not apply to flow through bogs. Before applying, drop ditch water, place flume boards, check the weather for rain, and hold water for 3 days at least and longer if possible. 2EC and ES formulations are phasing out at the end of 2024.

CRANBERRY TIPWORM (*Dasineura oxycoccana*)

Early season tipworm injury often is high, but good vine health enhances rebudding. Appearance of injury does not mean that insects are still present. Only very late-season injury, which is rare, appears to consistently reduce yield. Stressful vine conditions in the year of injury may also result in yield reduction. Diazinon is labeled for tipworm, but control is very poor.

Sprays are strongly discouraged for this insect.

Movento <i>spirotetramat</i>	8-10 fl oz	Post-bloom application only. No chemigation on label currently. Be aware of handler restrictions.
---------------------------------	------------	---

PREVIOUSLY COMMON INSECTS BUT SELDOM SEEN NOW

SOIL INSECTS

SCARAB GRUBS

Admire Pro	7-14 fl oz	<i>Imidacloprid</i> products. Use soil drench treatment. Limit 2 apps/season but 1 app at higher rate is recommended. No aerial app, 30-day PHI. <i>Best results are achieved when the compound is present just prior to egg hatch.</i> Irrigate before and after application, but do not apply to saturated soil. Compound has very long soil residual. Highly toxic to bees; do not apply when pollinators are on bog.
Alias 4F, Nuprid 4F, Wrangler	8-16 fl oz	
Malice Widow	16-32 fl oz	
Summer flood	Remove winter flood, allow bog to dry out. Reflow mid-May and keep well flooded until mid-July. This will eliminate cranberry root grub and cranberry white grub larvae, as well as the crop for that year. Oriental beetle and <i>Hoplia</i> are also likely impacted.	

Cranberry root grub (*Lichnanthe vulpina*) - grubs turn into low-flying beetle adults that look like bumblebees; they emerge from the soil during cranberry bloom and set. Males fly after dawn through mid-morning.

Cranberry white grub (*Phyllophoga anxia*) - grubs turn into large-bodied "June bugs" as adult beetles and are active in the evening in May and June.

Oriental beetle (*Anomala orientalis*) - small beetle (5/8 inch), vary greatly in color and pattern from light brown to black. Grubs develop over two years and are similar in appearance to small white grubs. An adult sex pheromone trap is available.

Hoplia equina - adult beetles emerge synchronously from the soil during bloom in late afternoon. The small brown beetles are about 5/16 inch in size. The grubs develop over two years and are similar in appearance to small white grubs.

In the spring, look for grubs in both root layer and lower soil associated with areas of weak or dying vines. In grub-infested areas, try to avoid stress to vines such as high doses of Casoron and drought.

BLACK VINE WEEVIL AND STRAWBERRY ROOT WEEVIL

(*Otiorhynchus sulcatus* and *Otiorhynchus ovatus*)

Nematodes	Availability limited—need to plan ahead and order well in advance of application. Target immatures (weevil grubs) in soil. Apply in early evening in May and/or September. Best results occur when soil temperatures are higher than 56°F. Irrigate before and after application.
Fall Flood	Flood for 10-14 days as soon as possible after harvest. May also negatively impact vines. Warmer water enhances effectiveness.
Winter Flood	If you can winter flood, populations should be less abundant.

In the spring, look for grubs in soil of areas with dying vines (often near bog edge) that may have an orange halo of vines around edges. Grubs feed on the bark of the vine. Adult beetles emerge in June; they must feed for about 4 weeks before egg-laying starts. Night sweep for weevils at edge of weevil-damaged areas, starting after dusk but before dew forms mid-June through July. Notched new foliage indicates adult feeding. Sweep when vines are dry. These pests are more abundant in bogs with no winter flooding or which have high spots.

CRANBERRY GIRDLER (*Chrysoteuchia topiarius*)

Nematodes	Availability limited—need to plan ahead and order well in advance of application. Apply Nematodes 2 weeks after end of moth flight. Target immatures in soil.
Fall Flood	Flood for 1 week, at end of September. Vines must be completely covered. These floods are best done when fruits have been removed. Research shows that this flood timing may negatively impact vine health.
Regular Sanding	Sanding with 1-3 inches every 3rd year will reduce favorable girdler habitat.

In June through July, appearance of silvery-white moths with a "snout" on front of head that make short, jerky flights as you walk through the vines may signal a problem. If there is a history of girdler on your bog, use pheromone traps to time treatments. Be aware of girdler's true appearance; a very similar non-pest moth is also picked up in traps. A bad girdler infestation can exist even with low pheromone trap catches. Just below the trash line, look for old feeding damage that may be quite deep in the wood of the vine. Thorough trash flows are beneficial.

STRIPED COLASPIS (*Colaspis costipennis*)

Admire Pro	7-14 fl oz	<i>Imidacloprid</i> products. Soil drench targets immatures in soil. When adult beetles are picked up in net, application should be made to target larvae as eggs hatch. Compound has very long soil residual. No aerial application. Limit 2 apps/season, but 1 app at higher rate is recommended. Irrigate before and after application. Highly toxic to bees; apply after bloom in mid-late July. 30-day PHI.
Alias 4F, Nuprid 4F Wrangler	8-16 fl oz	
Malice, Widow	16-32 fl oz	
Diazinon 50 W	4-6 lb	FIFRA 2(ee) recommendation targets adults. It is advisable to hold water for at least 3 days. 3 apps/season, 5-day REI, 7-day PHI, 14-day spray interval.
Diazinon AG 500	2-3 qt	
Diazinon AG 600	51-76.5 fl oz	
Sevin XLR Plus Carbaryl 4L	1.5-2 qt	FIFRA 2(ee) recommendation targets adults. Do not apply when bed is in bloom. 5 apps/season, 7-day spray interval, 7-day PHI. *Beware, most handlers restrict with much longer PHI.

Imidacloprid (Admire, Alias, etc.) applications should target hatching eggs in the soil. Diazinon and carbaryl (Sevin) sprays should target adults being picked up while sweep netting. Highly toxic to bees; advise beekeepers to remove or cover hives before application; these daytime applications will kill native bees foraging during bloom. The striped colaspis beetles are ca. 1/6" long and oblong-oval. Head area is metallic greenish-black and wings blackish, striped with yellow. Legs and antennae are yellow. Grubs in soil feed in root area, killing vines. Adult feeding results in distinct notching in top leaves of uprights, particularly in infested area. Prefers upland bogs.

SOUTHERN RED MITE (SRM) (*Oligonychus ilicis*)

Nexter <i>pyridaben</i>	4.4 – 10.67 oz	2 apps/season. Ground and chemigation only – no aerial application. Hold water for 3 days after application. No flow-through bogs. 5 hours of drying time required.
Late Water	Late water can eliminate mites in the year that the flood is held. In the second year following late water, mite pressure may still be low. See Late Water Section.	

Look for tiny red mites in sweep net and for red/orange streaks on rim of net or white card. Use a 10X magnifier to examine leaves to determine that mites are present; misidentifications frequently occur. Areas of discolored vines late in the season are often an indicator of mite infestation.

CHEMISTRY FAMILIES OF CRANBERRY INSECTICIDES

Diamide-based compounds. Altacor, Exirel and Verdepryn are newer chemistry insecticides registered in the diamide class of chemistry and provide a new mode of action compared to all other classes. They cause paralysis of the insect by sustained contraction of the muscles. It has excellent activity against our key lepidopteran pest (cranberry fruitworm). Altacor also has long residual activity and is safe to key natural enemies. Exirel and Verdepryn in comparison have high bee toxicity and cannot be used during bloom.

For all these compounds, a good chemigation system, under 6 minutes, is likely necessary to get good efficacy. Target eggs and tiny larvae, these compounds will not manage larger caterpillars effectively.

Bacillus thuringiensis (B.t.) based products. Examples labeled in cranberry are Dipel, Xentari, Crymax and Biobit. These compounds are most effective when applied multiple times and in low gallonage against small caterpillars feeding on foliage. Thorough coverage is essential. Well-timed chemigation systems are critical for good efficacy (6 minutes or less rinse time). *Early attention to infestation is critical.* Caterpillars stop feeding after eating compounds but may take several (3-10) days to die. Use aerial application or low-volume ground applications when possible to improve performance.

Insect growth regulator products. (Intrepid (methoxyfenozide), Confirm (tebufenozide) and Rimon (novaluron)). Growth regulators are caterpillar-specific, need to be eaten to work, and conserve natural enemies and pollinators. These compounds are most effective when applied multiple times and in low gallonage against small caterpillars feeding on foliage. Intrepid is restricted use and is Zone II restricted. Coverage and well-timed chemigation systems are critical for good efficacy (6 minutes or less rinse time); excessive chemigation washout will remove active material. A spray adjuvant should be used. 6 hours drying time following application is required. New vine growth is not protected. Larval death may not be observed until a week or more has passed. Pollinator safe!

Spinosyn-based products. These include Delegate and Entrust (an organic formulation). Delegate is more active and provides longer residual control than Entrust; Delegate is the compound of choice. Spinosad-based products are fast-acting nerve poisons but are still reduced-risk compounds. Allow 7 days between applications. These compounds are the better choice (compared to Intrepid) once the caterpillars have reached a larger size. For Delegate, only use lower rates if rinse time is 4 minutes or less. Keep in mind that spinosyn products can be toxic to natural enemies and are **highly** toxic to bees. Sprays made when bees are actively foraging must be avoided (this includes Entrust, even though it is an organic formulation!). Wet residues are toxic, dry ones are considered safe. If treating during bloom, be sure that overnight conditions are such that evening chemigation applications will dry by morning.

Neonicotinoid products. Neonicotinoids affect the nervous system of insects but have low human toxicity. They are the most toxic insecticides to bees. Do not apply during bloom. There are a number of neonicotinoid compounds registered in cranberry including Actara (thiamethoxam), Assail (acetamiprid), Scorpion/Venom (dinotefuran) and Admire (imidacloprid). While these compounds could help manage our insect complex, you should be informed before you use them.

Organophosphate and carbamate products. Organophosphate and carbamate products are in an older class of chemicals and are nerve agents acting on the enzyme acetylcholinesterase. These compounds are generally acutely toxic to bees, wildlife and humans. Do not apply during bloom. Diazinon, Imidan, Orthene and Sevin remain in use although much reduced. Sparganothis fruitworm, cranberry weevil, tipworm and leafminers are resistant to this chemistry.

Pyrethroids. (Fanfare, Danitol, Pyganic) Pyrethroid insecticides are an older class of chemicals and disrupt nerve signals by disrupting the sodium channel (sodium channel modulators). These compounds are acutely toxic to aquatics. They have low human contact toxicity but high oral toxicity. Do not apply during bloom.

NOTE: Restricted Use Insecticides (Actara, Diazinon, Fanfare, Intrepid, and Scorpion/Venom)

A private applicator certification is required to purchase, handle and apply these compounds to your bog.

REFLOODING OPTIONS

- a.) Late Water Flood – Starting April 10-20, hold water for 30 days to manage cranberry fruitworm, southern red mite, gypsy moth, and cutworms. See Late Water section.
- b.) Spring Flood – mid-late May, 24-hour reflow manages false armyworm and blossomworm, 48 hours necessary to impact black-headed fireworm and yellow-headed fireworm. Care must be observed as these floods must be completed before roughneck stage or likely to increase fruit rot and seriously reduce the crop.
- c.) Summer Flood – Mid-May to mid-July kills all insects, especially cranberry root grub and white grub, but with the loss of crop and impact on following years as well.
- d.) Fall Flood – Sept. 20-30. Flooding within this time for 1 week every third year discourages girdler and blossomworm. A 3- or 4-week flood at this point will manage cranberry fruitworm. These floods are best done when fruits have been removed. Research shows that this flood timing may negatively impact vine health.

44 INSECTS

ORGANIC OPTIONS FOR INSECT MANAGEMENT

Organic production may not be a profitable unless there is low to moderate insect pressure and a good water supply. Cranberry fruitworm, black-headed fireworm and cranberry weevil pose the greatest threats to viability. Certifiers work under standardized USDA rules. Growers who wish to be certified organic need to go through *Bay State Organic Certifiers* (www.baystateorganic.org). All inputs must be listed with OMRI (Organic Materials Review Institute; www.omri.org). Some products are listed as A (allowed) others as R (restricted). The restricted products have certain conditions attached to them that have to do with the generic materials in the product (amounts or frequency of application, etc.). OMRI also has a Generic Materials List. Three years of no synthetic chemical applications (transition period) are necessary before a crop can be certified organic.

Use of cultural practices (sanding and water floods) is the most effective strategy in organic management.

Late Water	Holding late water is an excellent choice to reduce cranberry fruitworm pressure; however, moths may move into late water-treated beds from other areas of infestation. False armyworm, blossomworm, gypsy moth, and southern red mite may be managed with late water. See Late Water Section.
Fall Flood	May be used to reduce cranberry girdler populations. Flood for 10-14 days as soon as possible after harvest. May also impact vines to some degree. Warmer water temperatures enhance effectiveness.
Sanding	If you can sand, populations of most insects should be less abundant.
Winter Flood	If you can maintain a good winter flood, populations of most insects should be less abundant.

These are options cleared for organic management on cranberry, but efficacy has not been quantitatively assessed.

<u>Azadirachtin products</u>		Target small caterpillars with this biological insecticide – it serves as a repellent, antifeedant, and interferes with the molting process.
Aza-Direct	1-3.5 pt	
<u>Bacillus thuringiensis (B.t) products</u>		These compounds are most effective when applied multiple times in low gallonage against small caterpillars feeding on foliage. Treating early infestations is critical. Well-timed chemigation systems are critical for good efficacy (6 minutes or less rinse time). Beware, not all B.t.s are certified organic or have cranberry on the label.
Dipel DF (<i>kurstaki</i> strain)	0.5-1 lb	
Biobit HP (<i>kurstaki</i> strain)	0.5-1 lb	
XenTari (<i>aizawai</i> strain)	0.5-1.5 lb	
Entrust 80W	1.25-3 oz	An effective, fast-acting, but short-lived spinosyn insecticide. More effective than Bt once caterpillars have reached a larger size. When chemigating, a short rinse time (6 minutes or less) is necessary for good efficacy. Spinosyn compounds are highly toxic to bees, but thoroughly dried residues are safe. Thus sprays must go on at night and dry by morning. Apply when drying conditions are optimal overnight.
Entrust SC	4-10 fl oz	
<i>spinosad</i>		
Grandevo	2-3 lb	No chemigation allowed. <i>Chromobacterium subtsugae</i> strain.
M-pede Insecticidal Soap	1-2% solution	No chemigation allowed.
<u>Neem Oil Products</u>		Useful as a dormant application for suppression of southern red mite egg hatch. Do not chemigate. Use 1% rate for ground application or 1 qt/A for aerial application in 10 gallons of water. Be aware that it accelerates plant growth stage and adjust frost protection accordingly. Also suppresses eggs and motile mites post bloom.
Trilogy		
Nematodes		Availability limited. Expensive but available organic option for grub and girdler management.
Pyganic EC 1.4	16-64 fl oz	Restricted. Spot treating using low gallonage may be helpful for patchy infestations. Note: other Pyrethins with added piperonyl butoxide are not allowed.
Pyganic EC 5.0	4.5-18 fl oz	
Venerate XC	1-4 qts	Heat-killed <i>Burkholderia</i> spp. strain A396. Ground or Aerial, no chemigation. 4-hr REI, 0-day PHI.

WEED MANAGEMENT 2024 - 2026

Prepared by Hilary A. Sandler and Katherine M. Ghantous

<u>Herbicides</u>	p. 59	Dewberry	p. 48
Callisto	p. 60	Goldenrod	p. 52
Casoron	p. 61	Grasses, Annual	p. 56
Devrinol	p. 62	Grasses, Perennial	p. 54
Evital	p. 63	Grass, Poverty	p. 51
Poast	p. 63	Greenbrier, common	p. 52
QuinStar	p. 64	Greenbrier, glaucous	p. 49
Roundup	p. 65	Japanese knotweed	p. 57
Select Max/Intensity	p. 67	Joe-pye weed	p. 57
Spartan/Zeus	p. 68	Leatherleaf	p. 53
Stinger	p. 69	Meadowsweet	p. 53
Weedar 64	p. 69	Mosses	p. 53
Adjuvants	p. 59	Orangegrass	p. 57
Ditch management	p. 74	Phragmites	p. 49
Non-producing bogs	p. 73	Pitchfork, Ragweed, and Fireweed	p. 57
Off-bog Uses	p. 71	Poison ivy	p. 49
Renovations	p. 73	Red maple and other trees	p. 54
<u>Weeds</u>	p. 46	Rushes	p. 54
Dodder	p. 46	Sedges	p. 55
Allegheny blackberry	p. 48	Sheep laurel	p. 52
Aster	p. 53	Steeplebush	p. 56
Chokeberry	p. 52	White violet	p. 56
Cinquefoil	p. 53	Wild bean	p. 52
Clover, Vetch	p. 56	Yellow loosestrife	p. 50

New Herbicides and Updates. Check our web site (ag.umass.edu/cranberry) and upcoming newsletters for further information about any new uses or products. UPI has discontinued the production of Devrinol 10G and 50DF formulation. It is still legal to use remaining stock. Follow the label of the product you are using!

Cranberries have been removed from the Princep label. Other products with the same active ingredient (simazine), such as Simazine 4L, are labeled for cranberry and registered in Massachusetts. We are unaware of product availability or efficacy.

Special Labels available for herbicides (see Cranberry Station website under “Services” for labels):

Callisto: Special Local Need (24c) label for concentrated spot-treatment, and adjusted adjuvant rate for chemigation.

Citrine-Plus: 24c for management of algae in late water flood. See Late Water section.

Devrinol 2-XT: 24c for the use of 1) multiple applications on new plantings and 2) multiple applications before bloom or after harvest on established beds.

Intensity One: 24c allows for application by chemigation, and application between hook and fruitset. NOTE: The 24c for Intensity has been rescinded, and ONLY Intensity One can be chemigated.

QuinStar: 2ee to permit shorter injection times.

Spartan 4F/Zeus XC: 24c to allow use for control of moss and other susceptible weeds. NOTE: The 24c for Spartan was added in 2023, and will be the only sulfentrazone available when Zeus expires December 31, 2024.

Weed Life Cycles. *Annual plants* complete their life cycle in one year and reproduce by seed (e.g., dodder). They germinate from seeds, grow to maturity, flower, and make seeds all within a single growing season. *Biennial plants* take two years to complete their life cycle. They typically germinate from seeds and grow vegetatively in the first year, then enter a period of dormancy over the winter. They flower and make seeds the following growing season. *Perennial plants* can live for many years and may reproduce by seed, runners, rhizomes, etc. Most of the weeds in cranberry production are perennials. With the exception of dodder, annual weeds are much less common and easier to control than perennials. However, infestations of annual weeds should not be taken lightly, especially on new plantings. Annual plants are designated with an (A). Unless otherwise noted, all other weeds are perennials.

Weed Priority Ratings. (Very High, High, Medium, and Low)

The Priority Rating of each weed is determined by considering the following: 1) impact of a given weed on cranberry, 2) the biological form or type of weed, 3) its invasive and/or reproductive capacity, and 4) its adaptation to the cranberry habitat. Each criterion has 4 possible values (1, 2, 4, or 8). The values of the 4 criteria are added together to determine the rating. Totals of 24 to 32 points = Very High Priority, 16 to 23 = High, 8 to 15 = Medium, and 1 to 7 = Low. Please see the **ID Guide for Weeds in Cranberries** (available for purchase at the Cranberry Station) for the specific ranking criteria of each weed (pp. 261-272) for more details. Page numbers in the ID Guide are provided in this section as appropriate. Some weeds are in the Chart Book but were not included in the ID Guide and have been given a Priority Rating by the Extension Weed Specialist.

Weed Mapping. Weed maps can help you organize the management of your weed problems, especially with perennial weeds. Weed maps should be done every few years, depending on weed pressure and management objectives. Several steps are involved: 1) Correctly identify the weeds, 2) Document the location of the weeds (by drawings, GPS, or photographs), and 3) Designate a priority rating to the weed. Growers may change and adapt weeds into priority ratings to best fit their own management program.

VERY HIGH PRIORITY WEEDS (Rating values 24 – 32)

DODDER (A) *Cuscuta gronovii* (see ID Guide, p. 247)

Dodder is an abundant seed producer. All management efforts should be directed towards minimizing or eliminating seed production. A single plant can produce thousands of seeds in one season. The seed bank is very long-lived (>20 yr), so do everything possible to eliminate seed production and/or reduce seed viability.

Dodder is an obligate parasite and must have a host plant to survive. Woody cranberry stems are somewhat less appealing to dodder, so control of succulent weeds (such as goldenrod, looserstrife and asters) early in the season may be important.

Prevention: The best management strategy for dodder control is prevention of infestation. This is best accomplished through **good sanitation**. Dodder seed is easily moved in harvest water and on equipment. When possible, dodder-infested beds should be harvested after clean beds. Floats used to corral berries should be inspected for the presence of dodder seed before they are placed in beds that are dodder-free.

Dodder may also be spread vegetatively; pieces of stem can be moved on equipment and become attached to healthy plants. Care should be taken when moving any piece of equipment from a bed infested with dodder to one that is not. Equipment should be sanitized in these situations!

Where dodder infestations are just beginning, **careful scouting and hand removal** of seedlings prior to infection is a good practice. Weeds that are infected with dodder should be completely removed from

the bed; dodder stems will re-grow if haustoria (the part of the parasite that penetrates the host) remain embedded in the weed. Infected cranberry vine tips should be cut off and thrown away.

Scouting: Begin scouting for dodder in early-mid April (unless your bog history or unusual weather conditions indicate otherwise). Mild winter temperatures may promote earlier emergence of dodder. Scout in areas where infestation has occurred in the past. Often, dodder seed will accumulate in the areas where berries are removed from the beds at harvest. Dodder seedlings may also be seen in warm, bare areas or newly sanded areas. Newly emerged seedlings are usually yellow in color, very slender, and 0.5 to 3 inches long. If the vine cover is good, move the vines aside so that you can see the duff layer; this is where early emerging seedlings will be seen.

Dodder populations in MA emerge slowly at first, but then quickly peak (50-90% germinate 30-45 days after first or early emergence) and subside. In addition, as the seeds accumulate year after year in the soil, seedlings emerge later and later, creating overlapping generations. The most vigorous population is the one most recently seeded (from last year). At least two separate species of dodder have been found on MA cranberry bogs, sometimes growing together.

Preemergence Herbicide Use: Scouting is necessary for correct timing of preemergence herbicide application. Herbicides should be applied within 10-14 days of early seedling emergence, so that the chemical is present when peak germination occurs.

Low rates of Casoron may control dodder germination. However, some growers have experienced poor control with 30-40 lb/A rates. If this is your experience, consider increasing the rate and/or making a second application for improved control. Make applications at least 3 weeks apart (not to exceed 100 lb/A in a 12-month period). Multiple applications may be more effective than a single application, especially if there are many frost irrigation events, significant rainfall, or past failures with a single application. See Notes on Casoron.

Handlers may be restricting QuinStar use, so check before using! QuinStar can be used during the preemergence and postemergence phase. Time preemergence QuinStar (8.4-16.8 fl oz/A) application as described for Casoron, targeting the majority of the seed population as they are germinating and emerging. Two applications are permitted (not to exceed 16.8 fl oz/A in a 12-month period) but a minimum of 30 days must elapse between applications. See notes on QuinStar.

We do not have field study data that demonstrate that Callisto will control dodder populations when applied preemergence, but some growers have tried this application timing with good results. Please contact the Station and share your observations. Leave a message and an extension specialist will return your call (508-295-2212).

Postemergence Control: For heavy infestations, raking can prevent the onset of uprights dying, prevent leaf-drop due to shading of the cranberry by the dodder canopy, and reduce dodder seed production. Raking is more effective at reducing seed production if it is done before the seeds are formed (flowering). Raking too early may not be effective because the dodder stems can re-grow from the portions embedded within the cranberry. No benefit is gained from raking more than once. For light to moderate dodder infestations, raking is not recommended.

Trash Floods: A good trash flow after harvest is helpful in removing seed capsules from the bed, but is not a replacement for prevention since subsequent infestation occurs. Growers could consider multiple trash flows if seed production is high.

Chemigating Callisto: Control has been reported when Callisto is chemigated but overall, results seem better when this herbicide is used as a spot-treatment. Dodder will turn white after application, and may re-grow. Applications made before dodder flowers are more effective than those made after flowering. Higher rates are better. See notes on Callisto.

48 WEEDS

Spot-treatment with Concentrated Callisto Solutions: Spot-treatments with concentrated Callisto solutions, as permitted via Special Local Needs (SLN or 24c), significantly reduce seed production. A single treatment made before dodder flowers reduces seed production more than applications made after flowering has started (though both are better than untreated). If you spot-treat with Callisto, you must not exceed 8 oz/A per application (2 applications permitted per year whether by spot and/or chemigation)! At 1.5 oz/gal, you can only spray out 5.3 gallons per acre per application to stay within the label rate. Lower rates (1 oz or less/gal) can also be effective and allow you to treat more area. NIS or COC must be used with POST applications. See Notes on Callisto.

