IPMSP

Integrated Pest Management Strategic Plan
for
Oregon and Washington Cranberries

Photo Credit: Katie Murray

Summary of a workshop held on
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Process for this Integrated Pest Management Strategic Plan

In a proactive effort to identify pest management priorities and lay a foundation for future strategies and increased use of IPM in cranberry production, growers, commodity group representatives, processors, university specialists, and other technical experts from the cranberry industry in Oregon and Washington formed a work group and assembled this document. Members of the group met for a day in March 2017 and a day in April 2017, where they discussed and reached consensus on this document, outlining major pests, current management practices, critical needs, activity timetables, and efficacy ratings of various management tools for specific pests in cranberry production. The final result is a comprehensive strategic plan that addresses many pest-specific critical needs for the Oregon and Washington cranberry industry.

A list of top priority critical needs was created based on a group voting process at the April meeting that included all of the needs appearing throughout the document and compiled from either meeting. A list of broader IPM needs was also compiled, based on input from both the March and April meetings, where attendees were asked to summarize needs related to specific topics. Crop-stage-specific critical needs are also included, listed and discussed throughout the body of the document.

The document begins with an overview of cranberry production, followed by discussion of critical production aspects of this crop, including the basics of IPM in cranberry production in this region. Each pest is briefly described, with links provided for more information on the biology and life cycle of each pest. Within each major pest grouping (insects, diseases, and weeds), individual pests are presented in alphabetical order, not in order of importance. The remainder of the document is an analysis of management practices and challenges organized by crop life stage in an effort to assist the reader in understanding whole season management practices and constraints. Current management practices are presented using a Prevention, Avoidance, Monitoring, and Suppression (PAMS) framework to place practices within a simple IPM classification and to demonstrate areas where additional tools or practices may be needed (for more information see Appendix titled "Using PAMS Terminology" on pXX).

Trade names for certain pesticides used throughout this document are included as an aid for the reader. The use of trade names in this document does not imply endorsement by the work group or any of the organizations represented.

Work Group Members

In Attendance:
Joe Arndt, Arndt Cranberry Farms
Stephanie Arriola, Arriola Bogs
Tony Arriola, Arriola Bogs
Cassie Bouska, Oregon State University
Bob Donaldson, Oregon Cranberry Growers Association
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Martin Paulson, Paulson Farms
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Others in Attendance:
Paul Jepson, Integrated Plant Protection Center, Oregon State University
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Contributing Workgroup Members Not in Attendance at Workshop:
David Bellamy, Ocean Spray, Washington
Dennis Bowman, Bowman Bogs
Joe DeFrancesco, Oregon State University
Don Kloft, Ocean Spray, Oregon
Sarah Osborne, Peters Cranberries
Delmar Robison, Cran Flora Bogs
Sam Stoddard, Glen Flora Bogs

Top Priority Critical Needs

The following list of critical needs was voted as the "Top Priority" needs by the workgroup members present at the April meeting. Crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout the body of the document.

Research:

- Continued research on replacement chemistries/alternative chemistries for all major cranberry pests.
- Expanded/increased decision-support tools for cranberry pest management.
- Research on critical cranberry pests (e.g. scale, sheep sorrel, lily of the valley, etc.) and best management practices that responds to critical needs.
- Research to establish economic thresholds for major cranberry pests.
- Research effective controls for black vine weevil (other products have not offered lasting control).
- Better understanding of the mechanism for frost protection using sprinklers (micro-climatology for coastal cranberry industry).
- Research on optimal timing for irrigation management and frost protection.

Regulatory:

- Continued support for communication with relevant parties regarding the challenges with MRLs and exporting cranberries.
- Maintain current registrations for commonly used pesticide products.
- Pursue registration of additional horticultural oils for use in cranberries.

Education:

- Resistance management education for insecticides, fungicides, and herbicides.
- Continued education on proper use and timing of commonly used pesticides.
- Education to growers on available decision-support tools (e.g. leaf wetness model, ET monitoring for irrigation scheduling, value of various sensor systems, etc.)
- Education for growers on economic thresholds for major pests, once established.
- Education to growers on optimal timing for irrigation management and frost protection.
- Educate growers on the importance of scouting and monitoring for black-headed fireworm.

Cranberry Production Overview

American cranberry, *Vaccinium macrocarpon* Ait., is cultivated in the Pacific Northwest (Washington, Oregon and British Columbia), Upper Midwest (Wisconsin), Northeast (New Jersey, Massachusetts and Maine), Canadian Maritime Provinces and Chile. It has been grown commercially in the PNW since the 1880's.

There are approximately 4,600 acres in cranberry production in Oregon and Washington. The bulk of this acreage is concentrated in the southwest coastal regions of both states, with approximately 2,900 acres in Oregon and 1,700 acres in Washington. Farms average 10-20 acres in size, with some as large as 200 acres. Combined Oregon and Washington production comprises an annual farm gate value of $18 to 25 million, and accounts for roughly 9% of US cranberry production.

Photo Credit: Katie Murray

Cranberries are produced on low-growing, long-lived perennial vines that are grown in 1 to 20 acre plantings called "beds." Vines are established by spreading freshly pruned vines on a carefully prepared field of sand (6-10 inches of sand over peat, muck or topsoil), and the vines are set to a depth of 1-3 inches into the sand with a disc like implement. Another method of establishment involves planting greenhouse-raised plants to a similar depth on a 12" square pattern. As these vines take root, new shoots grow, and the field eventually fills in. The vines root only in the top 2 inches, and must be fertilized and watered frequently. Beds will fill in with a solid mat of vine over several years.

Production occurs after the second or third year of planting, and reaches it peak

after 4 to 6 years. Maintaining production requires control of pests over the duration of the bed's life, which can be from 20 to 30+ years.

Cranberries require acidic soils with a pH of 4.0-5.5, which is why the coastal region is so well suited to their production. In Oregon, beds are constructed by layering sand over organic or clay subgrade soil. In Washington, beds have traditionally been planted on muck or peat soils, but more commonly, a thick layer