Thermal Weeding: Spot treating small areas of dodder with flame cultivation (thermal weeding) may control dodder. Cranberry plants exposed will also be injured but will recover. Thermal weeding may be better suited to treating dodder in ditches, on dikes, and other non-crop areas. Reports from New Jersey indicated that short exposures may not kill the haustoria that are embedded inside the plant. Repeat applications or longer exposure times may be needed. Treating before seeds are produced is most effective; before flowering is best.

Spring Floods: Short (24-48 hr) floods in early to mid-May may be effective for reducing dodder infestations. Floods should cover vine tips adequately. No adverse vine or yield impact has been reported when growers have held these spring floods. Dodder floods may coincide with floods used to control black-headed fireworm. Flooding dodder 3-4 weeks after early seedling emergence appears to be more effective (compared with flooding 1-2 weeks after early seedling emergence).

ALLEGHENY BLACKBERRY *R. allegheniensis* (Upright dewberry) (see ID Guide p. 148)

This weed has become much less prevalent but is a Very High Priority if found in the cranberry bog. Scout and control early because it can form large colonies and reduce the vigor of the vines. Control may be obtained with glyphosate wipes since it grows tall above the vine canopy. It is not controlled by floods. Young plants can be pulled or dug out by the roots. Weedar 64 may be used as described for other *Rubus* (dewberries) species.

BRISTLY AND PRICKLY DEWBERRY *Rubus hispidus*, *R. flagellaris* (see ID Guide p. 151)

Dewberries spread rapidly on bogs by rooting at the tips of canes/stems. Both types will kill vines if allowed to spread. The most effective way to manage dewberries is to prevent them from establishing or eliminate them as they invade the bog. Remove young plants by pulling or digging out by the roots. Control of established plants with glyphosate products is difficult because the weed grows close to vine level. Sparse or moderately colonized spots can be hand wiped with glyphosate products. Some growers opt to stake the stems of the dewberry plants to make wiping easier and to allow shorter drying time. Clipping stems with herbicide-dispensing applicators may offer partial control. See notes on Roundup. Wipes with Weedar 64 may also be effective when used in late June and July. See notes on Weedar 64.

Callisto will discolor and injure dewberries, however, the long-term management of this weed with Callisto is not yet known. Spot-treatments with concentrated Callisto solutions are more effective than chemigating. Use 2 applications of Callisto (at least 14 days between applications) to manage dewberry infestations. Repeated annual applications will likely be necessary to reduce infestations. If dewberries are in a mixed canopy with tall weeds, target the spray to reach the lower portion of the canopy (where the dewberries are). See notes on Callisto.

Non-chemical options

Late water floods reduce numbers of dewberry crowns and offspring plants in that year. Summer refloods (May 10-12 through July 15-20) may be used in desperate circumstances. This will eliminate the crop for that year! It is particularly helpful to hand pull or hand wipe remaining dewberry plants after the flood has been withdrawn. Fall floods may suppress populations of *R. hispidus* (bristly dewberry); results have varied from no impact to reduced crown density. Start the flood as early as possible (mid-

September) and hold for 4 weeks for best dewberry management. It is important to remove the flood by early November to allow the vines time to become dormant prior to winter.

Recent research indicates that using flame cultivation (thermal weeding) can reduce dewberry plant size. One short duration (3-6 sec/yd² if using an open flame torch; longer times, 15-30 sec are needed with infrared torches) exposure made mid-summer seems effective (for reducing shoot and root biomass). Cranberry vines will be injured when exposed to thermal weeding but they will recover. Typically, however, few cranberry vines are present in heavy dewberry infestations, so the risks are much lower than in well-vined areas. For more information about thermal weeding, leave a message and an extension specialist will return your call (508-295-2212).

Knife-raking or pruning in the fall may help uproot offspring plants. Significant dewberry patches should be scraped and replanted with new vines.

GLAUCOUS GREENBRIER *Smilax glauca* (Silverleaf sawbrier) (see ID Guide p. 241)

Greenbriers are very difficult to control because they have extensive underground storage organs. Glaucous greenbrier (silverleaf or sawbrier) is more difficult to control than common greenbrier (greenleaf). Sawbrier grows in dense patches, spreads rapidly, and usually reaches just above vine level. It significantly impacts fruit production. Digging up the root system is not practical and will cause significant vine and bog damage. Infestations of sawbrier are more likely to occur on high edges or in locations where the bed is out of grade.

Sawbrier may be managed by hand wiping if sufficient coverage is obtained. Summertime wipes of Roundup may offer partial control. Clipping stems with Roundup-dispensing applicators in August may offer additional partial control. Severe infestations of sawbrier may necessitate bog renovation. Weedar 64 and Callisto may be used on sawbrier as per dewberry recommendations. Flooding is not effective against sawbrier. A single exposure of a mid-summer thermal weeding (hand-held flame cultivators or torches) treatment are not effective for reducing sawbrier growth.

PHRAGMITES *Phragmites australis* (Common reed) (see ID Guide p. 206)

This highly invasive species and aggressive weed is being observed more frequently on commercial bogs and must not get a foothold on the bog. Scout often and pull young plants. Expanding or established populations should be **treated and controlled immediately!!** Control has been obtained on-bog by glyphosate wiping early and then wiping again when the plant re-grows. Other options include glyphosate applications (10-20% solutions) in early to mid-summer (before it gets too tall) followed by mowing approximately 3-4 weeks after herbicide application. You can also mow first and then apply glyphosate about 4 weeks later when plants regrow. Control any infestations that are occurring near the bog as well. Maintaining good drainage will make the bog less favorable for Phragmites.

POISON IVY *Toxicodendron radicans* (see ID Guide p. 153)

Treat small infestations of poison ivy (PI) early and eradicate! Repeated annual applications of a concentrated Callisto solution decrease PI cover and increase cranberry cover, especially where PI infestations are severe. Our results showed slightly better control with mid-June applications compared to late May applications. If you spot-treat with Callisto (Special Local Needs label), you must not exceed 8 oz/A limit (2 applications permitted per year)! At 1.5 oz Callisto/gal, you can only spray out 5.3 gal per acre per application to stay within the label rate. Lower rates (1 oz or less Callisto/gal) might also be effective and allow you to treat more area, but we have not tested this. Wait until PI has fully leafed out before making the first application. Allow the PI to recover from the first application and grow new leaves before making the second application.

Late-season or post-harvest control. Glyphosate wipes will control this weed, but the potential for vine damage is high. Research has shown that clipping the stems with herbicide-dispensing applicators may offer partial control. Adding 1-part Weedar 64 to 4-parts of the Roundup mixture may be helpful but will likely increase the possibility of crop injury. See 2,4-D cautions. If wiping once, early-mid September applications may give better control than August applications. Glyphosate has a 30-day PHI. Later applications can be made on bogs that will not be harvested due or very late harvested bogs. Rates as low as 5-10% solutions gave decent control. Control for significant infestations of PI is post-harvest spot treatments with Roundup sprays or mechanical spot renovation followed by replanting.

DO NOT USE thermal weeding or burning for poison ivy control. The toxic plant components can become air-borne and cause significant health problems.

Many people are highly allergic to PI. Protective lotions and soaps are available that minimize the irritation caused by PI oils; these work very well when applied according to label instructions. Lotions are usually applied prior to exposure and soaps are used to remove oils after exposure to the plant. Rinse with a lot of cool water; small amounts of water may only spread the oils.

YELLOW LOOSESTRIFE *Lysimachia terrestris* (see ID Guide p. 118)

Although recent research indicates that yield loss was weakly associated with increasing yellow loosestrife (YLS) stem density, it is difficult to control and few viable options are available. Management efforts should begin while patches are still small and before they have a chance to spread. YLS should also be managed as it can serve as an early season host for dodder and tips may harbor *Sparganothis* larvae.

QuinStar can be applied postemergence in mid-July at 8.4 oz/A plus NIS or COC. The evidence of control is seen in the year AFTER application. This timing may coincide with YLS post-bloom. Recent work has shown that preemergence applications of QuinStar made in early spring are also effective for reducing YLS. Handler restrictions may apply for QuinStar – please check with your handler before using.

Fall or spring applications of Casoron may offer some control of loosestrife. Wipes with Roundup or Weedar 64 may also provide control. Efficacy of chemigated Callisto on YLS seems low.

HIGH PRIORITY WEEDS (Rating values 16 – 23)**POVERTY GRASS** (*see ID Guide p. 190*)

Poverty grass (PG) refers to two similar species of perennial grass (little bluestem (*Schizachyrium scoparium*) and broomsedge (*Andropogon virginicus*)) that reproduce by seeds. To control these perennial grasses, control effort should be directed at all life stages. It is important to stop seeds from germinating (preemergence herbicides), stop adult plants from making seeds (mowing and postemergence herbicides) and to control adult plants (postemergence herbicides, hand weeding/digging out clumps).

PG species are “warm season” grasses. The seeds do not germinate until air and soil temperatures are warm (above 60°F) and existing adult plants do not begin to grow rapidly until later in the summer (mid-July). In the spring and early summer, plants are at the same height or lower than the cranberry canopy, making problem areas hard to identify.

Preemergence

In demonstration plots, Evital (80 lb/A) in the fall injured existing plants but did not prevent new plants in the spring. The spring application of Evital seemed to give better control of existing plants than the fall application, and also decreased the appearance of new PG plants. The spring application did cause visible symptoms of vine stress (on Stevens). The stress did not result in yield loss. Growers report good control when winter sanding followed a fall Evital application (60-75 lb/A).

Preemergence herbicides like Devrinol may stop seeds from germinating and becoming new clumps of grass, but will not control existing clumps of grass. Spring Casoron (80 lb/A) seemed to provide only slight control of existing plants.

Postemergence

Postemergence herbicides that work on grasses include sethoxydim (Poast) and clethodim (Select Max, Intensity, and other registered products with this active ingredient). Growers have reported good results chemigating Intensity One (when used with required surfactant and applying at the proper timing) for PG. Growers have also reported good control with a pre-bloom (cranberry) spray of Select by air, and August applications of Select Max by backpack and boom sprayer. Spot-treatment of individual clumps in mid-July with one application of Select, Intensity, or Poast reduced PG biomass compared to the untreated and the PG did not produce seeds. Caution: regardless of application method, applying clethodim products when cranberry plants are at roughneck stage can cause deformities in cranberry flowers. This seems to be more severe for ‘Howes’ than other varieties. We have not seen significant yield reductions from clethodim associated floral deformities in test plots, but growers have reported yield loss on Howes showing severe symptoms.

Glyphosate wipes of grass clumps during summer may also offer control, but should be done before PG begins to make seeds. Postharvest, Roundup (0.7% solution) sprayed directly into the base of grass clumps in the fall injured existing plants but did not reduce seed production (PG had already made and shed seeds at this point) or new plant growth in the following year. Poast sprayed directly into the base of grass clumps in the fall also injured existing plants, but was less effective than Roundup.

Hand weeding PG clumps is effective but very labor-intensive. After weeding, we did not observe any regrowth from root fragments left behind. Weeding done before plants make seeds will help control the emergence of new plants the next year. However, hand weeding can be done anytime to control existing plants, including after harvest. Use of a dandelion puller tool can be useful to remove small isolated clumps.

Mowing: Try to mow as early as you can. Remove the seed heads from the bog (bag them) if possible. Even if seed heads appear immature when they are mowed, these seed heads can open up within several days after being cut down.

52 WEEDS

CHOKEBERRY *Photinia melanocarpa* (see ID Guide p. 147)

Infestations of chokeberry can reduce yields and will spread in the beds. The best management strategy is to prevent infestation and treat patches before they get large. Chokeberry plants do not grow tall on the bog. Take care when using postemergence glyphosate wipes to minimize vine injury. When chokeberry plants are short, it may be more effective to hand wipe them rather than wiping with a hockey stick wiper. They can also be removed with pliers.

COMMON GREENBRIER *Smilax rotundifolia* (Greenleaf sawbrier, bullbrier) (see ID Guide p. 242)

Common greenbrier is bushier, more upright, and spreads more slowly than glaucous greenbrier, and grows above the cranberry vines, making it easier to control with glyphosate wipes than glaucous greenbrier. Thorough coverage is important. Repeat applications in successive years may be needed for total control. See Notes on Roundup. Digging up the root system is not practical and will cause significant vine and bog damage.

GOLDENRODS *Euthamia* and *Solidago* spp. (see ID Guide p. 63)

Recent data indicate that yields decline with as few as 10 narrow-leaved goldenrod (NLGR) plants per 0.5 yd². They can be extremely difficult to control and spread rapidly. For this reason, every effort should be made to control patches before they spread. Preemergence (Casoron) and postemergence (Callisto) herbicides can provide partial control of this weed.

Postemergence applications of Callisto work very well against NLGR. Stinger applications also offer reasonable control of NLGR. Use the lowest effective rate of Stinger as cranberry vine injury is likely with over-application or off-target coverage. Wipes with Roundup or Weedar 64 may also offer control.

SHEEP LAUREL *Kalmia angustifolia* (see ID Guide p. 144)

Although not a common weed, sheep laurel is very well adapted to the bog habitat. It can spread on the bog and reduce yields. Young saplings should be pulled by hand (pliers help). Larger plants are much more difficult to control but can be wiped with glyphosate products. See Notes on Roundup.

WILD BEAN *Apios americana* (Ground Nut)

Wild bean is well controlled with Stinger applications, but carries a significant risk of cranberry vine injury. Wild bean is very sensitive to Stinger at rates lower than the usual label rate (e.g., 1/16 oz/gal). When using wipes, stake the wild bean vines to make wiping easier.

Many growers have reported good wild bean control with Callisto. Glyphosate products can also be used to wipe wild bean. A salt water solution applied after berry set can also be used to burn the bean tops off (1 lb/gal water, do not exceed 200 gal/A).

Preemergence options can include Casoron (75 lbs/A) followed by Devrinol DF-XT (15 lb/A) or 2-XT at 15 qt/A. Allow 10 days between applications.

MEDIUM PRIORITY WEEDS (Rating values 8 – 15)**ASTER** *Aster spp.* (see *ID Guide pp. 52*)

The impact of asters on cranberries is variable. Asters are usually found in bare patches on the bog. Once the patch becomes established, asters are much harder to control. Higher rates of Stinger as POST application offer the best option; use care to avoid contact with cranberry vines during application to minimize any vine injury.

Glyphosate wipes in the summer may be helpful. Thorough coverage and repeat applications are necessary. Weedar 64 may also be effective. Some growers report efficacy with chemigated Callisto against asters, but results were not always compelling. Applications of Casoron in March-April or November offer some suppression but will probably not eradicate this weed.

CINQUEFOIL *Potentilla spp.* and *Argentina anserina* (*Five-finger*) (see *ID Guide p. 121*)

The impact of cinquefoil is variable. Colonization of cinquefoil may indicate a problem with vine growth and higher than ideal pH. Improvement of fertilizer program may help control this weed. If the soil pH is greater than 5.0, the use of sulfur to lower pH will favor the growth of the cranberry vines over that of the weed. See Notes on Sulfur.

Callisto seems to work well on this weed, but it takes a while for symptoms to appear and for the weed to die; be patient! Hand wiping or hand pulling can also be used to eliminate small patches. Growers report using 60 lb Casoron in early May (as a spot-treatment) with very good results.

LEATHERLEAF *Chamaedaphne calyculata* (see *ID Guide p. 143*)

Leatherleaf is a perennial, woody plant that can spread on the bog and reduce yield. Scout and remove young plants. It can be controlled by hand wiping during the summer with a solution of glyphosate products. Weedar 64 can also be used as a wipe as per dewberry recommendations.

MEADOWSWEET *Spiraea latifolia* (see *ID Guide p. 155*)

Meadowsweet is a slow spreader on cranberry bogs. Scout and remove young plants. This weed should be pulled out by hand or wiped with Roundup during the summer.

MOSSES *Polytrichum spp.* (*Haircap moss*), *Sphagnum spp.* (*Sphagnum moss*) (see *ID Guide p. 258*)

Moss infestations are on the increase and may warrant a higher Priority Rating in some situations. The presence of these plants on the bog usually indicates a drainage problem. Evaluate the drainage in the area and improve prior to starting a chemical control plan.

Spartan/Zeus (sulfentrazone) is available through a Special Local Needs label (2020). This herbicide appears to be very effective against both types of moss. Application must be made to dormant buds or vine damage will occur. See notes on Spartan/Zeus.

A 20% acetic acid product (known as horticultural acetic acid) is sold as a biopesticide for use on food crops. Spot-treatment applications of 20% acetic acid have shown good control of moss; actively growing cranberry plants were damaged but recovered. Use of 5% acetic acid (store-bought vinegar) is mostly ineffective.

Growers report using 100 lb/A Evital in the spring against Sphagnum moss with good results. Casoron is labeled for haircap moss control, but control has not been seen at 60 lb/A. Other products may be available. Contact the Weed Specialist for updates.

PERENNIAL GRASSES (see ID Guide pp. 185-211)

Depending on the species, perennial grasses could be considered Medium to Very High Priority (see related species information if not specifically listed). These grasses often colonize bare areas and are becoming more problematic, especially on newer bogs. Encouraging vine growth may reduce potential for problems. Some species may be difficult to eradicate once established.

Postemergence herbicides that work on grasses include sethoxydim (Poast) and clethodim (e.g., Select/Max, Intensity/One). Clethodim products usually have better efficacy against perennial grasses. Callisto (chemigated) may offer some postemergence control of grasses with wide leaves such as deer-tongue grass. **Preemergence herbicides** Casoron or Evital (spring or fall) or Devrinol (spring only) may all offer control. Use high-end rates for preemergence herbicides.

Roundup wipes or sprays (1-1.5%) that are directed into the base of grass clumps may also offer control.

PREEMERGENCE OPTIONS

<i>Deer-tongue grass, Broad-leaved panicgrass</i>	Evital gives partial control. (<i>Dichanthium clandestinum</i> ; ID Guide p. 182)
<i>Mannagrass</i>	Use Casoron (Spring). (<i>Glyceria obtusa</i> ; ID Guide p. 198)
<i>Poverty grass</i>	Devrinol applications (combined with repeated mowing to remove seed heads) is the best PRE herbicide recommendation.
<i>Rattlesnake grass</i>	Casoron (Spring). Clean ditches in infested area. Pulling helps a little. (<i>G. canadensis</i> ; ID Guide p. 197)
<i>Rice cutgrass</i>	Best choice is Devrinol applied before April 10. Casoron and Evital can also be used; give partial control. Improve drainage. Can tolerate pH<3. (<i>Leersia oryzoides</i> ; ID Guide p. 199)
<i>Smokegrass</i>	Evital (Spring). (<i>Muhlenbergia capallaris</i> ; ID Guide p. 204)
<i>Summergrass</i>	Devrinol, Casoron or Evital. Hard to mow. (<i>Agrostis hyemalis</i> ; ID Guide p.189)
<i>Switchgrass</i>	Evital (Fall). Difficult to control, repeated mowing helps. Best to dig out plants prior to seed formation. (<i>Panicum virgatum</i> ; ID Guide p. 182)
<i>Velvetgrass</i>	Casoron (Spring). (<i>Holcus lanatus</i>)

RED MAPLE and other trees (see ID Guide pp. 135-140, 158-167)

The best management strategy is to pull saplings before the root system becomes established (hopefully less than 1 year old). Larger trees must be dug out. Glyphosate or Weedar 64 wipes may be used to control small maples and to weaken large trees to facilitate removal. Clipping stems with Roundup-dispensing applicators in August may offer partial control. Wisconsin reports best results with early applications of Callisto at high rates with COC, and glyphosate wipes with an organosilicone surfactant included in the wipe solution. A weed wrench or pliers can be helpful for removing large saplings.

RUSHES *Juncus* spp. (see ID Guide pp. 231-237)

The impact of rushes can be very variable depending on the species and the location of the infestation. Rushes grow in clumps and can become quite large when well established. Control of large plants with

preemergence herbicides may be difficult except at very high rates. Control may also be possible with hand-digging or repeated hand wiping with glyphosate solutions.

Casoron and/or Devrinol applied in the spring may offer partial control of rushes. Evital may also offer some control. Salt (1-3 tsp) applied at the base of each clump in the spring can also be effective. Glyphosate wipes can be used in summer. Flame cultivation (thermal weeding) may help to control rushes, and may be practical for use in ditches and along bog edges. For more information, call the Station to leave a message and an extension specialist will return your call (508-295-2212).

SEDGES (see *ID Guide pp. 212-230*)

Management of sedges combines both cultural and chemical controls. Hand dig and/or pull small patches or spot-treat with one of the preemergence herbicides listed below. Encourage vine growth in the bare areas so the sedges will not re-colonize.

Refer to the following table to locate the target weed and recommended control options and related information. **TIMING:** Spring applications are typically done from March through mid-April; Fall applications are typically done 1-2 weeks after harvest but at least 3 weeks prior to the winter flood. (S) or (F) following the weed name indicates 'Spring only' or 'Fall only' applications are preferred.

Preemergence Control Options			
HERBICIDE	RATE	WEEDS CONTROLLED	NOTES
Devrinol DF-XT	12-18 lb/A (peat bogs) 8-12 lb/A (mineral soils)	Toothed flatsedge (nut sedge)	
Devrinol 2-XT	12-18 qt/A (peat bogs) 8-12 qt/A (mineral soils)		
Casoron 4G	up to 100 lb/A	Tussock cottongrass, Dulichium (S), Fresh meadowgrass (F), Needlegrass, Nut sedge, Spike rush, Woolgrass	
Evital 5G	80-120 lb/A	Needlegrass (S), Nut sedge	Needlegrass is difficult to handpull. Broom sedge may be controlled with glyphosate wipes. Dig up clumps.
	120-160 lb/A	Broom sedge, Needlegrass (F), Spike rush, Woolgrass	
Postemergence Control Options			
HERBICIDE	RATE	WEEDS CONTROLLED	NOTES
Callisto	4-8 fl oz/A	Nut sedge, perhaps others	Spot treatment or chemigation. See Notes on Callisto.
Weedar 64		Chairmaker's bulrush (Three-square)	Mix 1 part Weedar to 2 parts water for hockey stick (wiper) application. Best results when used in late June and July. Do not drip or touch vines.

56 WEEDS

STEEPLEBUSH *Spiraea tomentosa* (Hardhack) (see ID Guide p. 157)

Hardhack is a solitary plant that does not spread except through seed. Scout and control young plants. Pulling this weed is very effective, but the roots of established plants can be woody and larger plants may cause damage to the bog when pulled. Wipe with glyphosate.

WHITE VIOLET *Viola lanceolata* (see ID Guide p. 131)

Found most often in bare patches on beds, white violet is thought to compete poorly with established vines. Thus, the best management approach is to fill in bare spots on the bog by encouraging runner growth. Otherwise, hand pulling is the next best recommendation, especially on new bogs. No chemical controls are recommended.

LOW PRIORITY WEEDS (Rating values 1 – 7)

ANNUAL GRASSES

Generally, annual grasses are most likely to appear in bare patches and/or on new bogs. Hand pulling and/or treatment with postemergence grass herbicides may be used on new and established bogs. Encourage vine growth to reduce ability of weeds to colonize the bog surface. Preventing seed production may also be important in managing these weeds.

Devrinol, Casoron, and Evital give effective preemergence control for annual grasses. Use at high-end label rates. Early reports indicate that Spartan/Zeus may work to stop some the grass seeds of some species from germinating.

Postemergence herbicides that work on grasses include sethoxydim (Poast) and clethodim (Select Max, Intensity, and other registered products with this active ingredient). Callisto may provide control for some species but appears to be more effective on large-leafed grasses like crabgrass.

<i>Barnyard grass</i>	Evital, Devrinol (S). (<i>Echinochloa crus-galli</i> ; See ID Guide p. 177)
<i>Fall panicgrass (corn grass)</i>	Devrinol (S), Evital. (<i>P. dichotomiflorum</i> ; See ID Guide p. 181)
<i>Witchgrass</i>	Devrinol (S). (<i>Panicum capillare</i> ; See ID Guide p. 179)
<i>Crabgrass</i>	Casoron (S). (<i>Digitaria</i> spp.; See ID Guide p. 174)

CLOVER and VETCH *Trifolium* spp. and *Vicia* spp. (ID Guide pp. 94-97)

Clover and vetch tend to occur in areas of high pH. If soil pH is 5.0 or above, spot treat with two applications of sulfur at the rate of 0.2 oz/sq. ft. Apply in the late spring when soil is drained and frost protecting is over. Refer to Notes on Sulfur. Lower rates of herbicides may be effective when sulfur has been added and the pH is lowered. Vine overgrowth has been reported in heavily infested areas after clover is treated and dies back (acts like a green manure, releasing nitrogen into the soil).

Stinger offers good postemergence control of these weeds. See Stinger notes. Control clover early in the spring prior to budbreak; this minimizes crop injury. Use lowest effective rate.

Callisto can also control clover and can be used during the growing season.

FIREWEED/AMERICAN BURNWEED (A) (*Erechtites hieracifolia*) (see ID Guide pp. 23)

Fireweed is an annual weed. It was traditionally seen in areas with weak vines and bare ground where seeds could germinate, but has been increasingly reported on mature bogs with closed cranberry canopies. If present, effort should be made to prevent plants from producing seeds, and preemergence herbicides should be used the following spring.

JAPANESE KNOTWEED *Polygonum cuspidatum* (Mexican bamboo, Fleecflower)

This is an invasive species that has been seen on bog ditches but rarely on the bog itself. It would be considered Very High Priority if on-bog. It is common (relatively) on new plantings. Japanese Knotweed has heart-shaped leaves that become quite square at the end close to the stem. It produces abundant white flowers in June-July. It is a perennial plant and can form dense patches (large rhizome system underground). It may die back at the end of the season and form a dense mat of dead material.

The best control is prevention!! It is absolutely best to eradicate before the plant establishes on the bog. Individual plants should be dug out or wiped with glyphosate when they are small. Repeated mowing or flame cultivation may offer control of off-bog populations.

JOE-PYE WEED *Eupatorium dubium*

This perennial plant generally grows along the ditch areas. Due to its tough stem, it may be difficult to hand-weed. Some growers use pliers to uproot large plants. Glyphosate wipes during the summer offer good control. Stinger/Spur should also control this weed (in Aster family).

SHEEP SORREL, RED SORREL *Rumex acetosella* (ID Guide pp. 113)

This perennial weed can produce large colonies by growing multiple shoots on spreading underground rhizomes. It has typically only found on newer plantings or beds with sparse vines, but has recently been appearing on mature beds with closed canopies. The extensive root system makes it difficult to control by handweeding. The historical management recommendation is application of Casoron (dichlobenil) in the spring. Callisto (mesotrione) is labeled to control other *Rumex* species, and postemergence application may offer control of this species.

ORANGEGRASS (A) *Hypericum gentianoides* (Pineweed) (see ID Guide p. 32)

Orangegrass is most likely to appear in bare patches and/or on new plantings. Other common names may be used (horsetail, horseweed, or mare's tail), but those are very different plants. High rates of Casoron should control orangegrass but be careful using Casoron on new plantings. In Wisconsin, growers reported good control with 30 lb/A Casoron. There has been a report of efficacy with preemergence applications of Callisto at 8 fl oz/A, but this has also NOT been verified. Success with combinations of Callisto and Devrinol (both as PRE) on new plantings has also been reported. Orangegrass can be hand-pulled if infestations are not too large.

PITCHFORK (A) (*Bidens frondosa*), RAGWEED (A) (*Ambrosia artemisiifolia*) (see ID Guide pp. 18, 22)

Casoron may be applied in the spring or fall for control of ragweed. Weedar 64 wipes may be used for ragweed control postemergence. Stinger (wipes or spray) is effective for pitchfork and ragweed. Use lowest effective rate to minimize vine injury. These are annual weeds that germinate from seeds. If present, effort should be made to prevent plants from producing seeds, and preemergence herbicides should be used the following spring.

58 WEEDS

ALGAE (Green scum)

Barley straw can be used to help clarify cloudy water on flooded bogs with excessive algae growth (common mostly in late water floods). When water temperatures are cool (<50°F), it may take 6-8 weeks for the straw to decompose; 1-2 weeks if water temperature is >68°F. The bales should be contained in nets and maintained at the surface (floats can be inserted) to be most effective. For water that requires treatment, 90-225 lb/acre of surface area should be enough to clear the water. Use higher end rates if the density of the algae and/or the turbidity (cloudiness) of the water is high. Do not use more than you need; overdosing may cause fishkills as the straw deoxygenates the water as it decays.

A Special Local Needs (SLN or 24c) label is available for Cutrine-Plus to use for management of algae in LW flood in Massachusetts. Cutrine-Plus is a liquid copper-based formulation that is used to control a broad range of algae. Applications only prevent further growth (it does not work well to eliminate existing algae), so prompt treatment is critical. If your flood is shallow or if you have had scum problems in prior LW years, plan to treat 2 weeks into the flood period. Scout for algae and apply when growth is first visible on the water surface.

Citrine-Plus is injected into the sprinkler system running at 20 psi (30-minute injection; you may continue running for 1-2 hours after injection to disperse the material). Rates are calculated using label information and the number of acre-feet to be treated. To calculate acre-feet, multiply the number of acres by the depth of the flood in feet. Multiply the desired rate (gallons per acre-foot based on the chart from the pesticide label) by the acre-feet of water (calculated as above) for the bed being treated.

MINOR WEEDS

If weeds are scattered or of minor importance, consider potential vine stress or injury when choosing herbicide and rate. Consider hand pulling instead. For localized weed patches, consider spot treatment. Postemergence treatment with glyphosate products may also offer some control. Combine herbicide treatments with steps to improve vine growth.

Common minor perennial weeds include: Blue joint (*Calamagrostis Canadensis*; ID Guide p. 192), Hawkweed (*Hieracium* spp.; ID Guide p. 59), Horsetail (*Equisetum* spp.; ID Guide p. 254), *Hypericum* spp. (ID Guide p. 76), Marsh St. John's wort (*Triadenum fraserii*; ID Guide p. 85), Sweet pepperbush (*Clethra alnifolia*; ID Guide p.141), Plantain (*Plantago* or *Littorella* spp.; ID Guide p. 112), Common yellow oxalis (*Oxalis* spp.; woodsorrel- ID Guide p. 111) and Wild Strawberry (*Fragaria virginiana*; ID Guide p.120). Common minor annual weeds include: smartweeds, knotweeds, and ladythumb (*Polygonum* spp., ID Guide pp. 36-42).

Casoron will control many of these minor weeds. A single application of 75 lb/A Casoron is the traditional recommendation for horsetail control but growers have reported success using 40 lb/A at first signs of emergence followed by 30 lb/A 2 weeks later. Postemergence Roundup wipes may also control these minor weeds. Weedar 64 wipes are labeled to control *Hypericum* species and sweet pepperbush. A grower has reported control of horsetail with 60-75 lb/acre Evital in the fall followed by winter sanding.

HERBICIDES

ALWAYS read the label of any chemical before use and always comply with the manufacturer recommendations.

Preemergence – (PRE) These are herbicides that are applied prior to the emergence of weeds. In general they work by targeting weed seeds that are germinating, but some can also act on perennial plants that spread by rhizomes, tubers, and stolons. Application is timed to coincide with when the target weeds are about to begin germinating. These herbicides mainly prevent new weeds from establishing, but most do not impact weeds that are already growing.

Multiple frost protection or rain events in the spring following an herbicide application might affect herbicide effectiveness. Preemergence herbicides move through the soil at different rates. We do not have good information on how these chemicals move in cranberry soils. Based on information from noncranberry soil types, Evital has high soil mobility. Devrinol is also likely to leach through the soil profile. In a loamy sand soil, it will move about 1 inch for every inch of rain or water. Casoron is relatively less likely to leach but we have no numbers for Casoron (like with Devrinol). Sandier soils are less likely to hold onto herbicides than soils with some organic matter. Whenever possible, it is best to delay applications of herbicides until a reasonable window of dry weather is predicted.

Postemergence – (POST) These herbicides work on actively growing weeds. They can be absorbed by the leaves or roots of the plants, depending on the chemical. Some herbicides like Callisto (mesotrione) have activity both PRE and POST.

Adjuvants – These products are added to a pesticide mixture to improve its effectiveness. They include surfactants, stickers, penetrants, compatibility agents, etc. Pesticide labels may list specific types of adjuvants that will maximize effectiveness of the pesticide. Be sure to use the proper category of adjuvant if the manufacturer makes a specific recommendation.

Several herbicides require the use of adjuvants, commonly either non-ionic surfactant (NIS) or crop oil concentrate (COC). Adjuvants are recommended because research has shown that their addition increases efficacy of the herbicide. If the label advocates the usage of an adjuvant, do not omit the adjuvant solely to save money. NIS spread the spray droplet evenly over the leaf surface and help the droplet to stick to the leaf. Common commercial NIS products include Induce or Activator 90. COC may consist of petroleum, vegetable, or methylated vegetable or seed oils designed especially for use in agricultural pesticide spray programs. Many COCs are available and may be sold as Crop Oil or under other trade names such as Herbimax. They increase penetration of the herbicide through the leaf cuticle.

A note about generics – More and more formulations of herbicides are becoming available. In addition to glyphosate, clethodim (Select, Intensity, Arrow, and others) there are now different mesotrione products (Callisto, Explorer, Sotrion, Bellum, and others). Even if the active ingredient in a pesticide can be used in cranberry NOT ALL products with that active ingredient can be used in cranberry. For any product you use on your farm, it is your responsibility to make sure that cranberry is on the label and the application method you are using is also on the label. The percent active ingredient can vary from product to product, which means the application rate may also vary. It is unclear how different formulations work in comparison to other products. In addition to an active ingredient, herbicides contain a lot of “other ingredients” – in most cases more than 50%. These include spreaders/stickers/adjuvants, carriers, binders, drift reducers, and trade secrets that might impact efficacy and/or vine injury.

Dyes - If you want to add a dye to an herbicide mix to track your coverage, many choices are available. Be sure the dye you use is labeled for food crops.

CALLISTO (mesotrione) - Used PRE and POST**WSSA/HRAC Group: 27**

Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
16 fl oz/A Max 8 oz/A per application	12 hr	45	2

Callisto is a systemic preemergence and postemergence herbicide. It works mainly on broadleaf weeds, and does not work well against many grasses. It has better POST activity on grasses with large leaves like crabgrass and deertongue grass. When used PRE, weeds take up the product through the soil during emergence. When used POST, weeds absorb the herbicide through the treated foliage and also through the soil.

Please note that you CANNOT exceed the maximum allowable amount of Callisto used, regardless of how you apply it. For example, if you chemigate 8 oz/A twice, you CANNOT also spot treat. You can chemigate once at 8 oz/A and spot treat once at 8 oz/A, etc. There must be at least 14 days between applications. Callisto cannot be applied by air.

Chemigating with Callisto. Callisto can be used through the chemigation system. Adjuvants should be added for postemergence use. Use a “per acre” rate for the adjuvant when chemigating (e.g., 1-4 pt/A, not a % or v:v rate). NIS and COC should work equally well with Callisto; however, some COC may cause injury on cranberry under certain conditions (hot temps with high humidity).

Spot-treatment with Callisto. Some growers also use Callisto, either at chemigation rates or as a concentrated solution (as per SLN), to spot-treat weeds. If adding a dye to the herbicide mix, the manufacturer recommends using Spray Tracer; do not use Blazon Blue (NOT labeled for food crops). Add NIS at 0.25% v:v or 1.9 tsp per gallon or COC at 1% v:v or 2.5 Tbsp per gallon with all postemergence applications, regardless of Callisto rate.

Suggested amounts of Callisto per gallon of water for spot-treatments

Callisto per gallon of water	Surfactant	Solution description	Max solution per acre per application
0.8 teaspoon	+ 2.5 Tbsp COC	approximates 4 oz/acre rate	30 gal
1.9 teaspoons	or	approximates 8 oz/acre rate	30 gal
3 Tablespoons	1.9 tsp NIS	concentrated solution (SLN), for dodder and woody weeds like PI	5.3 gal

Plants affected by Callisto will turn white. Injury may take several days or weeks to show. Allow a minimum of 14 days between applications. Hardier weeds will likely need 2 applications per year over a period of successive years for control. Callisto should work well against crabgrass but is weak against foxtails. Callisto is rain-fast in less than 4 hours and has no known bee issues.

Use on New Plantings. Callisto is an excellent choice for use on newly planted vines. Weed control is best when using Devrinol as a PRE herbicide in combination with Callisto as a POST. Some growers have applied Callisto within days of planting with no injury (especially with rooted cuttings). Lower rates are often a good choice as many early weeds are annuals. If a minimalist approach is desired, make one POST application of Callisto.

Resistance Management Concerns. Resistance to Callisto has been reported in weeds in other crops.. It is important that we do not lose this tool for dodder and general weed management. Occasionally rotate Callisto out of your herbicide sequence and substitute other herbicides. Use non-chemical forms of weed

control whenever possible. Do not use Callisto repeatedly year after year. You CANNOT EXCEED 2 APPLICATIONS per year, even if you remain below the 16 oz/acre annual maximum.

There are several mesotrione products available (e.g., Callisto, Explorer, Motif, Sotrion, Bellum, and Willowood Mesotrione). Please read all product labels carefully to make sure products are registered for cranberry and use the correct rates for the product you are using. Callisto is the only product with the concentrated solution SLN.

CASORON 4G (dichlobenil) – Used PRE		WSSA/HRAC GROUP: 29	
Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
100 lb/A	12 hr	N/A	N/A

Casoron is a preemergence herbicide that works on germinating seeds, very small seedlings, and also some perennial weeds that propagate by rhizomes, tubers, and stolons. It is effective against both grasses and broadleaf weeds. Applications of Casoron are most effective when applied as close to the time of weed germination or emergence as possible. Casoron is labeled to be applied in early spring (pre-budbreak) while perennial weeds are still dormant and annual weeds have not started to germinate, or in late fall after the crop has been harvested. The efficacy of fall applications for many weeds has not been documented, but growers have reported good success in some cases.

Casoron may be applied by air or by ground equipment. Since Casoron volatilizes quickly, avoid applying during warm temperatures (air and soil temps should be <60°F). It must be incorporated by irrigation or rainfall ASAP after application. The amount of water needed to melt Casoron particles will depend on preexisting soil moisture and other conditions. After Casoron is applied and is incorporated by initial irrigation or rainfall, it binds to soil particles. It is not known if frequent frost protection impacts the efficacy of Casoron. Do not exceed 100 lb/A in any 12-month period. Multiple applications may be made as needed. Allow an interval of 3-6 weeks between applications. Single doses of high rates of Casoron may be needed to control some perennial weeds. Some growers have experienced poor dodder control with 30-40 lb rates, and improved control when increasing the rate to 60 lb. If you are not getting the control you expect, consider increasing the rate and/or number of applications for improved control.

Distribute Casoron uniformly. Avoid overlapping of herbicide. Temporary reddening of vines may occur, especially with late spring application or when applied on sandy bogs. Do not apply after bud elongation as vine injury may occur and yields may be reduced. Do not apply to young beds (less than 3 years old unless root systems are well established) or on bogs prior to or immediately after mowing vines. Do not sand (spring or fall) on top of a Casoron application. Applications on top of sand or late applications can be made, but must be watered in *immediately*. Low rates (<40 lb/A) may be applied after removal of a late water flood to control dodder with minimal risk of phytotoxicity.

Yellow-vine Syndrome (YVS) shows up as a yellowing along the margins (edges) of cranberry leaves with the areas along the leaf veins remaining green. Usually the symptoms show up first in the old leaves and then move up the stem into the new growth. The most common time for the symptoms to become severe is around fruit set when demand for resources in the plants is high. Symptoms are most likely due to nutritional imbalances in the cranberry plants due to root problems (not fertilizer management) caused by water stress (too much OR too little). Casoron use can aggravate the problem.

62 WEEDS

Casoron is labeled for use on:

Sensitive fern	Summer grass	Woolgrass	Wild strawberry
Bracken fern	Velvetgrass	Cotton grass	Aster
Royal fern	Bent grasses	Needle grass	Buckbean
Haircap moss	Little hairgrass	Oniongrass	Hawkweed
Common horsetail	Rice cutgrass	Arrowleaf tearthumb	Western Lilaeopsis
Water horsetail	Bunch grass	Beggarticks	Marsh pea
Rush (<i>Juncus</i> spp.)	Muskrat grass	Knotweed	Plantain
Dodder	Nutsedge (Nutgrass)	Loosestrife	Smartweed
Bluejoint grass	Short wiregrass	Tideland clover	Pacific silverleaf
Rattlesnake grass	Wideleaf grass	Ragweed	Marsh St. Johnswort
Manna grass	Stargrass	Sorrel	Crabgrass

DEVRIKOL DF-XT and 2-XT (napropamide) - Used PRE WSSA/HRAC GROUP: 0

		Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
Established peat beds	DF-XT	12-18 lb/A	24 hr	N/A	1
	2-XT	12-18 qt/A			
Established sand beds	DF-XT	8-12 lb/A	24 hr	N/A	3
	2-XT	8-12 qt/A			
New plantings	DF-XT	18 lb/A*	24 hr	N/A	3
	2-XT	18 qt/A*			

* 24c (SLN) label permits use 2-XT for multiple apps (up to 18 qt/A total) on new plantings. Obtain label when purchasing product or download from the UMass Cranberry Station website.

Devrinol is typically applied in the spring before growth begins, but it may also be applied in the fall after harvest. Do not apply when beds are under winter flood. The efficacy of fall applications for many weeds has not been documented.

Rate differences for the soil types (higher rates with more organic matter) are primarily due to efficacy issues rather than toxicity or groundwater concerns. The label states that it should be applied with sufficient water to wet the soil to a depth of 2 to 4 inches, so continue to run irrigation after injection. Use the appropriate rate for the age of the bog and soil type. Devrinol can be used under or on top of sand.

Devrinol is a preemergence herbicide and will not control existing weeds. This herbicide provides some control of grassy weeds, nutsedge, and annual broadleaf plants, but works best on weed-free areas. It may also work against your goals if you are trying to establish grass on ditch banks and your irrigation system delivers coverage to the ditch bank area.

EVITAL 5G (norflurazon) - Used PRE**WSSA/HRAC GROUP:12**

	Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
Established beds	160 lb/A	12 hr	N/A	1
New plantings	80 lb/A	12 hr	N/A	1

Apply Evital 5G as a single application in the early spring after removal of winter flood and before weed growth resumes OR in the fall after harvest at least 2 weeks before winter flood. Only one application per 12-month period can be made. Compared to spring rates, higher rates are usually applied in the fall. Individual experiences vary greatly; growers have reported good results with low rates (50-75 lb/A) for fall applications on sensitive varieties, such as Stevens and McFarlins. Higher rates are recommended (for either season) when one or more of the following conditions exist: established vines, established weed clumps, mat of weed stems overlay the soil, high organic matter soils, and no sprinkler irrigation. Use lower rates on stressed vines or sensitive cultivars. Spring applications are typically less than 80 lb/A. Vine injury may occur in areas where water stands several days after flooding or heavy rains.

Sanding can be done on top of an Evital application, but be careful especially on bogs that have drainage problems or sensitive varieties. Sanding after applications of 50 lb/A or less has given good weed control. Growers have reported that applications of Evital (50-60 lb/A or less) on top of sanded vines work adequately on healthy, well-drained beds. Although higher rates may injure cranberry, the product label does recommend using higher rates for poverty grass control (120-160 lb/A).

Be conservative when applying Evital to new plantings! Usually, new vines are very sensitive to Evital. However, growers have reported using 35 lb/A in the fall on Stevens that were planted in the same year with good success. In other instances, vines have shown severe phytotoxicity to rates as low as 25 lb/A when applied 3-4 weeks after planting.

POAST (sethoxydim) - Used POST**WSSA/HRAC Group: 1**

	Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
Broadcast	5 pt/Acre (80 oz) max 2.5 pt/A per app	12 hr	60 days	NA
Spot treat	1-1.5% solution			

Poast **CANNOT** be applied through the irrigation system! It may be applied by broadcast applicator or air. Spot treatments with small sprayers are effective. If applying by ground applicator, spray to wet the leaves, not to run-off. Herbicide efficacy will be reduced when applied to stressed weeds. Allow 14 days between applications.

Poast is a postemergence herbicide that controls true grasses (most annual grasses and some perennial grasses). Sedges and rushes are not controlled. Poast is absorbed through foliage after application. The effects range from slowing or stopping growth (generally within 2 days), to foliage reddening and leaf tip burn. Subsequently, foliage burnback may occur. These symptoms will generally be observed within 3 weeks. Do not apply Poast if rainfall or irrigation is expected within one hour of application. Poast should be applied when grasses have 6 to 8 leaves to provide enough leaf surface for absorption. Poast works best when applied before grasses begin to flower.

64 WEEDS

Cranberry plant injury may occur if the herbicide is applied during the heat of the day or during bloom (due to added crop oil concentrate; COC). Application during cool periods of the day, but after dew has dried, is preferable. If you have never used this material before, it may be wise to test a small area before applying the product to a larger area.

Poast should always be used with a COC. Physical incompatibility, reduced weed control, or crop injury may result from mixing Poast with other pesticides (fungicides, herbicides, insecticides, or miticides), additives, or fertilizers.

Spray Solution Volume (gallons)	COC (1%)	Poast Spray Solution	
		1%	1.50%
1	1.3 fl oz	1.3 fl oz	1.9 fl oz
3	3.8 fl oz	3.8 fl oz	5.8 fl oz
5	6.4 fl oz	6.4 fl oz	9.6 fl oz
25	2.0 pints	2.0 pints	3.0 pints
50	4.0 pints	4.0 pints	6.0 pints

Thoroughly wet the grass foliage, but do not let the solution run off the leaves.

Broadcast Application. Use standard high-pressure hollow cone or flat fan nozzles only. Use 5-20 gal of spray solution per acre at 40-60 psi. Inadequate coverage of grasses due to heavy cranberry canopy may reduce control. Do not use re-circulating sprays, wiper applicators or shielded applicators. Use of Poast with control drop application is not recommended due to erratic coverage.

Aerial Application. Do not apply if wind speed is greater than 10 mph.

Use on New Plantings. Poast can be safely used on newly planted vines. Wait for roots to develop before application. Growers report mid-July applications approximately 6 weeks after planting worked well. Grass control was enhanced when Poast applications were followed by Callisto applications.

QUINSTAR 4L (quinclorac) - Used PRE and POST

WSSA/HRAC Group: 4

Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
16.8 fl oz/A	12 hrs	60 days	2

There are export issues with this herbicide. **Check with your handler before using**, because handler restrictions may apply. Do not apply to crops that are stressed. Do not apply by air.

Dodder, loosestrife, and other broadleaf and grasses may be controlled by this herbicide. A maximum of 2 applications (8.4 oz/A each) are permitted per 12-month period, not to exceed 16.8 fl oz/A. As per FIFRA 2(ee) granted in 2015, injection times of less than 30 minutes can be used (label states 30-45 minutes). See Station web site, under "Services" for special label. Applications must be separated by at least 30 days. COC at a rate of 2 pt/A may be added to the spray mixture.

Quinclorac is taken up through roots and leaves. Adequate rainfall after application and good soil moisture is important for root uptake. Symptoms include twisting, stunting, reddening and chlorosis;

symptoms on perennial plants may take more than 3 weeks to show. The full effect of the herbicide may not be evident for 3-6 months after application. Some growers report good dodder control the year after application, even if they did not see results in the year of application.

ROUNDUP and other glyphosate products – Used POST

WSSA/HRAC Group: 9

Many Roundup and glyphosate products are available on the market. **Please read the label of any product you use to ensure compliance.** Available glyphosate products vary as to whether they carry a 'Caution' label or 'Warning' label. Check the label for appropriate protective clothing. These products may also vary in the amount of active ingredient, the REI times, and length of dry time before they are rain-fast. Check the label. For example: Roundup Weathermax has 48.8% active ingredient (a.i.) while Roundup Ultra has 41% a.i.

Most Roundup products do not need an additional surfactant. It may be necessary to add a NIS to other glyphosate products (again, check the label of the specific product you are using). Ammonium sulfate may improve uptake of these Roundup products when moderate to large amounts of carbonates ('hard water') are present in water, but this is rarely an issue in MA waters (typically <50 ppm calcium carbonate). Follow instructions on the label.

Make herbicide mixtures fresh each day for maximum effectiveness. Do not store in galvanized containers. Always use a dye to track your coverage with any wipe product. Depending on the label, glyphosate products can be applied by wiper, by clipper, as a spot treatment spray in dry ditches, and as a spot treatment post-harvest spray.

Glyphosate is absorbed into plants through the leaves. Cranberry vines are very sensitive to glyphosate and can be killed by exposure. Avoid cranberry plants and do not allow material to drip onto vines during application. Glyphosate can be applied any time weeds are present, and repeat applications are permitted. There is a 30-day preharvest interval.

During the growing season glyphosate can be applied (on bog) by wiper. Some products (but not all) are also labeled for clipper use (stump-cut).

Spray application to DRY ditches - Some products are also labeled for spray use in DRY ditches. The ditch should be dry for 1 day before application, and ditches must remain dry for 2 days after application.

Post-harvest sprays - Certain products allow for post-harvest sprays. CHECK THE LABEL of the product you are using for specific uses. The risk of vine injury is lower when cranberry is dormant. Varieties can respond differently; we have seen that Howes are slightly more sensitive to postharvest spray injury than Early Black. Weeds must be alive and active (green leaves) for glyphosate to be absorbed.

Type of application	Roundup Rate (for a 48% a.i. product)
Wiper	10-20% (1 part glyphosate product to 4-9 parts water)
Dry ditch spray	1-1.5 % (2.5-3.8 Tbsp or 38-57 ml per gallon water)
Clipper	50-100% (use full strength or dilute by half)
Post-harvest spray	0.4 – 0.7% (3-5.5 tsp or 15-27 ml per gallon water)
IF additives are needed:	
Surfactant	1 oz (2 tablespoons or 30 ml) per gallon of mixed solution
Ammonium sulfate	3 oz (6 tablespoons or 90 ml) per gallon of mixed solution

Wipes - Use an applicator that permits excellent coverage with minimal dripping. Adequate coverage of weeds must be obtained for glyphosate to be absorbed. Several leaves (at least 50%) on each stalk must be treated with the herbicide. Application by hand with sponges or specially designed applicators may be necessary with low-growing weeds (e.g., bristly dewberry, poison ivy).

Repeat applications within a season are legal and may be necessary, especially for well-established perennial weeds. Poor growing conditions such as drought stress, disease, or insect damage may reduce effectiveness. Some growers have had success staking the weeds (tomato stakes or similar) for wiping and allowing them to dry prior to laying them back on the vines. This certainly reduces vine injury.

	Wiping Solution Strength			
	Weaker	Moderate	Strong	
	Roundup (fl oz)			
To make 1 gallon	13 fl oz	17 fl oz	25 fl oz	+ enough water make 1 gallon of solution
To make 2 liters	7 fl oz	9 fl oz	13 fl oz	+ enough water make 2 liters of solution

Clipper Applicators - Make sure the product you are using has “Cut Stump” instructions on the label. Availability of commercial clippers has become limited over the past few years. Growers may need to manufacture their own clippers.

Concentrations of 50-100% Roundup have worked well. The herbicide should flow out consistently, but not so fast that herbicide drips from the blades. Be sure to use a dye. Clip weeds close to the ground, without contacting the vines. Roundup must contact the stem as you are cutting! ‘Clip and dab’ or ‘mow and wipe’ techniques may have reduced efficacy as the herbicide is not applied simultaneously with the cut. Late-season treatments give better results than early season treatments. The effectiveness of post-harvest treatments with clippers is not known. Be sure to clean the blades after use to prevent corrosion.

SELECT MAX, INTENSITY, etc. (clethodim) – Used POST			WSSA/HRAC Group: 1
Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
<u>Select Max/Intensity One</u>			
9 - 16 fl oz/A per app (64 oz/A per year)	24 hrs	30 days	n/a
<u>Select/Intensity</u>			
6 - 8 fl oz/A per app (32 oz/A per year)			14 days between apps

Clethodim herbicides may be applied by broadcast applicator or air. You **MUST** include the recommended adjuvant. Clethodim **will not** work well without one! Spot treatments with small sprayers are effective, but care should be taken not exceed the maximum rate allowed on a “per acre” basis. Clethodim is similar to Poast (sethoxydim). It is a postemergence herbicide that controls true grasses (most annual grasses and some perennial grasses). Sedges and rushes are not controlled. Treat grasses when they are actively growing, but **BEFORE** they start to flower/make seeds. Time your application for the grass you are trying to control.

A Special Local Needs (SLN) label permits **chemigation of Intensity One; the SLN for chemigating and removing the application window restrictions for Intensity has been rescinded!** See Station web site under ‘Services’. Other clethodim products such as Select **CANNOT** be chemigated. If chemigating Intensity One, make sure to include the adjuvant recommended on the label or it will not work well (use 1-4 pt adjuvant per acre). This herbicide is absorbed through the grass leaves. If your chemigation system has long rinse time, less product will remain on the plant and efficacy may be diminished.

There are several products registered for use in cranberry that contain the active ingredient clethodim. The labels are different for each product (rates and adjuvants). Please read the label carefully and follow the manufacturer recommendations. For example, you can use an NIS with Select Max but not with Select 2EC.

Caution: regardless of application method, applying clethodim products when cranberry plants are at roughneck stage can cause deformities in cranberry flowers. This seems to be more severe for ‘Howes’ than other varieties. We have not seen significant yield reductions from clethodim associated floral deformities, but growers have reported yield loss with Howes showing severe symptoms.

Intensity One can be applied anytime during the growing season per SLN label (check label on Station website under “Services”); Intensity, Select and Select Max cannot be applied between hook and full fruit set.

For each gallon of spot-treatment solution, mix:

	teaspoons	fl oz	ml
Select Max or Intensity One	2.6 to 5	0.44 to 0.85	13 to 25
+ NIS (0.25%)	2	0.33	10
Select or Intensity	2 to 4	0.33 to 0.65	10 to 20
+ Crop Oil (1%)	8	1.3	40

SPARTAN 4F/ZEUS XC (sulfentrazone) – Used PRE
WSSA/HRAC Group: 14

Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
12 fl oz/A	12 hrs	N/A	1

We obtained a Special Local Needs (SLN) label for Zeus in 2020 and Spartan in 2023 to allow cranberry growers in Massachusetts to use these FMC products for control of moss and other susceptible weeds. See Station web site under ‘Services’. The SLN for Zeus expires December 31, 2024 and will NOT be renewed. Please use all remaining stocks prior to that date.

Apply after the winter flood is removed and prior to cranberry vines breaking dormancy (buds are spring dormant through cabbagehead). Some growers use a frost tolerance of 25°F as their cut-off point. Risk of injury is likely to increase if applications are made too close to when the vines break dormancy and start active growth. We recommend applying **before** the cabbagehead stage. Make a single application of 8-12 oz/A through the chemigation system or by ground rig. The addition of an adjuvant is NOT recommended.

Since we first obtained sulfentrazone in 2020, many growers have now used it with good results. This herbicide can damage cranberry plants if applied too late. You **MUST** apply to plants that are spring dormant (bud scales closed, no potential for herbicide to contact tender new growth inside the bud). It is more important to time this herbicide for cranberry safety than it is to time it for the weed growth stage! It may also cause stress symptoms if applied to already stressed cranberry vines (e.g., ones that have scale infestations, were heavily pruned, have poor root development). In 2022, we observed some areas on some sporadic beds that were treated with Zeus where the old growth (leaves from the previous growing season) remained red as the plants emerged from dormancy. The new shoots appeared to develop normally for the remainder of the season.

Spartan/Zeus is NOT safe for use on new planting established from unrooted vines. Preliminary research shows that sulfentrazone can be used on beds established from plugs (rooted cuttings) the year after planting.

Check with your handler prior to use for restrictions. Use of the product includes release of FMC from any liability from damage that might occur with applications of the herbicide.

Zone II restricted! Spartan/Zeus is a state-restricted use product since sulfentrazone is included on the Groundwater Protection List. Application of Spartan/Zeus in a Zone II may be allowed because there is no viable alternative for moss. However, paperwork must be submitted to MDAR. Contact extension specialist.

STINGER (clopyralid) – Used POST**WSSA/HRAC Group: 4**

Annual allowable formulation	Restricted entry interval (REI)	Preharvest interval (PHI)	Max number of applications
16 fl oz/A (8 oz/A per app)	12 hrs	50 days	2
Type of application		Rate	
Wipe		2% solution - 2.5 oz (5 Tbsp) per gallon	
Spray (wild bean)		0.06-0.12 fl oz (0.37-0.75 tsp) per gallon	
Spray (aster, ragweed, etc.)		0.33-0.5 fl oz (2-3 tsp) per gallon	

Stinger **CANNOT** be applied by air or through the irrigation system! Do not apply within 5 hours of expected rainfall or irrigation.

Stinger is a postemergence herbicide used to control wild bean, narrow-leaved goldenrod (NLGR), asters, clover, ragweed, pitchfork (and other members of the Aster and Legume families), and certain other weeds within the treated area. Growers have reported effective control (and reduced vine injury) when using lower rates than recommended on the label. This is particularly true for wild bean control.

Apply when weeds are actively growing. It is best to apply Stinger when vines are dormant, if possible. For weeds that emerge late (NLGR, wild bean, etc.), wait until after fruit set to apply. Cranberry plants are most sensitive to Stinger applied prior to bloom. Do not apply Stinger from 1 week prior to bloom until 1 week after bloom. After bloom, Stinger can be applied up until 50 days prior to harvest. Higher rates of Stinger can be applied to cranberry plants post-bloom because the plants are less sensitive to Stinger than during the spring flush. Stinger can also be applied in autumn after harvest.

Stinger may be applied as a broadcast spray, as a wipe or as a spot treatment with a handheld sprayer. Spray to just wet the weeds, but not to run-off. **BE VERY CAREFUL!** Overspray can cause injury that may take 1-3 years for full vine recovery. Minimize drift when applying as a spray. Results may be slow to show; be patient. Two applications per season are permitted, not to exceed a total of 1 pint per acre.

WEEDAR 64 (2,4-D) – Used POST**WSSA/HRAC Group: 4**

This and other 2,4-D products are State Restricted Use pesticides. They have considerable potential to evaporate and cause crop injury. 2,4-D products can be highly effective at controlling some weeds. However, the potential for significant vine injury may outweigh the advantages of using these materials. Only one application per year is permitted. Do not exceed 2.4 pt/A.

Avoid applying 2,4-D on hot, sunny, and humid days when there is little air movement. Weedar 64 is the only 2,4-D product that can be used on the bog. Weedar 64 has a 30-day PHI and may only be applied once per season. For wipers, mix 1 part Weedar to 2 parts water for hockey stick application. Best results are obtained when used in late June and July. Do not drip or touch vines.

If you are using Weedar with Roundup, first mix your Roundup solution. Then mix Weedar in a 1:4 ratio with the Roundup solution (1 part Weedar to 4 parts RU solution).

70 WEEDS

SALT – Used POST

Salt (sodium chloride) granules or salt sprays may injure certain weeds (e.g., wild bean, rushes). Judicious applications do not inhibit re-colonization of cranberry vines once the weed dies. Do not use during bloom. It may be sprinkled at the base of weeds (for rushes use 1-3 teaspoons per clump) or sprayed in a solution. For wild bean, 1 lb/gal water used after fruit set can help to control this weed. Do not exceed 200 gallons per acre. One grower recently reported that they obtained some control of dodder using a salt water spray. Use of calcium chloride or other types of salts is not recommended. Salt is corrosive to machinery. Be sure to wash equipment thoroughly after application.

FLAME CULTIVATION (FC) or THERMAL WEEDING – Used POST

The use of hand-held propane torches can provide control of some weeds (e.g., dewberry, rushes, and dodder). Applications (in test studies) have been made in the summer months. FC is a good option on organic farms or as an alternative to continual POST herbicide use. Several torches, called open flame (OF) or infrared (IR), are available. Cranberry vines can be injured during a FC application but the vines will recover. Short exposures (~8 sec) provide control when using OF; longer exposures are needed (~30 sec) with IR. May be practical for use in ditches, on dikes, and non-production areas.

VINEGAR (horticultural vinegar, acetic acid) – Used POST

Treatment with 20% acetic acid gives moss control, but also injures cranberry vines. Data are limited for control of other weeds. Research from Canada on organic beds shows that soil injections of vinegar into the root zone of weeds (spot treatment) can injure or control some weeds. If using vinegar to control weeds, make sure to use a product labeled for use in agriculture.

Soil pH management to improve weed control

SULFUR

Determine soil pH in the weedy area prior to sulfur application. If pH is 5.0 or above, use two applications of 500 lb/A each (or 4 applications of 250 lb/A) to reach 1,000 lb of elemental sulfur per season. Begin application in late spring when soil is drained and the need for frost protection is over. Most growers allow 3-6 weeks between applications. Do not apply sulfur to puddled or waterlogged areas as resultant production of hydrogen sulfide can cause severe vine toxicity. Changes in pH can be very slow. Granular applications may take up to 9 months to reduce pH enough to affect weed populations. The smaller the sulfur pellet size, the faster the pH is lowered. Use pelletized sulfurs only. Do not use flowers of sulfur (usually bright yellow powders); they can be phytotoxic and are difficult to apply. Reducing soil pH below 4.0 may weaken the cranberry vines. Do not use potassium sulfate since *sulfate* (SO₄) will not lower soil pH. Yearly sulfur applications may be needed as the pH can creep up in subsequent years. Test soil pH yearly to determine the effectiveness of sulfur applications. The effect of lowered pH on control of cinquefoil is moderate. Eye protection and dust masks are recommended when making sulfur applications. See Nutrition Section for more info on sulfur and soil pH.

OFF-BOG AQUATIC WEED CONTROL

Diquat	0.5-2 gal per surface acre	Use during Summer months. Water use is restricted for various time periods depending on product and pattern of use. CHECK THE LABEL! Use only on still water areas outside of bog (e.g., farm ponds, reservoirs). Water temperature should be >50°F for best activity. Do not use in or on bog ditches.
Reward	(37.3% ai diquat dibromide)	
WSSA/HRAC group: 22		
Rodeo	(53.8% ai glyphosate)	Apply during the Summer months. Rodeo is registered for use on noncrop land only. Use in interior ditches is not permissible. Recommended spray solution: 5 fl oz/3 gallons. Add NIS at the rate of 0.25-0.50% volume basis (1-2 fl oz or 2-4 Tbsp in 3 gal.).
WSSA/HRAC group: 9		More effective against cattails and water lilies. Not effective against submersed weeds.

OFF-BOG USE: WEED MANAGEMENT OUTSIDE OF PRODUCTION AREAS

AQUATIC WEEDS. Reports of grower problems with aquatic weeds have been increasing. Aquatic weeds can be submersed, floating plants, floating leaf plants or emergent plants. Common aquatic species for our area may include fanwort, variable watermilfoil, bladderwort, hydrilla, duckweed, and water lilies. Be sure to get a correct identification of the weed problem before treating. Treatment of some water areas may require a permit. Non-chemical methods (e.g., harvesting, suction, hand pulling, dredging) are available but are very expensive. The use of grass carp for aquatic weed control is NOT permitted per MA Fish and Wildlife. Call 508-389-6300 for more information.

DIQUAT. This herbicide should only be used on water weeds growing in areas **outside of the bog.** Do not use in any ditch associated with the production area. Diquat will control water weeds such as bladderwort, coontail, elodea, and pondweeds. A non-ionic surfactant (e.g., Induce, Activator 90) may improve performance. Check the label for rate information, and directions on spot treating surface weeds.

RODEO. This glyphosate product can only be used to control weeds that occur **outside of the production area.** Application is spray to wet leaf surfaces, not to runoff. Extremely cool or cloudy weather following application may slow the activity of this herbicide. Best control is obtained when plants are at late growth stages approaching maturity. Weeds under stress will not be controlled as well as healthy plants. Rainfall within 6 hours of application may reduce effectiveness, and heavy rainfall within 2 hours of application may necessitate reapplication. Do not add ammonium sulfate to Rodeo mixtures.

ALGAEICIDES

Algaecides for control of algae (green scum) are usually prescribed on an acre-foot basis. An acre-foot is the amount of water needed to cover one acre of bog with one foot of water (~300,000 gallons of water). These include products like Cutrine Plus (can be used both off- and on-bog, see Late Water section), which are labeled for use in ponds, ditches, and canals. Read all product labels carefully before using.

NAUTIQUE (by SePro) is a copper carbonate (double-chelated copper formulation) product that is labeled to control floating, emerged, and submerged vegetation in still or flowing aquatic sites such as reservoirs, ponds, slow-flowing water bodies, crop and non-crop irrigation systems. Use lower rates if carbonate hardness of the water is less than 50 ppm (this is generally the case in MA); as water hardness increases (>50 ppm), efficacy may be decreased and non-target toxicity may be increased. If applying to public waters, check with the local authorities for permit process. Nautique can be mixed with other aquatic herbicides; check the label. When applying to irrigation ponds, hold water for a minimum of 3 hours before irrigating plants. It is highly corrosive and carries a DANGER label. It may be fatal if absorbed through the skin. Be very careful with this product!! Wear all recommended protective equipment. Application rate varies by vegetation density and depth of treated area. Please read the label. If you have any questions, please consult with a Weed or Aquatic Weed Extension specialist prior to treating.

NOTE ON IRRIGATION SOURCES TREATED WITH AQUATIC HERBICIDES: In some instances, municipalities or homeowner associations (or similar) may opt to apply aquatic herbicides to water bodies that cranberry growers use for irrigation or flooding. Some products may or may not have a tolerance, some have ‘incidental tolerances’ and some are tolerance-exempt. Depending on the product and timing of application, the impact to your farm operation could be small or great. Please reach out to the Station and your handler if you anticipate that a situation might occur.

OFF-BOG WOODY AND BROADLEAF PERENNIALS CONTROL

(not in ditches or canal banks)

Hand pulling is most beneficial in Spring and early Summer when the soil is moist and the plants are fairly small.

CROSSBOW, WEEDONE (2,4-D). Crossbow and Weedone are labeled for **non-bog use only** and are State Restricted Use pesticides. Be cautious! Crossbow contains triclopyr for which there is **no food tolerance**. Do not use Crossbow or Weedone on dikes or canal banks. Use it only on weeds located far away from the bog. These products have considerable potential to evaporate and cause crop injury. They have the potential to drift far from the site of application, and can injure nearby plants such as apple trees, grapes, etc. Avoid applying 2,4-D on hot, sunny, and humid days when there is little air movement. 2,4-D products can be highly effective at controlling some weeds.

Weedone 650
WSSA/HRAC
Group: 4

Follow spot
treatment
instructions

Spray to wet. Avoid drift onto bog. Controls woody plants on roadsides and non-crop areas.

Crossbow
WSSA/HRAC
Group: 4

1-1.5%
solution, see
spot treatment
instructions

Drift to desirable plants may cause injury (esp. grapes and tomatoes). Do not apply to water. Read the label! See Notes on 2,4-D.

RENOVATION AND NON-PRODUCING BOGS

FUMIGANTS. Basamid (dazomet) and Vapam (metam-sodium) are soil fumigants that can be used on cranberry beds. They can only be used if fruit will not be harvested and delivered for 12 months post-application. **DO NOT USE FUMIGANTS AS A SPOT-TREATMENT IF ANY VINES WITHIN A DIKED SECTION WILL BE HARVESTED**. If it is used on part of section, no fruit can be harvested or delivered from the entire (contiguous) section. If you are renovating an entire section, a portion of that section can be spot-treated with a fumigant. More information on the use of fumigants may be found in the Planting New Cranberry Beds Fact Sheet (<http://ag.umass.edu/cranberry/fact-sheets>). Contact the Weed Specialist if you have any questions about using these chemicals.

You must complete EPA fumigant training before applying any fumigant. You **must** get certified/pass the module on EPA's web site. As required by updated soil fumigant product labels, certified applicators must successfully complete an EPA-approved training program covering the new soil fumigant provisions. Please go to the EPA's web site for more information:

<https://www.epa.gov/soil-fumigants/soil-fumigant-training-certified-applicators>

Note: There is a provision that if you are already certified in a soil fumigation (sub)category and your state is listed with additional training option and requirements, you can bypass the training. Massachusetts is NOT one of these states! So you must take and pass the modules.

REGLONE, and others (Diquat dibromide). Non-selective herbicide. Reglone and other diquat products registered for use on non-producing beds should only be used on bogs that will be renovated or will not be harvested for 1 year. The intended use is as a site-preparation product, not for use for spot weed control on an active farm. This product works as a plant desiccant and should be used as a directed spray. Reglone cannot be applied by chemigation. Use 1.5-2 pt/A in a minimum of 15 gallons water by ground. May need repeat applications. Add NIS. WSSA/HRAC Group: 22.

FUSILADE (Fluazifop). This selective grass herbicide can only be used on non-producing bogs. It is used postemergence for control of true grasses. Sprayed grass will turn yellow and die back over a 1-4 week period depending on climatic conditions. It is rainfast after 1 hour. Add a COC at 0.5-1% v:v or 0.25-0.5% v:v if using a NIS. Use 0.75 fl oz herbicide per gallon water. REI is 12 hr. WSSA/HRAC Group: 1.

DITCH MANAGEMENT

WOODY AND BROADLEAF PERENNIALS ON DIKES (BOG-SIDE)

Cultural controls include mowing the ditch and dike areas during the summer months. Some areas may need to be done more than once. Hand pulling is most beneficial in the spring and early summer when the soil is moist and the plants are fairly small. Controlling weeds on the dikes may be useful in reducing spread of these weeds onto bogs.

DITCH WEEDS (*e.g., Arrowhead, Pickerelweed, Pond lilies, Bur-reed, Duckweed*)

Clean ditches by hand or mechanically preferably twice a year. Draining ditches can sometimes be helpful in killing some aquatic weeds (*e.g., duckweed*). Preemergence herbicides registered for use on the bog may **NOT** be used in the ditches for weed control. Roundup use is permitted in dry ditches as a wipe or a spray. See notes on Roundup. Flame cultivation may be an effective nonchemical tool for ditch weed management.

NOTES ON CONSERVATION SEED MIXES FOR DIKES AND DITCHES

The seed mix recommended by Plymouth County Soil and Water Conservation District contains perennial species, at least one nitrogen-fixer, is drought-resistant, must not introduce known weed seeds, contains at least 3 species, and is economical to purchase. The current permanent seeding mixture recommend for well to moderately well-drained soils on “Embankments, Steep Slopes, Roadsides, Dikes, Dams, and Ponds” is creeping red fescue (15 lb/A), perennial ryegrass (5 lb/A), redtop (2 lb/A), and white clover (4 lb/A). For cranberry bog dikes, consider replacing the clover with 6 lb/A birdsfoot trefoil. For more information on planting rates and cost, please contact the West Wareham Office <https://www.plymouthswcd.com/>.

Other seed mixes may be used but if you want to take advantage of cost-sharing, be sure to confer with NRCS prior to using a non-standard, non-recommended seed mix. Creeping red fescue and hard fescue may offer good stabilization coupled with low maintenance. You may want to consider the addition of an annual ryegrass (small proportion of total) for quick colonization along with the fescues. If you wish the fescues to predominate, be sure to mow the ryegrass prior to seed production (late summer-early fall).

Use herbicide with caution when re-seeding dikes, as some herbicides will control grasses and legumes present in seed mixes. Red clover was susceptible to injury from Callisto. Hard and creeping red fescue and switchgrass showed symptoms briefly but recovered within a few weeks.

CAUTIONS AND OTHER NOTES

1. Chemicals not registered for use on cranberries must not be used.
2. Herbicide use may weaken vines and crops may be reduced.
3. To be most effective, rain should follow the application of any dry herbicide formulation within 4 days or the bog should be irrigated.
4. Wash equipment with soap (or detergent) and water immediately after using. Rinse with ammonia after using hormone-type herbicides (such as 2,4-D).
5. Hand wiping with glyphosate products is often practical with some weeds if roots are weakened. This is particularly useful for dewberries after late water or a summer flood.
6. Mowing of tall weeds helps to prevent shading and reduces seed formation.
7. Late water causes general reduction of annual grasses and may reduce dewberry populations and re-growth.
8. Agricultural burning of brush or grass is allowed under regulations from the Director of Air Pollution Control, Southeastern Office of the Dept. of Environmental Protection and under permit from the local fire chief.
9. Review the Weed Management BMP in the UMass Best Management Practices Guide.

ag.umass.edu/cranberry/publications-resources/best-management-practices

NUTRITION MANAGEMENT FOR PRODUCING BOGS 2024 - 2026

Prepared by Carolyn J. DeMoranville, Katherine M. Ghantous, and Peter Jeranyama

The Commonwealth of Massachusetts 330 CMR 31.00 Plant Nutrient Application Requirements for Agricultural Land and Land Not Used for Agricultural Purposes took effect in 2018. The regulation requires that nutrient management plans for agricultural lands, including cranberry, will be based on plant needs (as determined by testing and research) and UMass Extension recommendations. This section of the Chart Book encompasses UMass Extension recommendations for cranberry nutrient management. Use of these recommendations constitutes a Nutrient Management Plan as required in the regulations. Having a copy of the Chart Book and the required records of your applications satisfies the final version of the regulatory requirements – you are not required to have a separate written plan.

Tools for Nutrient Management: The Cranberry Station website provides information regarding nutrient management planning and record keeping based on Chart Book recommendations. To view these resources, follow the 'Nutrient Management for Cranberries' Quick Link on our home page (<http://ag.umass.edu/cranberry>). Resources include a plan template and Excel files with sample record keeping formats and nutrient calculators (determine fertilizer rates based on how much nutrient you want to apply). Growers may also choose to use the BOGS system, available from the Cape Cod Cranberry Growers Association. It is an online tool designed to plan and keep records that meet regulatory requirements for pesticide and nutrient applications.

Plants are primarily made up of carbon compounds (the products of photosynthesis) and water. Mineral elements, the materials provided in fertilizer and the soil, are present in much smaller quantity, making up only about 10% of the plants' *dry* mass. The essential mineral elements required for the plant to grow, develop, and produce fruit need to be provided in the right amounts, in the right form and at the right time. Management must be flexible, adjusted for changing weather and observations of the plants. It should also be implemented in an environmentally sound way.

Cranberry is a perennial plant. As such, many of the mineral elements and carbon compounds are stored over the winter in stems and roots, then remobilized to support new growth in the spring. In addition, decaying plant material in the soil can provide minerals, especially Nitrogen (N) and Phosphorus (P), back to the growing plants. In a mature cranberry bed, these processes account for about half of the plant's need for mineral nutrition. The rest is supplied in fertilizers. The plants in new sand-based cranberry plantings depend primarily on fertilizers for their nutrients.

Nutrient requirements must be met to assure optimum growth and to achieve the yield potential possible for each cultivar. The plant must be healthy, with an adequate root system in order for it to take up the nutrients it needs. Overly saturated or dry soil or soil outside the pH range optimal for cranberries (4.0 to 5.5) can limit yield. Uniform irrigation is essential to maintain moist, *but not saturated* soil. Pest pressure, frost, or shading are other potential limiting factors. Additional fertilizer applications will not compensate for any of these problems.

The recommendations in the Chart Book are developed based on knowledge of mineral content in a healthy productive plant. The recommendations focus largely on Nitrogen (N), Potassium (K), and Phosphorus (P). Added nutrients are required to replace minerals removed in the harvested crop and associated leaf trash.

- N is found in the highest concentration of all of the nutrient elements in plant tissue, and is removed in the greatest quantity in fruit and harvest detrashing.
- K is found in the highest concentration in cranberry fruit and as a result, K removal in crop harvest is similar to that of N.
- P removal in crop harvest is much less than that of N and K, but research trials support the need for a modest annual addition of P to producing cranberry beds.
- The remaining mineral elements are seldom deficient in plant tissue tests and/or are found in substantial quantity in the bog soil. Their application is primarily recommended when a deficiency exists and not on a routine basis.

NITROGEN (N)

The N fertilizer is not primarily used to produce fruit in the current year, rather it supports the building of the new growth that is the photosynthesis factory to support future production. In our research, current season N applications correlated to current season yield only 10-15% of the time, while in almost all cases applied N correlated significantly with production in the following two years.

Recommended N fertilizer rates are based on the amount of N removed during harvest (in fruit and in trash). To replace the removed N, we need to apply fertilizer. Plants are not able to take up all the fertilizer applied. The amount of N removed is then multiplied by a correction factor of 1.4 to account for the less than 100% efficiency of fertilizer uptake. The base rates can then be adjusted based on seasonal conditions, observed plant growth, previous summer tissue tests, and historic bog responses. The base rate recommendations for N vary by cultivar group. The N *concentration* in fruit and new growth is similar among the cultivars. The N *amount* in biomass (fruit and plant material) produced and then lost in harvest operations differs among the groups.

N lost in fruit:

- Each 100 bbl of fruit has 5.1 lb of N.
- As crop size increases, we can scale up from the 5.1 lb/100 bbl to the numbers of bbl/A produced or expected.

N lost in detrashing during harvest:

- Each acre of Early Black loses 13.4 lb N in plant biomass (in addition to what is removed in the fruit). That amount is likely similar in Howes.
- Larger fruited cultivars are larger plants with bigger leaves, and lose more biomass per acre.
- Ben Lear and first generation hybrids such as Stevens and Grygleski, lose 20.1 lb N per acre.
 - 1.5 x Early Black rate to compensate for larger plant size.
- Newer Rutgers and University of Wisconsin hybrids lose 26.8 lb N per acre.
 - 2 x Early Black rate to compensate for larger plant size.

The base range reflects varying crop loads: up to 600 bbl/A for the newest hybrids and up to 300 bbl/A for the others. This does not mean that higher yields necessarily would require more N. In fact, for all but the newest cultivars, adding more N than required can result in yield *decline*.

Recommended base Nitrogen rates

Cultivar group	Base N rate lb/A	Other considerations
Natives: Early Black and Howes	25-40	Reduce to 25-30 for crops less than 200 bbl/A
Older hybrids and large fruit: Ben Lear, Stevens, Grygleski, Pilgrim	35-50	Reduce to 35-40 for crops less than 200 bbl/A
Rutgers and University of Wisconsin cultivars: Crimson Queen, Demoranville, Mullica Queen, HyRed	50-80	Reduce to 50-60 for crops less than 300 bbl/A

The aim is to provide enough N to produce a stand of uprights with optimal density and length that will support an optimal crop of good quality fruit. When the upright stand is too dense or too long, shading occurs, pollinators may be impeded, and conditions are perfect for fungal rot infections. A thin, stunted stand will not support a large crop since there will not be adequate leaf area, leading to a deficit in photosynthesis and a shortage of carbohydrates for making fruit.

78 NUTRITION

Within the recommended rate ranges, previous observed outcomes, tissue test results (see page 85), and observations of the plants color and growth should be used to adjust your rate. Some potential yearly adjustments to the recommendation based on growth and tissue test N:

- If vines are stunted or yellowed and tissue N is low - use more
- If vines are stunted or yellowed and tissue N is high - look for other limiting factors
- If vine growth is adequate and tissue test is in the normal range - continue with the chosen rate
- If vines are rank or leggy and tissue N is low - use less or change timing; vegetative growth is being favored over production
- If vines are rank or leggy and tissue N is high or adequate - use less
- If yield potential is limited by pest damage or frost - use less

Length and density of uprights. The table below shows adequate stand density and upright length for four common cultivars assessed at hook stage (mid-June). Uprights generally should not be longer than 4 inches. An even and adequate stand of both flowering and vegetative uprights is important, as about 80% of this year's vegetative uprights will flower next year. 200 flowering uprights/sq. ft., each producing an average of 1 berry, will give a crop of 200-300 bbl/A. To sample upright density: count all uprights in a circle 4 inches in diameter. Total upright density (approximate) for 'Early Black' should be 50/sample; density for 'Howes', 'Ben Lear', or 'Stevens' should be 35/sample. Multiply the amount in the 4-inch diameter circle by 12 to approximate the number per square foot.

Upright density observations at hook stage (mid June)

Cultivar	Early Black	Howes	Ben Lear	Stevens
Upright density (per sq ft)	600	400	400	400
Minimum Upright total length (in)	>2.25	>2.25	>2.5	>2.5

- Density of total uprights per sq ft, >40% should be flowering
- Upright length above the fruit on a flowering upright should be 1.5 to 2 in.

Leaf greenness is related to the pigment chlorophyll that is involved in carbohydrate production through photosynthesis. Along with adequate growth (length) of the uprights, chlorophyll content is an important determinant of yield. Overall intensity and shade of leaf greenness (chlorophyll) is related to adequate N nutrition. With experience, growers can assess intensity of greenness by visual observation.

A bog with thin vine cover, pale leaves, or stunted vines may not be getting enough nitrogen. Vines that are too long and too dense have nutritional assets diverted to vegetation and not to fruit (small berries, poor fruit color, increased fruit rot, and inability of bees to reach pollination sites).

Nitrogen timing.

Plan nitrogen fertilizer applications based on soil type and soil temperature.

- On sandy soils (<1% organic matter), nitrogen fertilizer may be applied throughout the season.
- On more organic cranberry soils and older beds, applications should be based on soil temperatures.
 - For typical cranberry bogs (1-4% organic matter), applications of N should not be necessary early in the spring. From flood removal until soil temperatures exceed 55°F, adequate N should be available through biological processes (mineralization; the process by which microbes convert N to plant-available forms).
 - Nitrogen is slowly released from the soil early in the spring when the cranberry plants are dormant. This leads to a 'flush' of ammonium availability when the plants are breaking dormancy.
 - As soil temperatures increase from 55°F to 70°F, release of N through mineralization is only moderate. Fertilizer applications should be beneficial. This corresponds to the period from roughneck stage through bloom.

During spells of hot weather, when soil temperatures exceed 70°F and air temperatures exceed 85°F, soil N release increases and crop development slows, so planned fertilizer N applications should be reduced, delayed, or eliminated especially on beds with high organic matter in the soil.

It is best to time N applications by the growth stage of the plants. Cranberries primarily use N during three stages: early season leaf production, fruit set, and bud set. When N is applied pre-bloom, it is rapidly taken into the plant and moved to the new leafy growth. While such applications can assure adequate upright length, adding too much N at this stage can lead to excessive growth. Fruit production is a very high demand period that extends from earliest set to about 3 weeks after the final fruit are set. Bud set is occurring during fruit set, so set applications also support this function.

Since the fruit set window is such a high N demand period, it is not unusual to see some loss of green color in the leaves above the fruit as the fruit are drawing N from both those leaves and the soil. Minor yellowing is normal, severe overall yellowing can indicate inadequate N fertilization. This should not be confused with Yellow Vine (see page 83), a patterned yellowing related to root stress and not improved by the addition of N.

Stage/formulation	% of total N for the season
<i>Slow or controlled release</i>	
Pre-roughneck (mid-May)	50-100%*
<i>Fast-acting, soluble sources including soil-applied liquids</i>	
All but the newest cultivars	
Roughneck to hook	up to 20%
75% in bloom (early set)	50-60%
75% out of bloom (late set)	30-40%
<i>Fast-acting, soluble sources including soil-applied liquids</i>	
Rutgers and U-WI cultivars	
Roughneck to hook	up to 20%
First fruit set	30-35%
7 days later	30-35%
7 days later	20-30%

*if less than 100%, apply remainder at set using fast-acting sources

Nitrogen sources.

Most cranberry growers in MA apply N in NPK fertilizer (aka 'complete fertilizers') primarily to reduce application costs when N, P, and K are all needed. In such fertilizers, the first number on the bag or jug is the percent N in the material. Since P requirements are substantially less than those for N and K, materials with high middle numbers (phosphate) should be avoided. Note that when using liquid fertilizers, the percent on the jug is based on weight, so to calculate pounds per acre applied, one must correct for the liquid density (weight per gallon x gallons per acre x percent).

The best available evidence indicates that cranberries respond poorly to nitrate N especially in the absence of ammonium N; the AMMONIUM FORM is recommended. Monoammonium phosphate is an excellent source but can provide excess P (see the Phosphorus section below). Ammonium sulfate is also an excellent source. Light rates of urea, a material that breaks down to ammonium, are suitable to correct N deficiencies quickly (when the urea is dissolved and used as a foliar feed). Use blended fertilizers with ammonium N and excellent uniformity of particle size or ammoniated materials. Non-uniform blends may sort during application, giving poor results. Liquid formulations designed to be applied to the soil and taken up through the roots can be substituted for granular materials.

FISH HYDROLYSATE FERTILIZER is available commercially, is useful for organic production, and has been shown to be a suitable substitute for granular, inorganic NPK. It may provide benefits in soil conditioning and reducing movement of nutrients out of the root zone. Fish fertilizer is a good choice where the bog holds water poorly and/or has a history of needing larger than normal fertilizer rates. The nitrogen in fish fertilizer is tied up in organic compounds. As these degrade in the soil, nitrogen is slowly released for use by the cranberry plants. Leaching losses of nitrogen are reduced. Therefore, 20% lower nitrogen rates provided as fish fertilizer should give the same result as a higher nitrogen rate provided in granular, inorganic fertilizer. This has been demonstrated on commercial bogs. Fish is especially useful in the spring and can be incorporated into a program that includes other inorganic fertilizers if organic production methods are not required.

PHOSPHORUS (P)

PHOSPHORUS (P) RATES OF 10 LB/A (20 LB/A P₂O₅) OR LESS ARE STRONGLY RECOMMENDED ON NATIVE OR FIRST-GENERATION HYBRID VARIETIES UNLESS A DEFICIENCY IS DOCUMENTED.

Phosphorus is important for plant metabolism; it plays a key role in energy transfers, in transporting the sugars produced in photosynthesis, and is part of the DNA molecule. If P is deficient, growth and yield can be impacted. However, P does build up in the upper soil layers and some of that is available to the plants. This stratification often confounds P soil test results, making them difficult to interpret. Therefore, application recommendations are based on crop use and tissue testing. Of the three main nutrients, P is required in the smallest amount (compared to N and K). P removed during harvest accounts for only about 5 lb/A (250 bbl/A contains approximately 2.5 lb P and normal harvest and subsequent detrashing removes another 2.5 lb). Pruning operations can also remove P; 500 lb of vine prunings contain about 1/2 lb P.

P is often added with N in NPK fertilizers and is the second number on the bag. Fertilizer convention is such that the second number is actually percent *phosphate* (P₂O₅), so to calculate the actual P, that number is multiplied by 0.44.

Important considerations regarding P use and use reduction:

Very little P is removed from the bog in the harvested crop! Cranberries require additions of phosphorus fertilizer for sustained productivity, but there is *no evidence* that more than 20 lb/A actual P is required for productive cranberries (for native cultivars and first generation hybrids).

Research studies on P have shown:

- On high P sand soils, there was no response to P fertilizer on beds with adequate tissue P.
- On native cultivars, the greatest yields were on plots receiving 10-15 lb/A P, with no improvement at higher rates.
- If tissue P was in the sufficient range, rates well below 10 lb/A gave the best yields.
- If tissue P was in the deficient range, 20 lb/A gave the best yield.
- At several commercial sites, growers applying an average of 10 or less lb/A/yr P over a period of years have seen either no change or an *improvement* in their crops.

Based on these data and observations, the P rate recommendations in this Chart Book were developed. The only exception to these recommendations for native varieties and first-generation hybrids are for new beds with fresh sand planting medium. The recommendation for those is to use up to 20 lb/A at planting and no more than *a total* of 30 lb/A on new or renovated beds until the canopy is established.

Second generation hybrids produce much higher yields than native varieties and first generation hybrids, and tend to be larger and more robust plants. These varieties are reported to have moderately higher P demands than older varieties. On-going research is being conducted to quantify the increased nutrient demands.

P can be an environmental pollutant. Adverse environmental impacts are reduced by using moderate P rates (no more than 20 lb/A per season on native varieties) and by careful attention to harvest flood management. When bogs are flooded, especially when soil and water are warm, P from the soil can move into the flood water. When the flood is released, the dissolved P then leaves the bog system.

To minimize P release in harvest floods:

- 1) Hold harvest floods for 2-4 days to allow settling of P-containing particles.
- 2) Release gradually (to avoid flushing particles) so that discharge is completed within 10 days. Research has shown that holding floods beyond 10-12 days in the fall can result in oxygen depletion and release of P from iron in the soil.
- 3) Use no more than 20 lb/A P in fertilizer -- laboratory research showed that with higher P use, P movement into the flood begins immediately upon flooding and then accelerates as oxygen depletes. With low to moderate P use, P release into water is minimized.

Recommended Phosphorus rates for native and first generation hybrid varieties

Production system	Recommended P rate lb/A	as P ₂ O ₅ lb/A	Notes
New plantings	up to 30	up to 68	During establishment
Established beds, tissue test >0.16%	no more than 10	no more than 23	
Established beds, tissue test 0.11-0.15% and stable	no more than 15	no more than 34	Trying a lower rate (e.g. 10 lb/A) is encouraged
Established beds, tissue test <0.12% and trending down	up to 20	up to 45	15 lb/A P with testing should suffice
Established beds, tissue test <0.10%	20	45	

Research on Stevens, Ben Lear or native cultivars showed 10-15 lb/A P is sufficient to maintain productivity if tissue test P is in the sufficient range (0.1-0.2%). In plots and demonstration sites, production and fruit quality were maintained with an average of 10 lb/A; no significant relationship between P rate and yield was observed. As P fertilizer use was reduced, P output from the bog (in flood water) also decreased. Based on these studies, growers have reduced P applications well **below** the previously recommended maximum of 20 lb/A (5-year rolling average of ~10 lb/A) with no reduction in crop. When implementing a reduced P rate, it is important to collect August tissue tests and follow these recommendations: If P is <0.10% - increase the P rate and retest next season; if P is 0.10-0.11% - maintain the P rate and retest next season; if P is 0.12-0.15% - maintain the reduced P rate and retest in 2-3 years; if P is 0.16% or more - further P reduction should be considered.

These numbers above are based on Stevens, Ben Lear or native cultivars. Recently MA cranberry growers have adopted high-yielding second-generation hybrids. There is evidence that more P is being removed through harvest as yields of over 400 barrels per acre have been reported. To replenish P available for plant uptake slightly higher lb P/A may be required with the second-generation hybrids. It is suggested that up to 30 lb P/acre could be adequate. Ongoing research continues to quantify nutrient demands for these varieties.

Phosphorus timing and sources.

Phosphorus ties up in the soil quickly, binding to iron and aluminum. Therefore, P should only be applied when the plants are actively growing. Phosphorus is generally added with nitrogen and potassium (NPK) or as super phosphate (0-25-0) or triple super phosphate (0-45-0). Research indicates that foliar P or soil-applied liquid fertilizer that contains P, bone meal, or rock phosphate can supply the P needs of cranberry bogs as well. The second number on the bag of NPK fertilizer is *phosphate* - P₂O₅.

** To determine pounds of P in 100 pounds of fertilizer, multiply 0.44 by the second number on the fertilizer label.*

82 NUTRITION

When choosing fertilizers, remember that research indicates there is **no horticultural benefit** to high P rates (in excess of 20 lb/A actual P per season) and that high P applications can be associated with degradation in water quality. If tissue P is in the sufficient range, we do not recommend fertilizers with high P (middle bag number). In fact, excellent results have been seen in recent years with 1:1 or near 2:1 N:P ratios (for example, 18-8-18). **It is highly recommended that growers use reduced P ratio fertilizer on their bogs, especially if high N applications are planned.**

Use no more than 20 lb/A actual P (~45 lb/A P₂O₅) per season except on new beds or second-generation hybrids. See calculations on the last page of the Nutrition section.

POTASSIUM (K)

The amount of K in cranberry leaves is second only to nitrogen among the mineral nutrients and K is the element in the greatest abundance in the fruit. Potassium is important in the movement of sugars in the plant, in maintaining plant hydration, and in many enzyme reactions in the plant. Cranberry sand soils are naturally low in K, leading to an annual requirement for K additions.

Potassium rates.

K is often added with N in NPK fertilizers and is the third number on the bag. Fertilizer convention is such that the third number is actually percent potassium oxide (K₂O), so to calculate the actual K, that number is multiplied by 0.83. When tissue and soil tests are in the sufficient range, the K requirement is roughly similar to that for N, so choosing an NPK with similar first and third numbers works well.

Recommended Potassium rates

	Recommended K rate lb/A	Other considerations
Soil and tissue tests normal	up to 100	Look for NPK with similar first and third numbers
Soil and tissue tests low	60-100	Consider a supplement like SulPoMag or KMag at 100-150 lb/A or a soil-applied liquid K supplement
Tissue test high	0-60	Use no supplements

Potassium timing and sources.

Supplemental K may be applied as soon as the soil warms in the spring, generally in early May. Otherwise, K is generally added with nitrogen and phosphorus (NPK).

Supplemental K is often added with magnesium (SulPoMag or similar product), but may be applied as a foliar spray (of little value in research trials) or as potassium sulfate (0-0-50). Muriate of potash (KCl, potassium chloride, 0-0-60) may be less desirable due to the adverse effects of chloride on cranberry vines when used at high rates over years. However, modest rates appear to have no adverse impact. While foliar applied K seems to have little utility in cranberry production, soil-applied liquid products containing K have been used with good results.

OTHER ELEMENTS

Calcium and Magnesium.

The other major elements, Calcium (Ca) and Magnesium (Mg) are seldom lacking in cranberries. However, Mg is often added with K in SulPoMag or KMag. On bogs with Yellow Vine (see below), magnesium sulfate (Epsom salts) may alleviate symptoms. Diagnosed deficiencies (using tissue tests) of Mg or Ca may be treated with 30 lb/A of the deficient element in granular form applied in the spring or with liquid supplements pre-bloom.

Soil balance of K, Mg, and Ca is important. Excessive use of any one can induce deficiency of the others. This is especially a risk with large soil applications of Ca. Lime can have adverse effects by changing soil pH and is not recommended for use in cranberry production. Products that supply Ca may improve fruit quality or firmness. Examples of Ca supplements suitable for cranberry include those that are gypsum based (gypsum and some formulations of Solu-Cal) and liquid supplements such as Full Measure CAL 30™ (this material increased Ca concentration in cranberry fruit in research trials).

Yellow vine (YV) manifests as an apparent nutrient deficiency. Beginning with older leaves, yellowing presents along leaf margins and between the veins on the leaf, leaving green only along the veins. Tissue tests of such leaves often show higher than standard potassium and low-normal magnesium. However, extensive investigation has shown that the nutrient imbalance is *secondary* to the primary problem – root insufficiency due to too much or too little moisture. Cranberry bogs with patches of YV were found to have soil water content (in the YV areas) that was either much higher or much lower than that in the surrounding green areas. Additionally, in greenhouse experiments, plants subjected to very shallow or very deep water table conditions developed YV. The consistent finding in the field has been that the rooting depth in YV areas is shallower than that in unaffected areas. In most cases, YV appears in areas that were too wet early in the season leading to poor rooting depth. Rooting depth can be improved by keeping the bed well drained early in the season. When the water table is closer than about 6 inches below the surface, root development and root function is impaired. Examine your drainage and irrigation practices if you see YV on your bog. Another symptom of poor drainage is high manganese (Mn) in the tissue test. YV usually appears as temperature and water stress increase during mid-summer and may be more severe if Casoron has been used since it can affect rooting and root function.

Minor elements.

- Minor element deficiencies are rare in cranberries due to low requirements and high availability in acid soils. Deficiencies may be brought on by mineral imbalances or stress conditions (drought, waterlogging).
- If deficiencies are suspected (visual symptoms), confirm with tissue testing. If confirmed, deficiencies are best corrected with foliar sprays. Such sprays are applied between bud break and hook stage.
- CALCIUM-BORON (5% Ca, 0.5% B, no other minor elements) sprays were the only minor element supplements to give increased crops in our research on non-deficient bogs. Response was greatest on bogs yielding at or below 150 bbl/A. We found that 2 applications of 2 qt/A improved fruit set.

TIMING: 10% bloom, mid-bloom. The second application seems most effective. Application by sprayer is more effective than sprinkler application. This is a foliar feed - apply accordingly; do not wash off the leaves.

CAUTIONS : 1. Manganese-containing fertilizers or fungicides (Mancozeb group) may cancel any beneficial effect of CaB if applied with or around the same time as CaB.
2. DO NOT use when leaf analysis is above 75 ppm B.
3. If B levels are elevated, but below 75 ppm, eliminate the FIRST application.

APPLYING FERTILIZER TO CRANBERRY BOGS

- SPRINKLER SYSTEMS may be used to apply liquids, flowables, and foliar feeds. Make sure not to mix incompatible materials (jar test first). When using sprinkler systems to apply fertilizer - make sure that coverage is ADEQUATE AND UNIFORM. EVERY EFFORT SHOULD BE MADE TO PRESERVE WATER QUALITY - avoid application of fertilizer to water in ditches and canals.
- Foliar feeds should not be washed off the leaves. Liquid fertilizers should be washed onto the soil. Be sure that you know which you are applying. Liquid products that have recently been integrated into cranberry management in Massachusetts are primarily designed to be soil-applied and watered in.
- FISH FERTILIZER is a liquid fertilizer. It should be washed in.
- Make sure ground application equipment is properly calibrated.

84 NUTRITION

SOIL pH

The optimal pH for cranberry soil is between 4.0 and 5.5. Use of sulfate containing fertilizers (SulPoMag, ammonium sulfate) does **not** affect soil pH. However, acid is released into the soil as the plants take up ammonium N. Otherwise, to substantially lower soil pH, elemental sulfur (S) application is used. Soil pH may influence the types of weeds that invade a bog. See the Weed Management section for information on the use of sulfur for weed suppression. Prior to making S applications, seek advice from Extension specialists or consultants. Apply no more than 500 lb/A/season in one or two applications. **Apply elemental S only to well drained soils and test soil pH prior to application.**

Use this table (courtesy of the Wisconsin Cranberry Crop Management Newsletter) to calculate the amount of S needed to lower soil pH based on desired amount of change and soil organic matter content from the soil test. This is a SLOW process depending on bacterial activity in the soil - pH change will occur over a period of months. Change will be fastest when soil is warm.

Desired pH change	Soil organic matter content (%)					
	0.5-2.0	2-4	4-6	6-8	8-10	>10
	----- Amount of sulfur needed (lb/A) -----					
0.25 units	250	750	1200	1700	2300	2800
0.5 units	500	1500	2500	3500	4600	5500
1 unit	1000	3000	5000	7000	9200	11000

SOIL AND TISSUE TESTS

Soil and tissue tests are tools that a cranberry grower can use to help diagnose deficiencies of mineral elements, monitoring soil pH, and aiding in the decision making process for choosing fertilizer (tissue tests). These tests are also required for Nutrient Management record keeping.

However, there are no 'cookbook' type formulas for fertilizing a cranberry bog based on the test results.

- (1) standard soil tests poorly predict availability of nutrients and poorly correlate with yield in cranberry;
- (2) as a perennial plant, cranberries store nutrients from the previous season(s) making it impossible to base fertilizer choices only on soil content and yield potential;
- (3) there is virtually no variability in soil test N values from bog to bog;
- (4) tissue test N concentration may vary depending on length of upright (N concentration in the tissue does not always correlate well with added N);
- (5) nutrient availability changes with soil pH and soil pH is not uniform from bog to bog; and
- (6) common soil test methods for P do not give results that correlate well with cranberry yields due to very acid soils in cranberry production – standard P tests are of no predictive value if soil iron is above 200 ppm.

With these warnings in mind, tissue and soil analyses can be beneficial as a long-term record of changes in your bog. Soil and tissue tests are particularly useful when compared to one another - a soil test alone is virtually useless in determining a fertilizer recommendation for cranberry. Use periodic soil testing to monitor any change in soil pH; we recommend testing soil every 3-5 years for this purpose.

Tissue tests are more useful for setting target fertilizer ranges. Regular tissue testing meets the mandate for testing in the Massachusetts Nutrient Management Regulations since this is the UMass recommended testing for cranberry. We recommend tissue sampling every 2-4 years (but see also P use and P reduction section above for protocols when adjusting P rates). Keep the results and use them in conjunction with your records of your bog management and performance (growth and cropping) to aid in making fertilizer decisions. For further information regarding tissue testing, refer to “Cranberry tissue testing for producing beds in North America” fact sheet (available at http://scholarworks.umass.edu/cranberry_factsheets/6/).

When and how to test

The results you receive from a soil or a tissue test are only as good as the sample you supply to the analytical lab. Follow the instructions for sample collection provided by the lab you are using. Collect one composite sample for each management unit as instructed below. A management unit may vary in size but will generally be a single variety that is treated uniformly, often under one sprinkler system.

Tissue samples: Samples for cranberry tissue analysis should NEVER contain roots, soil, runners, fruit, or trailing woody stems. In general all of these contaminants contain less nutrients than the upright tips. Including them will give a falsely low analysis. Tissue samples are best collected from **mid-August to mid-September**. Samples collected at that time should include **upright tips only** (do not strip off the leaves). Collect no more than the **top 2 inches** of new growth (mix flowering and vegetative uprights). As you walk a transect across the bog, collect enough material to make about 1 cup (at least 50 upright tips). You may collect directly into marked bags as samples should not be washed. Collect samples when the plants are not wet. Do not mail samples in plastic bags. Moldy samples give poor results. **Always** request nitrogen determination. This increases the test cost, but nitrogen levels in the tissue test are an important indicator of plant status and the success of fertilizer programs.

Sampling other than in August-September: Tissue samples may be collected at other times of the year if absolutely necessary. However, nutrient levels change more rapidly outside of the recommended time and make interpretation of the results more difficult. If sampling in the spring, samples should be collected in June and consist of **new upright tissue** only. Do not include last season's leaves - they will lead to a falsely low result. *In June samples, nitrogen should be 1.2-1.5%, phosphorus 0.15-0.19%, and potassium 0.7-0.9%.* Interpretations for other elements are challenging in June samples.

Tissue samples should also be collected when deficiency is suspected or diagnosis of a specific problem is needed. For problem diagnosis, collect 2 separate samples - one from the problem area, and one from nearby 'normal' vines.

Samples collected after mid-September give lower analysis values than those collected earlier. This is especially true for nitrogen (it is transported out of upright tips and stored in older tissue as dormancy approaches). Also, late in the season the uprights become more woody so that more of a tip sample is stem tissue. Stems have less nutrient content than do leaves so the overall result is a lower analytical value.

TISSUE STANDARDS (August 10 to September 15 collection)

Standards developed in conjunction with researchers throughout the cranberry growing areas of the USA

Major Element	Concentration in dried tissue (percent)	Minor Element	Concentration in dried tissue (ppm)
Nitrogen (N)	0.90-1.10 *	Boron (B)	15-60
Phosphorus (P)	0.10-0.20	Zinc (Zn)	15-30
Potassium (K)	0.40-0.75	Copper (Cu)	4-10
Calcium (Ca)	0.30-0.80	Iron (Fe)	problem if less than 20
Magnesium (Mg)	0.15-0.25	Manganese (Mn)	problem if less than 10, if greater than 500-600 check bog drainage
Sulfur (S)	0.08-0.25		

* = As high as 1.3 % has been seen for Stevens, but monitor growth closely if N is > 1.1 %.

Soil samples: Samples for analysis of soil nutrients should NOT contain stems, leaves, or the surface duff layer (trash). These are all organic contaminants and will bias the organic matter (OM) determination for the sample. The inclusion of some roots is generally unavoidable. Use a soil probe with a 1-2 inch diameter to collect cores of 4-6 inch depth. Minimum requirements: 4 cores for up to 1 acre; and 1 core for each additional 2 acres up to a total of 10 cores/management unit. After the trash layer on the surface of each is discarded, these cores are combined to make a sample. Collect enough soil to fill a 1 qt plastic bag about ¾ full. At home, open the bags and dry the soil at room temperature for a day or two. Clearly mark each sample bag. Organic matter determination (usually an additional charge) is often useful.

Methods of analysis vary by lab - pick a lab and stick with it. The UMass Soils Lab uses the Morgan test. However, the Bray test for soil P is the most commonly used in other labs for samples from the eastern United States. The Bray test, like all common P soil tests, is of limited value in cranberry soils. Standard P ranges for both methods are provided on the next page. The best time to sample cranberry bogs is when the soil is not waterlogged. Wet soils give falsely high P values. Soil samples may be collected with tissue samples in the late summer if no sanding is planned. Otherwise, sample soil in the spring.

UMass provides soil analysis services at the Amherst lab for a fee. Submission forms for this lab are available at <https://ag.umass.edu/services/soil-plant-nutrient-testing-laboratory/ordering-information-forms>.

CONVERSIONS FOR SOIL TEST RESULTS	
lb/A K, Ca, Mg or P	divide by 2.27 to get ppm
lb/A K ₂ O	divide by 2.75 to get ppm K
lb/A P ₂ O ₅	divide by 5.2 to get ppm P

SOIL STANDARDS (ppm)			
Ammonium acetate extraction unless otherwise indicated.			
Element	Deficient if below	Normal	Excess if above
Phosphorus (Bray)	20	20 - 60	80
Phosphorus (P)	4	4 - 9	10
Potassium (K)	10	10 - 40	50
Calcium (Ca)	20	20 - 80	90
Magnesium (Mg)	10	10 - 25	25
pH		4.0-5.0	
<p>Base saturation: Ca should roughly equal the sum of K and Mg.</p> <p>Base saturation is the <i>proportion</i> of the various positive cations in the soil. In acid soils 45-70% should consist of hydrogen ions (these replace much of the Ca that would be found in higher pH soils).</p> <p>Cation Exchange Capacity (CEC): Measures ability of soil to hold positive ions (cations or bases). If CEC is low (<10), base saturation proportions are important. If CEC is high and all cations are in the normal range, the proportions in the base saturation are less critical.</p> <p>If soil iron is above 200 ppm, soil P tests will not accurately reflect P availability.</p>			

IMPORTANT CONSIDERATIONS FOR CRANBERRY NUTRITION

- REVIEW the Nutrient Management BMP in the Best Management Practices Guide for Massachusetts Cranberry Production on our website (<http://ag.umass.edu/cranberry/publications-resources/best-management-practices>). Excellent information and decision trees for planning N and P management are available as well (<http://ag.umass.edu/cranberry/publications-resources/books-pamphlets>). Select Nitrogen or Phosphorus for Bearing Cranberries articles.
- The Cranberry Station website has an entire page devoted to Nutrient Management and planning (<http://ag.umass.edu/cranberry/publications-resources/nutrient-management-for-cranberries>). There are templates for record keeping and nutrient calculator tools that can be downloaded from that page.
- GOOD DRAINAGE AND ADEQUATE IRRIGATION are essential for best response to fertilizer. Monitor and maintain adequate soil moisture. Small, frequent irrigations may not be adequate to provide moisture to the root zone. For further information, refer to the Irrigation section (pg 93) and BMP <https://ag.umass.edu/cranberry/publications-resources/best-management-practices>.
- KEEP GOOD RECORDS. Comparison of rate/material and crop response over time will help to refine fertilizer practices tailored to YOUR bog. OBSERVE YOUR BOGS OFTEN -- fertilizer timing depends on growth stage/plant development. Rate can be refined as plants respond during the growing season. For growers managing 10 acres or more, records of nutrient applications are required under Massachusetts regulations.
- Cranberry bog soil has little capacity to HOLD cations (e.g., K, Mg, Ca). Much of the holding capacity is taken up by hydrogen ions. It is important to maintain a BALANCE among cations. Overuse of one can induce deficiency of the others. When you test bog soil for pH, check this balance as well.
- WHEN SYMPTOMS OCCUR - rule out water management issues, disease, and pest problems first. Then look at nutrition. Collect tissue for testing if necessary.

CAUTIONS:

- PRESERVE SURFACE WATER QUALITY - avoid applying fertilizer to water in ditches and canals. As possible, lower water levels in ditches prior to fertilizer application and impound water during and after fertilizer applications.
- AVOID HIGH RATES APPLIED AT ONE TIME, particularly on bogs constructed on mineral soils or very sandy bogs. Such applications may lead to lateral movement of fertilizer into water.
- EXCESSIVE NITROGEN FERTILIZATION leads to over vegetative plants. This may increase susceptibility to disease, spring frost or insect feeding. **High nitrogen rates are associated with poor fruit quality** and may delay color development in the fruit. High nitrogen rates can have adverse carry-over effects in following years -- excess applied nitrogen leads to high nitrogen concentrations in plant tissues such as stems and roots that can be remobilized in the plant and lead to excess vegetation, particularly when more nitrogen is added to the soil.
- FALL FERTILIZER (after harvest application) is not recommended, particularly if crop was small and no deficiencies have been noted. Late-season applications may not be properly taken up by the plants depending on soil temperature and state of dormancy. Generally, if uptake does not occur in the fall, the nutrients are no longer available the following spring. Organic types of fertilizers may be the exception. If you choose to use fall fertilizer, use low N and low or no P formulations.

88 NUTRITION

EFFECTS OF WEATHER

- **WINTER INJURY.** If leaf drop occurs after withdrawal of winter flood, early spring fertilizer applications will aid in recovery by encouraging rapid, early production of new leaves. Do not skip spring fertilizer. SulPoMag (or similar material) at 100-200 lb/A may also aid recovery.
- **COLD SOIL/AIR TEMPERATURES**, particularly in the spring, will lessen or eliminate response of cranberry plants to fertilizer applications. If plants are already under stress, they may respond even less. If this occurs, care should be taken not to reapply before you are sure that the plants are not going to respond to the initial application. Soil temperatures should rise to 55°F before application of fertilizer to ensure response. If long-lasting, slow-release, controlled release, or organic forms were used, reapplication may not be necessary -- response may only be delayed.
- **IF FLOWER BUDS ARE DAMAGED BY SPRING FROST**, high N rates can lead to overgrowth. Use lower rates.

EFFECTS OF PESTS AND CULTURAL PRACTICES

- **BOGS CONSTRUCTED ON MINERAL SOILS** without a permeability restricting or confining layer have little ability to hold nutrients in the root zone. Use organic or slow-release N and avoid large rates applied all at once.
- **DECREASE** fertilizer rate if the bog has been **SANDED**. Sanding promotes production of new vegetative uprights from the runners. Sanding combined with high fertilizer rates can lead to overgrowth.
- **DECREASE** fertilizer rate if late water has been held. Spring fertilizer rate may be eliminated on late water bogs. Overall fertilizer rate may be decreased 30% or more. However, do not decrease fertilizer N by more than 40% at the risk of adverse impact on the following season crop.
- **ELIMINATE** fertilizer applications for the entire season if the bog has been subjected to a long **SUMMER FLOOD** (May-July, see Insect section) for grub control.
- If eliminating crop using a **FLASH FLOOD**, reduce fertilizer rate. Two low-rate applications, in the spring and mid-season, should suffice to support the plants.
- **PRUNING** stimulates growth - reduce spring fertilizer on heavily pruned bogs. However, if the bog has been mowed, fertilizer applications are required to encourage the production of new uprights.

Calculating Fertilizer N and P Rates -- important for planning

Fertilizer labels have three numbers that are N-P-K. These numbers are percent by weight, and also the amount per 100 lbs of fertilizer.

Nitrogen (N) - First number on the bag is percent N

N example: You have a 50 pound bag of **18** - 8 - 18

To figure out how much N is in the bag of fertilizer:

1. Multiply the first number by weight of the bag
 - $18 \times 50 = 900$
2. Because the number on the bag is a percentage, you then divide by 100 to calculate how much nitrogen you are applying
 - $900/100 = 9$

For every 50 lbs of this fertilizer, you are adding 9 lbs of N.

**shortcut - for a 100 pound application - the first number is pounds applied on the bog

Phosphorus (P) - Middle number on the bag is percent phosphorus as *phosphate* - P_2O_5

P example: You have a 50 pound bag of 12 - **24** - 12

To figure out how much actual P is in the bag of fertilizer:

1. Multiply the second number on the bag by 0.44 (conversion factor)
 - 24×0.44 (conversion factor) = 10.56
2. Multiply this number by weight of the bag
 - 10.56×50 (weight of the bag) = 528
3. Because the number on the bag is a percentage, you then divide by 100 to calculate how much P you are applying
 - $528/100 = 5.28$

For every 50 lbs of this fertilizer, you are adding 5.28 lbs of P.

NOTE: if you want less than 20 pounds actual P on the bog, limit to no more than 45 pounds of *phosphate*

Potassium (K) - Last number on the bag is percent potassium as *potassium oxide* - K_2O

K example: You have a 50 pound bag of 0 - 0 - **22**

To figure out how much actual K is in the bag of fertilizer:

1. Multiply the third number on the bag by 0.83 (conversion factor)
 - 22×0.83 (conversion factor) = 18.26
2. Multiply this number by weight of the bag
 - 18.26×50 (weight of the bag) = 913
3. Because the number on the bag is a percentage, you then divide by 100 to calculate how much K you are applying
 - $913/100 = 9.13$

For every 50 lbs of this fertilizer, you are adding 9.13 lbs of K.

90 NUTRITION

Nutrient Planning Example

Since we fertilize based on nitrogen -- decide how much N you need. Then choose a fertilizer and calculate how much N, P, and K you will apply.

My bog requires 35 lb N/A; I want to use 12-24-12.

To get 35 lb N -- how much 12-24-12 do I need per acre?

1. Divide rate of N needed by percent N (first number on bag)
2. Then multiply by 100 to convert the percent into lbs

Rate of N needed	÷	first number on bag	x	100	=	lbs of fertilizer needed per acre
35	÷	12	x	100	=	292 lb/A of 12-24-12 to deliver 35 lb N per acre

If you are going to use this fertilizer, you should then calculate how much P you will also be adding.

1. Multiply pounds of fertilizer by middle on the bag number (24 in this case)
2. Then by 0.44 (to convert to actual P)
3. Then divide by 100

Lbs/A of fertilizer planned	x	second number on bag	x	conversion factor	÷	100	=	lbs actual P
292	x	24	x	0.44	÷	100	=	30.8 lb P per acre

If you are going to use this fertilizer, you should then calculate how much K you will also be adding.

1. Multiply pounds of fertilizer by last number on bag (12 in this case)
2. Then by 0.83 (to convert to actual K)
3. Then divide by 100

Lbs/A of fertilizer planned	x	third number on bag	x	conversion factor	÷	100	=	lbs actual K
292	x	12	x	0.83	÷	100	=	29.1 lb K per acre

That's more P than I expected! What if I switch to 18-8-18?

Rate of N needed	÷	first number on bag	x	100	=	lbs of fertilizer needed per acre
35	÷	18	x	100	=	194 lb/A of 18-8-18 to deliver 35 lb N/acre

Lbs/A of fertilizer planned	x	second number on bag	x	conversion factor	÷	100	=	lbs actual P
194	x	8	x	0.44	÷	100	=	6.8 lb P per acre

Lbs/A of fertilizer planned	x	third number on bag	x	conversion factor	÷	100	=	lbs actual K
194	x	18	x	0.83	÷	100	=	28.9 lb K per acre

FRUIT QUALITY MANAGEMENT 2024-2026

Prepared by Giverson Mupambi

Fruit quality is becoming very important in cranberry production. The major driver towards adopting fruit quality standards in cranberry production has been the introduction of new hybrid varieties. The new hybrid varieties are high yielding leading to an overabundance of fruit available on the market. Consequently, handlers are becoming stricter about the quality of fruit they are willing to accept. Currently, the fruit quality parameters being evaluated by handlers include fruit color, firmness, and size. Fruit quality standards are dependent on handlers and are not standardized throughout the industry. Also, depending on the handler, growers sometimes get paid an incentive for specific fruit quality parameters such as color and firmness. Growers can be assessed for fruit not meeting size requirements. Growers are advised to check with their handler every year to see which quality incentives are available. Currently, the options available for fruit quality management are very limited. As more research is conducted, more fruit quality management options will become available to growers.

Fruit color

Fruit color is an important quality parameter in cranberry production. The timing of cranberry fruit harvest is often based on red color development. The majority of fruit produced is processed for cranberry sauce, fruit juice, and sweetened dried cranberries. Uniform fruit color is very important for processed fruit. Currently, growers can use canopy manipulation and weed management to improve fruit color. Another option for growers is to plant varieties that develop color easily.

Canopy management

Pruning and sanding are cultural practices that improve fruit color in cranberry with minimal yield reduction. Pruning and sanding increase light penetration into the canopy. Light is essential for the formation of anthocyanins, which give cranberry their deep red color. Another option for improving fruit color in cranberry bogs that are overgrown is mowing. Mowing is a last resort as it will result in yield loss during the year in which it is done.

Weed management

Certain weed species such as dewberry, sawbrier, poison ivy, or dodder can sprawl across the cranberry canopy, thereby reducing light penetration that is essential for the anthocyanin formation. Weed management is also very crucial when pruning. Weeds such as moss can grow into the open space created by pruning, or weed seeds on the soil surface can germinate and establish thereby negating the benefits of pruning.

Choice of variety

When renovating, growers should plant varieties that develop color easily, keeping in consideration other parameters such as fruit size, firmness, rot, and yield potential. Varieties such as Demoranville, Crimson Queen, Scarlet Knight, HyRed and Ben Lear have been shown to color up easily under Massachusetts growing conditions.

Fruit firmness

Fruit firmness is another important quality parameter in cranberry production. Firmer fruit are easier to slice during the process of making sweetened dried cranberries (SDCs). Depending on handlers, cranberry growers are paid an incentive for fruit with high firmness, thereby increasing their returns. Factors that influence fruit firmness in cranberry can be divided into pre and postharvest factors.

Preharvest factors

Excessive nitrogen fertilizer can result in reduced fruit firmness.

Postharvest factors

Several postharvest factors can result in lower fruit firmness. Leaving fruit to float for extended periods after harvest results in a loss of fruit firmness. Slower reeling has shown a negative impact on fruit firmness compared to faster. When pumping the fruit off the bog, higher pump speeds have been shown to be associated with a loss in fruit firmness. When cleaning fruit with higher pressure nozzles, overripe fruit could show significant loss of firmness at higher pressures. The height of the truck used to deliver the fruit to the receiving station also affects fruit firmness, fruit at the bottom of a higher truck will be under increased pressure due to the sum of total weight from the berries above them.

Fruit size

Currently, there are no options for increasing fruit size in cranberry except renovating. If renovating, growers should plant new hybrid varieties that have been shown to have larger fruit size compared to the native varieties.

IRRIGATION WATER MANAGEMENT 2024 - 2026

Prepared by Peter Jeranyama

Water management is a key component of sustainable intensification of cranberry production in Massachusetts. Previous research has shown that water management directly affects (a) crop yield (Caron et al. 2016), (b) environmental impacts (Kennedy et al. 2016), (c) production costs (Olszewski et al. 2017), and (d) regulatory scrutiny (Mattson et al. 2015). One challenge facing Massachusetts growers is that soil moisture conditions are generally too wet to achieve optimal crop production (Lampinen, 2003). Water management is arguably one of the most critical issues affecting the cranberry industry for four major reasons: (a) crop production, (b) environmental concerns, (c) costs and (d) regulatory scrutiny. This section's objective is to introduce the concept of crop water stress index (CWSI) and discuss soil moisture monitoring devices such as tensiometers, moisture sensors and water level floats.

An evaporative demand study conducted in Massachusetts showed that for many weeks during the growing season, most cranberry beds were too wet (Lampinen, 2003). Wet conditions, which often derive from inadequate drainage, may enhance root rot (mostly *Phytophthora cinnamomi*) and fruit rot (many different fungal pathogens) diseases, restrict nutrient uptake, inhibit root development, and reduce fruit retention and productivity. Fruit rot in cranberry is an infection by many different fungal pathogens, among them *Allantophomopsis lycopodina* and *A. cystisporae* that causes black rot. These organisms are more prevalent under wet conditions, and a wet canopy may create a microenvironment for fruit rot pathogens to thrive.

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

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

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

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

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

Appearance and Feel Method.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

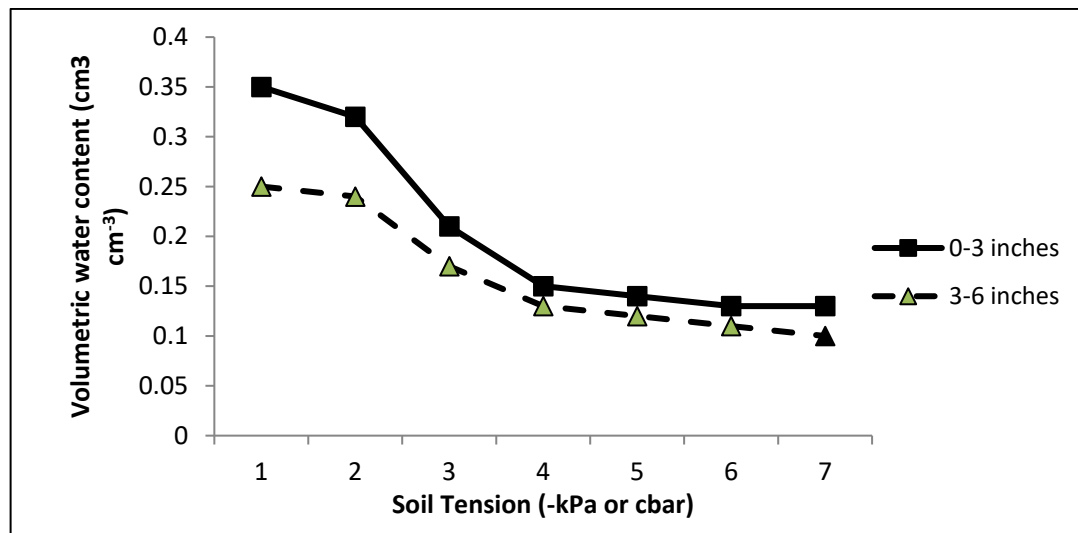


Figure 1. Water retention curve from a cranberry bog at 0-3 inches and 3-6 inches soil depth.

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

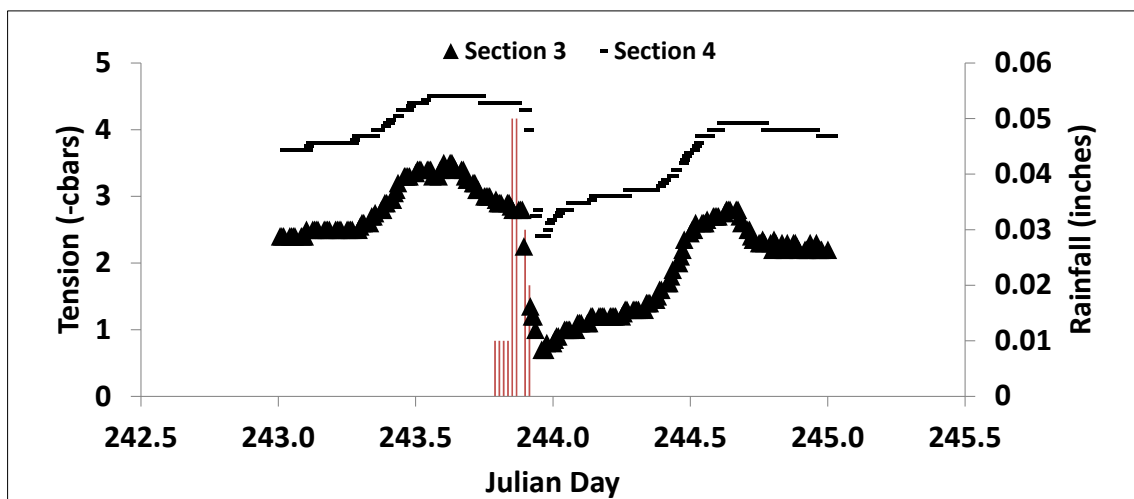


Figure 2. Precipitation (rainfall; vertical lines) effect on soil tension; Section 3 is the tension reading in one field and Section 4 is the reading from an adjacent field.

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

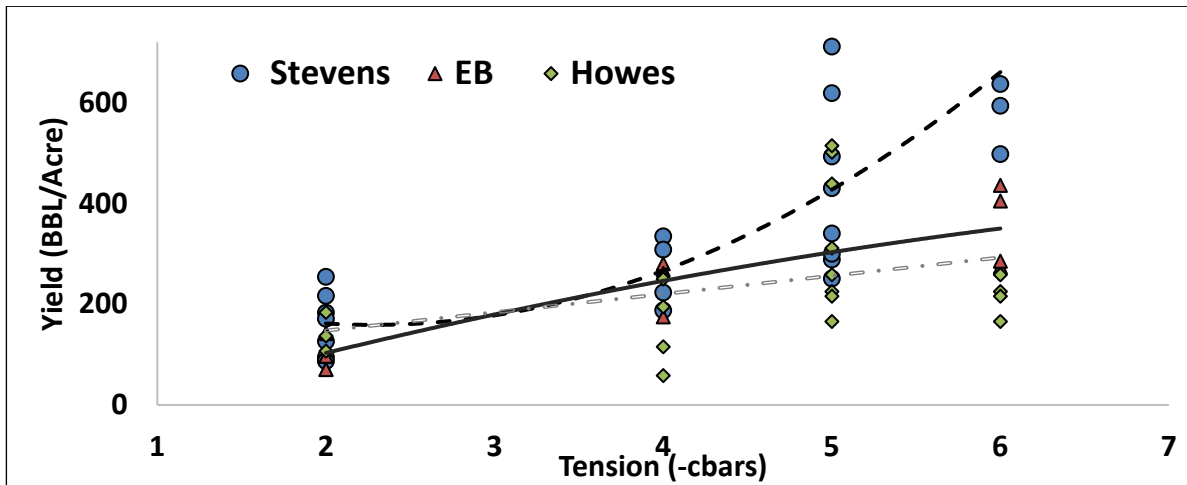


Figure 3. Effect of average soil tension in July and August on cranberry yield.

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

References

- Bland, W.L., J.T. Loew, and J.M. Norman. 1996. Evaporation from cranberry. *Agric. For. Meteorol.* 81(1-2):1-12.
- Bonin, S. (2009). Régie agroenvironnementale de l'irrigation en production de canneberges (*Vaccinium macrocarpon* Ait.). Québec, Québec, Canada: M.Sc. Thesis. Département des sols et de génie agroalimentaire, Université Laval.
- Caron, J., S. Bonin, S. Pepin, L. Kummer, C. Vanderleest, and W.L. Bland. 2016. Determination of irrigation set points for cranberries from soil-and plant-based measurements. *C. An. J. Soil Sci.* 96(1):37-50.
- Jeranyama, P., C. DeMoranville and C. Kennedy. 2017. Evaluating tensiometers and moisture sensors for cranberry irrigation. *Acta Horticulturae*. 1180:369-372.
- Kennedy, C.D., P. Jeranyama and N. Alverson. 2016. Agricultural water requirements for commercial production of cranberries. *Canadian Journal of Soil Science*, 97(1):38-45
- Olszewski F., P. Jeranyama, C. Kennedy and C. DeMoranville. 2017. Automated cycled sprinkler irrigation for spring frost protection of cranberries. *Agricultural Water Management* 189:19-26.

LATE WATER AND CRANBERRY MANAGEMENT 2024 - 2026

Prepared by Leela S. Uppala, H.A. Sandler, and A.L. Averill

Late Water (LW) is a one-month spring flooding practice (applied from mid-April to mid-May) before the plants have lost dormancy/before bud break, typically recommended once in 3 years. Several benefits of LW are documented, such as protection of plants from spring frost damage, reduction of fruit rot, some insects (cranberry fruitworm and scale), weeds (dewberries also known as brambles), enhancement of fruit quality and improvement of the keeping quality. LW also synchronizes bloom, producing fewer flowers per upright with a larger percentage setting fruit than their unflooded counterparts. Through bloom synchronization, LW helps to improve the efficacy of fruit rot control measures. Newly set berries grow to a more uniform size than fruit on unflooded controls. Due to these factors, LW beds can yield as well as beds not receiving LW. LW also reduces the pesticide and nitrogen requirement significantly for the year of LW.

FLOOD MANAGEMENT

When to use LW: It has been our long-time recommendation that LW should be used no more than one year in three. However, many organic growers and others trying to reduce costs have, in recent years, been using LW in successive years, the impact of which on the crop is not well documented. The most important factors in deciding to use LW in any given year are a thorough evaluation of the vine appearance and a review of factors that can lead to negative LW outcomes. If the vines are healthy and if the previous summer was very sunny and none of the adverse weather conditions listed below are present, the use of LW should be considered for its benefits in insect, mite, disease, and weed control (see below). Growers could also consider the preliminary KQ forecast issued by the Cranberry Station in early April to aid in decision making regarding the use of LW.

When not to use LW: To minimize crop reduction, LW should not be used when the vines appear stressed after the winter flood is removed. Bogs with poor quality water supplies may not be good candidates for LW. Beds that are severely out of grade may be poor candidates for LW. Any condition that leads to a reduction in the plant's carbohydrate reserves can lead to a poor LW outcome. Such conditions include a heavy crop, abnormally warm late fall, low previous year sunshine, oxygen deficiency, and winter temperature extremes. Do not use LW if the winter has been unusually cold or abnormally warm (particularly if the fall was also warm).

Do not use LW in the spring following a fall flood. Inspect the bog after withdrawing the winter flood - if stress, winterkill or leaf-drop are apparent, do not use LW. Do not use LW if the bog was sanded the previous fall or winter. However, barge sanding in the LW flood has been reported successful. Experience has shown that in some years (on average, 1 in 10 years) LW bogs may produce significantly (>10%) lowered yields. However, this low yield may be offset by reduced cost of fungicide/fertilizer inputs during the year of LW and higher yields in subsequent years. If the bog holds a flood well, costs in the LW year should also be less, particularly if inputs are reduced due to reduced pest pressure, helping to offset any losses. All factors that contribute to these occasional lower yields are not entirely understood but avoiding LW in the conditions listed above should provide some insurance against a large crop loss.

Timing of LW flood: The flood should be applied in the spring prior to the breaking of bud dormancy. The leaves will be beginning to lose their dormant red color but the flower buds should still be red and tight. Historically, the 30-day LW flood will be initiated between April 10th and 15th. However, recent changes in climate have shifted bud development to be earlier in some areas. If temperatures in late March - early April are warm (5°F per day above normal) or the season is early due to warm winter temperatures, the flood may be applied earlier (up to one week). Do not apply the LW flood if the buds have broken dormancy. We recommend putting sprinkler heads in place prior to the flood. This ensures that you will be ready if a frost night occurs immediately after flood removal and facilitates the addition of algacides if necessary.

<u>Late Water Flood Timing</u>		
Location	Apply the flood around:	Remove the flood:
Inland Areas	April 10-15	no later than May 15
Coastal Plymouth County	April 15-20	about May 20
Cape Cod	April 20 or later	late May

Choose actual application timing based on weather and bud dormancy, and hold for approximately 30 days.

Depth and temperature of LW flood: The flood depth should be maintained so that all vines are well covered by water. Shallow floods and/or flood temperatures consistently greater than 65°F (measured in the early morning) 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). If temperatures are approaching 65°F, recirculation of the flood water may prevent having to abort the flood prior to 4 weeks. However, keeping the flood too cool using this technique may reduce efficacy in the suppression of cranberry fruitworm (see the insect section on the next page for more information).

Prevention and treatment of scum: Algae (scum) often forms in LW floods. Water temperature is a major factor in the development of scum; shallow floods and inland (warmer) locations may be more prone to this problem. If scum is severe, early withdrawal of the flood may be necessary. If heavy scum is present after the flood, it should be broken up mechanically so that light can reach the vines. Even so, crop reduction may occur when scum is severe. Barley straw may be used to clear the water; research indicates its efficacy can be variable, working well in many situations but failing in others.

A Special Local Needs (SLN or 24c) label is available for the use of Cutrine-Plus for the management of algae in LW flood for Massachusetts. Cutrine-Plus is a liquid copper-based formulation that is used to control a broad range of algae. If you have had scum problems in prior LW years, plan to treat 2 weeks into the flood period. Scout for algae and apply when growth is first visible on the water surface. Applications only prevent further growth (it does not eliminate existing algae), so prompt treatment is critical.

Cutrine-Plus is injected into the sprinkler system running at 20 psi (30-minute injection; you may continue running for 1-2 hours after injection to disperse the material). Rates are calculated using label information and the number of acre-feet to be treated. To calculate acre-feet, multiply the number of acres by the depth of the flood in feet. Multiply the desired rate (gallons per acre-feet based on the chart from the pesticide label) by the acre-feet of water (calculated as above) for the bed being treated.

Draining: Release the flood slowly over the top board to protect water resources. The date of flood removal will vary with location and date of flood initiation. If air temperatures are unseasonably warm and flood water temperature becomes too high, the LW flood may need to be removed prior to 30 days. If the flood is removed early, pest management benefits may be affected (see insect management, next page).

MANAGEMENT AFTER LATE WATER:

Irrigation: There should be no need to irrigate (unless protecting for frost) for at least 2 weeks after the LW flood is withdrawn. However, we recommend that you schedule irrigation based on soil moisture status. Moisture sensors and tensiometers should be re-deployed soon after the flood is removed.

Frost protection: After removal of the LW flood, cranberry buds are sensitive to frost injury. During LW, the appearance of the terminal bud is arrested at the spring dormant stage. However, internal changes in the bud lead to a loss of frost tolerance despite appearances.

When using LW, frost management should be based on the actual duration of the flood, rather than relying on the appearance of the buds. After more than one week of LW flooding, the appearance of the buds will not be an accurate predictor of tolerance. A 1-week LW flood has no impact on frost tolerance -- protect the buds based on appearance. After LW of longer than 1-week, protect the bogs for 27°F (flood duration = 2 weeks) or 30°F (any duration longer than 2 weeks) regardless of how buds look.

Fertilizer use: LW bogs respond readily to fertilizer: N dose should be reduced to avoid overgrowth. A 30-40% reduction of N can be achieved by eliminating the spring application and/or reducing the fruit set dose. Further reductions may have an impact on bud development for the following year. Remember, fertilizer applied in the current season has the greatest impact on the *following* season's crop. The best tactic for a LW bog is to add no fertilizer for at least 2 weeks after flood withdrawal and then add small amounts with close monitoring of response. Generally, no fertilizer should be needed until bloom. Time your applications by the plant's development. This is especially crucial when development has been temporally shifted by the use of LW. If the LW flood was terminated early (3 weeks or less), standard fertilizer regimens may be followed.

Disease management: LW can be an excellent cultural control strategy against fruit rot.

Fresh fruit Howes and all processed fruit bogs in the year of the LW flood - Use reduced rates (never use less than the recommended rate listed on the fungicide label) and number of applications of fungicides. Fungicide application intervals may be extended to every 10 or 14 days depending on bloom. Fungicides may be eliminated on processed-fruit beds if the final keeping quality is forecast to be good. If one application is to be made, apply at 50% bloom. If two fungicide applications are made, apply the first at 10% bloom and the second two weeks later. *Reduced fungicide rates should be employed*, especially for Howes, which has greater resistance to rot. Scientific literature focusing on the effects of LW in the newer cultivars/hybrids is limited.

First year after LW has been held - Fungicide applications and rates can still be reduced without sacrificing fruit quality.

Second year after LW has been held - Fungicide applications and rates should be increased to a normal schedule. Otherwise, fungal inoculum will increase and may cause significant field and storage rot losses.

New Plantings - LW held in a newly planted (one- or two-year-old) bog will help reduce inoculum buildup, as well as helping the vines spread over the surface of the soil. Thus, LW contributes to minimizing rot during the initial two crop seasons. LW may also slow down weeds on new bogs (see next page).

Insect and mite management: Many insects are affected by LW. Emergence is delayed, and when a type of insect does appear, emergence is often synchronous, permitting better management. LW can be used to manage several pest insects:

Early season insects - False armyworm and Spongy (Gypsy) moth may be suppressed. Pre-bloom sprays are seldom needed but sweep net scouting should still be carried out. Spanworms (other than winter moth) have sometimes been found on LW bogs. Winter moth hatches from late April into early May, so on-bog populations of this insect should be suppressed by LW. BHF is not impacted by LW.

Cranberry weevil - is not impacted by LW.

Cranberry fruitworm - Cranberry fruitworms, which overwinter in the bog in hibernacula (cocoons), have been shown to be greatly reduced by LW, *particularly when held for the full duration of 4 weeks*. Mortality is higher when the flood is warm (approx. 60°F) and is significantly lower if the flood water is cool throughout the 4 weeks. Shorter duration (2.5-3 weeks) LW floods appear to have *little effect* on mortality in the hibernacula; populations are suppressed very little, compared to those on unflooded beds and significantly less than those on beds receiving a 4-week flood (see table below). A 4-week flood with water temperatures that rise to the 60°F level provides the best chance for fruitworm suppression. Therefore, growers should closely monitor flood temperature. While 60°F provides the best fruitworm suppression, greater than 65°F increases the potential for crop reduction. Monitoring for infestation is important (see the insect section for scouting practice after LW). Fruitworm sprays may be eliminated on LW bogs. Second and third sprays are seldom needed but scouting for eggs should continue as populations may move in from surrounding beds.

Effects of LW duration on cranberry fruitworm mortality. Data based on the failure of insect to emerge from hibernacula following flood are listed below.

Site	Flood length	CFW mortality	
		flooded	no flood
1	2.5 weeks	50%	28%
2	2.5 weeks	45%	13%
3	2.5 weeks	40%	34%
	4 weeks	98%	20%
4	3 weeks	41%	37%
	4 weeks	94%	71%

Scale - LW suppresses scale.

Sparganothis fruitworm - is not controlled by LW but flight is synchronized, making management easier.

Southern red mite - Mites can be severely impacted by holding LW. Intense infestations can be essentially eliminated in the year of LW. The mites begin to increase in the second year following the flood, but even then, may stay much below the original infestation level prior to the flood. Generally, LW affords 2 years of control for this pest.

Weed management: While LW may delay weed development and suppress the growth of some perennial weeds, this technique alone does not result in *control* of most established weeds. LW does not control dodder.

Dewberries (running bramble) - Some success in retarding the growth of dewberries by holding LW has been shown. Fall flooding also suppresses dewberries. However, severe crop loss resulted when LW was used in the spring following a fall flood. Do NOT combine these practices. ***Sawbrier*** (*Smilax glauca*) was less affected. LW suppression of dewberries should be followed up with other controls such as hand-wiping, clipping, flame cultivation or glyphosate. ***Dodder*** (seeds or seedlings) are not known to be controlled by LW.

Herbicide use:

- ✓ Do not apply preemergence herbicides prior to a LW flood.
- ✓ Casoron may be applied *after* the LW flood is withdrawn for the control of **dodder**. Apply herbicide as soon as possible after the withdrawal of the flood (be sure the vines are dry and the soil has drained).
- ✓ Use caution if considering the application of other preemergence herbicides after the flood is withdrawn. Evital use should be avoided. Sulfentrazone (Zeus/Spartan) can cause stress to cranberry plants, so adding additional stress after the stress of late water may increase the risk of injury and use after LW is not recommended. Herbicides such as napropamide (Devrinol) and mesotrione (Callisto) are likely safe for use as preemergence herbicides after the soil has drained, but we do not have research evidence that demonstrates this. If the bed is showing signs of stress (water and/or air temps were high, excessive leaf drop, etc.), our recommendation is to avoid preemergence herbicides. Please contact the Station if you have questions or concerns.
- ✓ POST herbicides can be applied when weeds have emerged, according to the label.

Bees: Bees for pollination may be more important on LW beds due to the fact that the period of flowering is of shorter duration than that for early water bogs. Protect bees from pesticide exposure.

WINTER MANAGEMENT 2024 - 2026

Prepared by Carolyn J. DeMoranville and Peter Jeranyama

Cranberry vines may be injured or killed by severe winter weather. The most common injury is classified as a 'physiological drought' when moisture lost from the vines due to wind and evaporation cannot be replaced due to freezing in the root zone. That injury is known as 'winterkill'. The symptoms are leaf discoloration and eventual drop. Such injury can occur within 3 days if the root zone is frozen to a depth of 4 inches, air temperature is below freezing, and strong winds (10 mph or greater) occur. Injury is prevented by a winter flood that should be in place when winterkill conditions exist. It is likely that 2-3 days with temperatures below 20°F will be enough to freeze the soil. New plantings (first year) are less susceptible to winterkill but should still be protected in severe conditions.

If crop elimination by mowing or flooding is planned for the following season, the winter flood may be eliminated.

General winter flood management:

The winter flood may be applied as early as December 1 and should remain on the bog as long as winterkill conditions are present or forecast. The flood may be delayed if winterkill conditions are not forecast if the plants are dormant. Exposure to moderately cold temperatures will encourage deeper dormancy leading to lower oxygen and carbohydrate demand and greater cold tolerance. However, an early cold snap following a warm fall could lead to actual cold injury in the plants (like frost injury). Under such conditions, the winter flood should be in place even before winterkill conditions are reached. Generally, the flood should not need to be held any later than March 15. However, holding the flood for a few days past that date will not harm the bog.

To be effective, the flood should cover the plants entirely (no vine tips sticking out). It is particularly important to maintain a sufficiently deep flood on new plantings to prevent heaving of the plants during freeze/thaw cycles during the winter.

Cold acclimation which occurs in the fall is a gradual process that enables plants to survive increasingly lower temperatures until they reach maximum hardiness. The process is genetically controlled and varies among cultivars in the *Vaccinium* genus (Rowland et al., 2013). In cranberry, floral buds for the following year are initiated in the summer, continue to develop into the fall, and must become cold hardy to survive the winter. Although frost protection of the buds in the spring is routinely required and practiced in commercial cranberry production, limited knowledge regarding the progression of cold acclimation in the fall raises questions regarding the need to implement bud frost protection in the fall.

For bogs that cannot maintain a winter flood:

On bogs that cannot maintain a winter flood, additional winter protection may be gained by the application of an antitranspirant. These waxy or resin-based materials reduce the amount of water loss from the leaves by providing an additional physical layer on the leaf surface. Research with Vapor Gard has shown that one application, made prior to the onset of winterkill conditions, may offer some protection against winter injury. Vapor Gard should be applied at the rate of 1 gal/A. Since the material becomes quite thick at low temperatures, application is best when done at temperatures above 45°F (above 50°F is much preferable). It may be combined with hot water to facilitate mixing. It can be applied through the irrigation system, by boom sprayer or tank spray apparatus. Vapor Gard needs at least 1 hour of sunny conditions after application to ensure proper set of the material on the leaf surface. Vapor Gard will persist on the plant for several months, so application should be planned for the fall (November typically has favorable conditions). Other products such as Wilt-Pruf or Moisturin are available, but we do not have much experience with these.

Oxygen deficiency injury:

Historic research by Bergman indicated that a lack of dissolved oxygen in the winter flood water was the cause of injury to cranberry plants, resulting in leaf drop and reduced yield potential. Plants, like animals, use oxygen in respiration so lack of oxygen could lead to plant injury. Bergman stated that oxygen deficiency injury may occur when oxygen levels in the winter flood water drop below 4 mg/l (full oxygenation = 10^+ mg/l). Bergman further stated that lack of light penetration led to poor photosynthesis, and it was the lack of photosynthesis that led to poor oxygenation in the water. The recommended remedy was to remove water from under the iced-over flood if light penetration was poor.

Removal of water from beneath the ice is standard practice in WI and in cold conditions in MA. In WI, the removal of remaining water is done as soon as a thick ice layer forms on the surface. Air then penetrates along edges and through cracks in the ice so that the vines are exposed to atmospheric oxygen. If the flood remains unfrozen as is often the case in MA and NJ, oxygen readily mixes into the water from the surrounding air with the possible exception of very deep (3^+ feet) areas in out-of-grade bogs. If plants are encased in ice for a prolonged period, they may be smothered by metabolic byproducts [e.g., CO_2 , ethanol ($\text{C}_2\text{H}_5\text{OH}$), and methanol (CH_3OH)] or injured when exposed to cold air due to the relatively low insulation value of ice (Durling et al., 1995). In contrast, snow can be highly beneficial to overwintering crops such as cranberry, providing effective insulation from extreme cold conditions and fluctuating temperatures (Leep, et al., 2001). The insulating properties of snow are generally the result of trapped air (low thermal matrix and the high reflectance of incident radiation on a snow-covered surface; these two factors in turn depend on the depth of the snow, its age, and its density (McComb, et al. 1992).

Research in both MA and WI has caused us to re-examine Bergman's theories and recommendations. Research by Justine Vanden Heuvel and Teryl Roper showed that cranberries require very little light for photosynthesis and the light that penetrates snow or sand may be sufficient for this purpose. Further, in a bog with a full layer of water beneath ice, even with 9 inches of snow on the ice, oxygen in the water beneath remained at 8 mg/l or greater. In WI, covering ice with black cloth, sand, or snow did not lead to leaf drop or crop reduction in the plants below the treatments. In MA, plants held flooded in darkness and low oxygen did not show reduced carbohydrate (the product of photosynthesis) or leaf drop.

So what is the cause of the leaf drop that is observed after the winter at certain bogs? Definitely, loss of leaves is a sign of some sort of stress on the plants. It is unlikely that lack of light is the cause. Lack of oxygen remains a possibility if the levels actually become severely depleted. A likely scenario for this would be pulling the water from beneath the ice and leaving a shallow layer of water in low spots. The smaller volume of water could become oxygen depleted where a large volume had not.

As wetland plants, cranberries can survive periods of poor oxygenation during flooded conditions. In particular, the plants can tolerate low oxygen levels in saturated soil. However, survival under these conditions requires using up carbohydrate (food) reserves. Plants with poor carbohydrate reserves due to large crops, poor sunshine the previous fall, or other stresses may have less ability to tolerate low oxygen stress and may show injury the next spring. In those cases, failure to prevent oxygen deficiency can result in leaf drop, inability of blossoms to set fruit, and crop reduction.

Certainly, any risk associated with using a winter flood is far outweighed by the benefit of protection from winterkill injury.

To assure that leaf drop potential is minimized:

- Remove the water from beneath a frozen flood as soon as is practical – this also minimizes mobilization of soil phosphorus into the flood water due to soil anoxia.
- If water is being held beneath ice, monitor oxygen levels in the underlying flood. Do not allow water with <3 mg/l oxygen to remain beneath the ice. Consider pulling water at a reading of 5 (mg/l) on a standard color kit.
- Try to avoid shallow layers of water beneath ice, they may lose oxygen more readily than deeper layers of water.
- If you pull the water from beneath the ice -- make sure that you leave no puddles behind. Vines trapped in these puddles under the ice are particularly susceptible to leaf drop in the spring.
- Manage plantings during the season so that stress is minimized, particularly irrigate properly.

Management after a mid-winter thaw:

Once the water has been removed from beneath the ice, the remaining ice may melt during a mid-winter thaw, leaving the vines exposed. Bogs may be left exposed if winterkill conditions are not present (see above). However, long exposures to abnormally warm temperatures (>55°F) may lead to loss of chilling. The result could be a reduction in hardiness and 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, re-flood the bog 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. Environmental factors may have a profound effect on the susceptibility of buds to winter injury. Cranberry buds can be injured due to repeated freezing and thawing.

Management after the winter flood:

Once the flood has been removed, the cranberry buds will break dormancy in response to exposure to warm temperatures. The earlier the flood is removed, the sooner the plants will experience enough heat units to break dormancy. To avoid the need for frost protection during the first half of April, hold the winter flood until March 10-15. In the early spring, cranberry buds will survive exposure to at least 18°F. As the buds lose their dormant color and begin to expand, they must be protected from frost damage. The tolerance varies by variety and growth stage. Refer to the "Frost protection guide for Massachusetts cranberry production", the Frost Management BMP, and Frost Tolerance Reports on the Station's website for further information:

<http://ag.umass.edu/cranberry> [look under Quick Links].

References

- Durling, J.C., O.B. Hesterman, and C.A. Rotz. 1995. Predicting first-cut alfalfa yields from preceding winter weather. *J. Prod. Agric.* 8:254–259.
- Leep, R.H., J.A. Andresen, and P. Jeranyama. 2001. Fall dormancy and snow depth effects on winterkill of alfalfa. *Agronomy J.* 93:1142-1148.
- McComb, T.J.L., A.B. Rimmer, M.L.B. Rogers, K.E. Turver, and A.F. Vickers. 1992. A mathematical model for the prediction of temperature in a dry snow layer. *Cold Reg. Sci. Technol.* 20:247–259.
- Rowland, L., E. Ogden, F. Takeda, D. Glenn, and M. Ehlenfeldt. 2013. Variation among highbush blueberry cultivars for frost tolerance of open flowers. *Hortscience* 48:692-695.

GROUNDWATER PROTECTION REGULATIONS AND ZONE II IN 2024 - 2026

Prepared by Martha M. Sylvia

The Massachusetts Department of Agricultural Resources (MDAR) is charged with maintaining clean groundwater. To this end, they have issued Groundwater Protection Regulations. These Regulations are intended to prevent contamination of public drinking water supply wells through regulating the application of pesticide products on the Groundwater Protection List within primary recharge areas. A primary recharge area is either an “Interim Wellhead Protection Area (IWPA)” or a “Zone II”. In this publication, we refer to all primary recharge areas including IWPA as Zone IIs. The Zone IIs are updated yearly. The pesticide groundwater protection regulations ONLY apply to public drinking water wells that pump greater than 100,000 gallons of water per day (gpd).

Some products registered for use on cranberry (listed below) have the potential to leach through the soil and as a result have been placed on the Groundwater Protection List. If your bog is in a Zone II, you should review the particulars for each compound to determine if you can use it in your situation. If you are able to use a compound, you must follow these rules:

- ❖ **MDAR notification** within 10 days of the end of the month for each application. You may use one form to report multiple applications that occurred in the same month. Forms are available at the Cranberry Station, CCCGA, points of purchase, or online:
www.mass.gov/forms/groundwater-protection-program-notification-form
- This reporting form must be filed in addition to the Pesticide Applicator Form that reports annual use to the state.
- ❖ Confirmation of 50% foliar cover. Assume an established working bog has at least 50% foliar cover but a new planting likely does not.
- ❖ An approved IPM program (use of Cranberry Chart Book) and an acreage-specific IPM plan.
- ❖ A support letter from UMass Extension and/or a copy of this Chart Book showing you have confirmed that your conditions allow the application.
- ❖ Proper documentation showing failure of alternatives. Generally, IPM records will suffice.

Cranberry Compounds on the Groundwater Protection List

Compound	Trade name	Notes
chlorothalonil	Bravo Chlorothalonil Echo, etc.	These compounds are listed on the groundwater protection list, but you may still use them within a Zone II area if you meet the conditions (outlined at end of chapter) and there are no viable alternatives. Contact Cranberry Station.
dinotefuran	Scorpion	There are alternatives available (Altacor, Avaunt, Delegate, Diazinon) and this product cannot be used in Zone II areas.
methoxyfenozide	Intrepid Invertid Turnstyle	Alternatives are available (Altacor, Delegate) and methoxyfenozide should not be used in Zone II areas. In special cases permission may be given for management of black-headed fireworm or Sparganothis fruitworm infestations during bloom. Contact Cranberry Station.
simazine	Simazine 4L	There are alternatives available and this product cannot be used in Zone II areas.
sulfentrazone	Zeus/Spartan	There are no viable alternatives available for moss so this product may be used in Zone II (complete paperwork).
thiamethoxam	Actara	If your weevil are resistant to Avaunt or you are targeting the summer generation of weevil you may use Actara in Zone II areas (complete paperwork).

Guidelines provided by Massachusetts Department of Agricultural Resources (MDAR):

Greater detail is provided on the MDAR website (www.mass.gov/pesticides-and-water-supply-protection) or from the Cape Cod Cranberry Growers' Association website under "Grower Advisories" (<http://www.cranberries.org/growers/advisories>).

Are you applying a product that is listed on the Groundwater Protection List within a regulated primary recharge area?

The pesticide groundwater protection regulations ONLY apply to public drinking water wells that pump greater than 100,000 gallons of water per day (gpd). The primary recharge area is designated as a Zone II or an Interim Wellhead Protection Area (IWPA) by the Massachusetts Department of Environmental Protection (DEP). Listed below are several ways to establish if you are in a regulated primary recharge area.

Determining the location of a Regulated Primary Recharge Area - Zone II or IWPA.

To determine if the application site falls within a Zone II or IWPA, you can use the following options:

Internet Option

Visit the Mass GIS system MassMapper

<https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html> . After advancing into your bog area, on the right side of the page click on the plus sign next to "Regulated Areas", then within that group "Wellhead Protection Area" and then click on "Zone IIs" and the Zone II areas will be highlighted in pink hatch.

Other Options

Check with the DEP Southeast Regional Office: 508-946-2700.

Are you applying pesticides in an area that has less than a 50% foliar cover?

If your area of application is located within the primary recharge area, you must determine if you are applying to an area with less than or greater than 50% foliar ground cover.

Assume an established, harvestable bog has at least 50% foliar cover.

If your bog is a new planting or it has not vined in to at least 50% foliar cover, and you wish to apply a pesticide listed on the groundwater protection list within a Zone II or IWPA, then the applicator must submit a Pesticide Management Plan (PMP) to MDAR for that use pattern and have it approved prior to the application. If this is the case, contact CCCGA or MDAR to develop this plan.

What is an Integrated Pest Management Program?

Pesticides on the groundwater list must be applied as part of an Integrated Pest Management (IPM) program from an MDAR approved source. These include:

- Use of the current "Cranberry Chart Book" published by the UMass Cranberry Station.
- UMass Extension generated fact sheets that outline IPM practices specific to the pest problem.
- IPM Programs specifically developed to meet the requirements of the Groundwater Protection Regulations.

The Department does not require the submission of IPM plans for approval. Instead the applicator should maintain a copy of their IPM program in their records. The plan should be specific to the pest problem requiring management with the Zone II chemical. The plan information should include:

- The name of the applicator.
- The location (Zone II and property) and dates of the application.
- A problem statement that outlines the reason for using the pesticide product on the Groundwater Protection List.
- An account of the method used by the applicator to identify the problem. Any laboratory diagnosis of the pest problem must also be maintained.
- An account of the IPM measures that have been taken to manage the problem.
- A letter or statement from the appropriate UMass Cranberry Station personnel stating that there is no viable alternative to the use of the product on the Groundwater Protection List to control the particular pest problem.

CONDITIONS TO ALLOW APPLICATION OF COMPOUND

Chlorothalonil - Bravo, Chlorothalonil, Echo, Equus, Initiate

If your cranberry bog is located in Zone II and you wish to apply a chlorothalonil product, you must consider the following conditions and select the most appropriate scenario that applies to your situation:

- If you have traditionally had good fruit quality (less than 3% rot at delivery), you should use any of the fungicides that do not have chlorothalonil as the active ingredient. It is advisable to keep records of fungicide performance (i.e., level of fruit rot incidence). This will provide evidence and documentation in case you need to use a chlorothalonil fungicide in the future due to the failure of alternatives.
- If you have previously used non-chlorothalonil fungicides on the bed located in the Zone II and you can show that these alternatives performed poorly or failed, you can use the chlorothalonil fungicides because you have no other viable option. You must have some documentation (scouting reports, IPM notes, delivery records with more than 3% rot present) that indicates fruit rot was not controlled with previous non-chlorothalonil fungicide applications.
- If you have previously used non-chlorothalonil fungicides on the bed located in the Zone II and you can NOT show that they did not perform poorly or failed, you must continue to use non-chlorothalonil fungicides. You cannot use chlorothalonil products until and unless you can document that alternatives do not work.
- If there was a significant amount of upright dieback in the bed located in the Zone II during the previous growing season and a pre-bloom application is warranted, Champ can be used instead of chlorothalonil for control of this disease. If you do not get adequate disease control using Champ, a chlorothalonil fungicide can be used in the subsequent growing season.

General Information

The chlorothalonil fungicides are considered to be a necessary component of an integrated approach to control fruit rot in cranberry. Many years of field testing in MA have proven that they are the best of the fungicides registered for cranberry fruit rot and upright dieback control. One of their strengths are sticking agents that help to adhere the fungicide tightly to the target tissue, which allows the fungicide to better withstand degradation by sunlight and washoff by rainfall. They are especially important to production of fresh fruit, where excellent fruit quality is desirable, particularly since these berries may be stored for two months. The chlorothalonil fungicides have consistently afforded the best control of storage rot (at 8 weeks after harvest) in field trials at State Bog.

USING ADJUVANTS WITH CRANBERRY PESTICIDES 2024 - 2026

Prepared by Martha M. Sylvia and Katherine Ghantous

Always check the specific label of the product you are applying for adjuvant requirements and recommendations. In general, adjuvant rates are based on the volume of water used for application or on an amount per acre, and are not related to the rate of pesticide being used. Depending on the type of adjuvant, they can help pesticides be more effective by giving better coverage, better penetration, or better adhesion. Some products suggest using an adjuvant to improve efficacy, while others may not work at all without an adjuvant included! Contact UMass Extension and/or your Ag Supplier for further guidance on which products to use for your particular situation.

FUNGICIDES

- **Abound:** Adjuvants may be added.
 - Do not use adjuvants that contain silicone (aka organosilicone).
- Chlorothalonil: **Bravo** already has Spreader-Sticker in it! Using extra could cause more run-off, reduce retention, and cause injury. The other formulations generally also have an adjuvant added.
- **Indar:** Adjuvants may be added.
 - Do not use penetrants.
 - For NIS, 0.25% v:v (or 1 pt/A if chemigating) is sufficient.
 - For organosilicones, a spray mix concentration of 0.05% v:v (or approx. 1.5 pt/A if chemigating) or less is sufficient.
- **Indar + Abound Mixtures:** Adjuvants may be added.
 - Do not use adjuvants that contain silicone (aka organosilicone).
- **Mancozeb products:** Adjuvants may be added.
 - Use a spreader-sticker to improve deposition / durability.
- **Proline:** It is recommended to use a non-ionic surfactant (NIS) at the “lowest recommended rate” for the adjuvant product. For most NIS products, 1 pt/A is typically the lowest rate. Check your product label for details.
- **QuadrisTop:** Adjuvants may be added.
 - Do not use high rates of silicone/organosilicone-based or oil containing adjuvants at high temperatures.

Do not exceed 0.125% v:v adjuvant (4 pt/A if chemigating).

INSECTICIDES - Adjuvants are recommended with:

- Intrepid, Confirm, and DiPel
 - A spray adjuvant should be used.
 - Improves: deposition, redistribution, and weatherability
- Delegate, Altacor, and Avaunt
 - Recommended to improved performance due to cranberry’s dense canopy and waxy leaves.

108 MEASURES AND CONVERSION

HERBICIDES - In general, adjuvants are not needed for PREemergence (soil-active) herbicide applications, and adjuvants are recommended or required for use with POSTemergence herbicide applications.

COC = crop oil concentrate, NIS = Nonionic surfactant

Callisto (*mesotrione*):

- Chemigation postemergence = 1 - 4 pt/A NIS or COC
- Spot-treatments postemergence:
 - NIS (0.25% finished spray volume) = 2 tsp or 0.3 oz/gal
 - COC (1% finished spray volume) = 2.5 Tbsp or 1.3 oz/gal

QuinStar (*quinclorac*): Chemigating postemergence

- 2 pt/A COC

Poast (*sethoxydim*): postemergence (grass herbicides don't have and preemergence activity)

It is **highly recommended** to use an adjuvant with grass herbicides.

- Boom or aerial applications - 2 pt/A COC
- Spot-treatment COC (1% finished spray volume) = 1.3 oz or 2.5 TBsp / gal

* * **Intensity One** (*clethodim*) is the **ONLY grass herbicide** that has 24C for chemigation!

It is **highly recommended** to use an adjuvant. If not included, you will have poor efficacy!

Chemigation postemergence = 1 – 4 pt/A NIS

Select Max, Intensity, and others (*clethodim*) **NOT for chemigation**

It is **highly recommended** to use an adjuvant with grass herbicides!

- SelectMax and Intensity One
 - Spot-treatment/Boom/Mist blower/Aerial, etc. postemergence = NIS at 0.25% v:v
- Intensity
 - Spot-treatment/Boom/Mist blower/Aerial, etc. postemergence = COC at 1% v:v

MEASURES AND CONVERSIONS CHART

Prepared by Hilary A. Sandler

Liquid Measures

1 oz = 2 tablespoons = 6 teaspoons = 29.6 ml
 1 cup = 8 oz
 1 pint = 2 cups = 16 oz
 1 quart = 2 pints = 4 cups = 32 oz
 1 gallon = 4 quarts = 8 pints = 16 cups = 128 oz
 1 cup = 237 ml
 1 pint = 473 ml = 0.473 liters
 1 quart = 946 ml = 0.946 liters
 1 gallon = 3.78 liters = 3,785 ml
 1 acre-foot water = 326,000 gallons
 0.1 inch water per acre = 2717 gallons
 1 fl. oz/gal = 7.81 ml/liter

Mass Conversions

1 oz = 28.4 grams
 1 lb = 454 g = 0.454 kg
 1 kg = 2.2 lb = 35.2 oz
 1 oz/gal = 7.49 g/liter

Temperature Conversions

$^{\circ}\text{F} = (9/5 ^{\circ}\text{C}) + 32$ (guesstimate: double $^{\circ}\text{C}$, add 30)
 $^{\circ}\text{C} = 5/9 (^{\circ}\text{F}-32)$ (guesstimate: subtract 30 and halve)

Length and Area Conversions

1 acre = 43,560 sq. ft = 0.405 hectares
 1 hectare = 2.47 acres
 1 meter = 1.09 yards = 3.28 feet = 39.4 inches
 1 yard = 3 feet = 36 inches = 0.914 meters
 1 cm = 0.39 inches
 1 inch = 2.54 cm
 1 rod = 16.5 ft
 1 sq. rod = 272.2 ft²
 1 square meter = 10.76 ft²
 1 cubic meter = 35.29 cubic feet = 1.30 cubic yards
 1 inch layer of sand per acre = 134 cubic yards

Other Conversions

pt/A * 0.473 = liters/A
 pt/A * 1.167 = liters/ha
 lb/A * 0.454 = kg/A
 lb/A * 1.12 = kg/ha
 gal/A * 3.78 = liter/A
 gal/A * 9.35 = liter/ha
 ton/A * 2,242 = kg/ha
 bbl/A * 0.112 = Mg/ha
 g/ft² * 0.958 = bbl/A
 1 fl. oz/A * 73.1 = ml/ha

PESTICIDE STORAGE GUIDELINES

Prepared by Hilary A. Sandler

Read and follow the pesticide label; it contains information concerning directions for use, application site and rate, storage and disposal, active ingredients, protective equipment needs, etc. **Pesticides should always be stored in their original containers**, according to label requirements, with the label intact.

Avoid carry-over of pesticides; buy only what you will need for the current season. In selecting an area for storing/handling pesticides, human and environmental safety should be foremost considerations. In particular, the area should be evaluated for potential risks to human health due to accidental spills, fires or contamination of drinking water supplies. Pesticides should not be stored over soil that is coarse or sandy or over surfaces that drain easily such as gravel because the pesticide can then easily move through the soil into the ground water.

A well-designed storage facility has four components: 1) a storage cabinet, room or building, 2) a mixing area, 3) an area for loading and rinsing spray equipment, and 4) a place to store and secure equipment and records. Depending on the size of your operation, you should have the appropriately sized storage facility. It should be large enough to accommodate new chemicals, opened containers, and unused material awaiting disposal but small enough to discourage significant carry-over from year to year. A pesticide storage facility should be on the ground floor with direct access to the outside. The storage area should be **locked at all times** and legibly and **prominently identified** as a place of pesticide storage. The area should be well ventilated either by windows or a fan to avoid the build-up of fumes.

Pesticides and fertilizers should be stored separately. Pesticides should be separated by type (insecticides, herbicides, fungicides) to avoid cross contamination and possible accidental misuse. Flammable and non-flammable pesticides should be stored in separate areas. Pesticides should never be stored alongside food, feed or seed. Pesticides in containers that can be damaged by moisture should be kept off the floor.

Dry pesticides (e.g., granular, powder) should be stored in a cool, dry place. Liquid or emulsified products may have restricted temperature ranges at which they should be stored. **CHECK THE LABEL!** In general, liquid or emulsified materials should not be stored at temperatures below 45°F or at temperatures that frequently exceed 100°F. These pesticides may form crystals at the lower temperatures. If crystals form, bring the pesticide into a warm place and gently agitate the pesticide container to re-dissolve the pesticide.

Affix fire extinguishers on the outside and the inside of the building. Be sure to inform your local Fire Department which buildings on your property are pesticide storage facilities. Post a list of materials outside of the building if possible and/or give a list to your local fire department so they know what is inside.

Disposal Resources. Some pesticides (but not all) are regulated as hazardous waste when disposed. The Department of Transportation (DOT) regulates the transport of hazardous materials. The Department of Environmental Protection (MassDEP) regulates and provides guidance on hazardous waste disposal. Properly dispose of used containers. Check with your local supplier for any available recycling programs. For further information, contact Steve Antunes-Kenyon, MDAR Pesticide Program Operations Coordinator at (857) 278-8318 or Hotze Wijnja at (857) 972-4670.

For more information, go to MA Energy and Environmental Affairs, Pesticide Storage and Disposal: <https://www.mass.gov/info-details/pesticide-storage-and-disposal>
MassDEP: www.mass.gov/orgs/massachusetts-department-of-environmental-protection
Southeast office: 20 Riverside Drive, Lakeville, MA. (508) 946-2700 (main office)

U.S. DOT: <http://phmsa.dot.gov/hazmat>
Hazardous Materials Information Center: 1-800-467-4922
Eastern Region Contact (Trenton, NJ): (609) 771-7890

- 2
- 2,4-D 69, 75
- A*
- Abound 9, 25
- acetic acid 53
- action threshold 26, 30, 32, 33
- adjuvants 59
- Admire 28, 41
- algae 58
- Aliette 25
- Altacor 36, 42
- annual grasses 56, 75
- Annual plants 46
- antitranspirants 101
- aquatic weeds 71, 74
- asters 46, 53, 69
- Avaunt 28
- B*
- B.t. 42
- barley straw 58
- Basamid 7, 73
- bees 28, 100
- Biennial plants 46
- black-headed fireworm 26, 27, 44
- bladderwort 71
- Blazon Blue 60
- brambles 97
- brown spanworm 26
- burning 50, 75
- C*
- calcium-boron 83
- Callisto 52, 53, 56, 60, 64, 74
- cinquefoil 53
- dodder 47
- goldenrod 52
- canopy management
- fruit rot 17
- carbohydrate loss 102
- Casoron 40, 53, 57, 61, 83, 100
- cinquefoil 53
- dodder 47
- yellow loosestrife 50
- chemigation 42
- chlorothalonil 14, 106
- chokeberry 52
- cinquefoil 53, 70
- clipping 48, 49, 54, 66
- clover 56, 69
- conservation seed mixes 74
- copper 25
- copper carbonate 72
- cranberry fruitworm 27, 42, 99, 100
- cranberry girdler 27, 31
- cranberry weevil 26, 36, 44
- crop oil 59
- crop water stress index 93
- Crossbow 73
- cutworms 32
- D*
- Delegate 35, 42
- Devrinol
- sedges 55
- dewberry 48, 66, 70, 75, 100
- difenoconazole 22
- Diquat 71, 74
- ditch stabilization 74
- ditch weeds 74
- dodder 46, 47, 50, 70, 100
- drainage 83
- duckweed 71, 74
- E*
- elodea 71
- emersed weeds 72
- Entrust 42
- evaporative demand 93
- Evital 63
- poverty grass 51
- Exirel 30, 31, 34, 35, 36, 39, 42
- F*
- fall floods 48
- false armyworm 32, 99
- fanwort 71
- fertilizer
- applying 83
- calculating rates 89
- effects of weather 88
- fall, use of 87
- fish 83
- late water 88, 99
- minor elements 83
- pest, cultural practices 88

- soil and tissue.....84, 85
 soil samples.....85
 tissue samples.....85
 yellow vine.....83
 fireweed.....57
 fireworm.....27, 34, 35
 fish fertilizer.....80
 fish toxicity4
 flame cultivation49, 55, 70, 74, 100
 floating weeds71
 Floods
 dodder48
 fall48, 97, 100
 fireworm.....34, 35
 flash.....88
 harvest.....17, 81
 insects.....43
 spring.....48
 summer.....75, 88
 trash.....17, 41, 47
 winter17, 34, 101
 frost protection.....98, 103
 frost, effect on herbicide movement59
 fruit rot14, 16, 18, 25, 78, 99, 106
 fumigants.....7, 73
 Fusilade.....74
 G
 girdler.....31, 41
 glyphosate48, 52, 53, 58, 65, 71, 75, 100
 phragmites.....49
 rushes55
 goldenrod46, 69
 grass carp71
 grass seed74
 grasses.....54, 56, 63, 64, 67
 green manure.....56
 greenbrier, greenleaf.....52
 greenleaf.....49
 Greenleaf sawbrier52
 groundwater protection list104, 105, 106
 growth regulator.....42
 grubs.....40
 gypsy moth.....26, 27
 H
 handheld torches70
 handler restrictions.....47, 64
 harvest floods
 P reduction81
 herbicide movement after rain or frost.....59
 herbicides59
 hydrilla71
 I
 Indar25
 Intrepid27, 28, 34, 35, 42
 invasive species.....49, 57
 irrigation.....76, 83, 93, 94, 98, 101
 J
 japanese knotweed57
 joe-pye weed57
 K
 knife-raking.....49
 L
 late water
 bees.....100
 Casoron61
 cranberry fruitworm100
 crop reduction97
 fertilizer88
 fertilizer99
 fruit rot97
 fungicides99
 herbicides100
 insects.....27
 sanding25
 southern red mite.....100
 weeds.....75, 100
 leaf drop102
 leatherleaf.....53
 loosestrife35, 46, 50, 64
 M
 MA Fish and Wildlife71
 mancozeb20, 25
 meadowsweet53
 Mexican bamboo.....57
 minor element83
 minor weeds58
 mites100
 moisture sensors93
 mosses53
 N
 narrow-leaved goldenrod69

- Nautique 72
 neonicotinoids 42
 new plantings 101
 Callisto 60
 Evital 63
 Nitrogen 76, 77, 79, 82, 85, 87, 90
 nutrient deficiencies 83
 Nutrient Management Regulations 84
- O*
- OMRI 44
 orangegrass 57
 organic 25, 42, 44, 70, 80, 84, 85, 88
 oxygen deficiency 102
- P*
- perennial grasses 54
 Perennial plants 46
 pesticide storage 110
 pheromone traps 27, 34, 35, 41
 Phosphorus 76, 80, 85
 Phragmites 49
 physiological drought 101
 pinweed 57
 pitchfork 57, 69
 Poast 63, 64
 poison ivy 66
 Potassium 76, 82, 83, 85
 potassium sulfate 70
 poverty grass 51
 preemergence herbicides 59
 Princep 45
 Private Applicator Certification 5
 pruning dewberry 49
 public waters 72
- Q*
- QuinStar
 dodder 47, 64
 yellow loosestrife 50
- R*
- ragweed 69
 rainfast 4
 raking 47
 red maple 54
 reducing inputs 27
 Reglone 74
 resistance management 9, 25, 60
 restricted use 42
- Ridomil 9
 Rodeo 71
 Roundup 54, 65
 dewberry 48
 greenbrier 49
 poison ivy 50
 poverty grass 51
 rushes 55, 70
- S*
- salt 70
 sanding 25, 86, 88, 93, 97, 103
 sanitation 46
 sawbrier 49, 100
 scale 29, 31
 scouting 26, 47, 99, 106
 scum 98
 sedges 55
 seed mix 74
 sheep laurel 52
 silverleaf 49
 soil samples 85
 southern red mite 97, 100
 spanworm 26, 33
 spanworms 32, 33, 99
 Sparganothis fruitworm 26, 27, 42, 100
 spinosyn-based products 42
 Spray Tracer 59, 60
 spring floods 48
 steplebush 56
 Stinger 53, 56, 57, 69
 submersed weeds 71, 72
 sulfentrazone 68
 sulfur 53, 56, 70, 84
 SulPoMag 84, 88
 summer re-flood 48
 surfactant 65
 sweeping 26
- T*
- tank mixes 25
 tensiometer 93, 94
 thermal weeding 48, 49, 55, 70
 tipworm 39
 tissue samples 85, 86
 trash 17, 34, 41, 47, 85
 trash removal 17
- U*
- upright dieback 106

<i>V</i>	
Vapam.....	7, 73
Vapor Gard.....	101
Verdepryn	42
vetch.....	56
<i>W</i>	
water level floats.....	93, 94
water lilies.....	71
water quality.....	87
water-holding times	4, 14
watermilfoil.....	71
weed life cycles.....	46
weed maps.....	46
Weed priority rating.....	46
Weedar 64.....	50, 69
dewberry	48
Weedone CB.....	73
weeds	
aquatic	71, 74
invasive species.....	49, 57
minor	58
weevil.....	26, 27, 30, 40
Wellhead Protection Area	104
white violet.....	56
wild bean.....	52, 69, 70
winter flood.....	101
winter moth	33
winterkill	97, 101, 102
wiping tips.....	66
<i>Y</i>	
yellow loosestrife	50
yellow vine.....	83
<i>Z</i>	
Zeus.....	68
Zone II.....	14, 42, 104–6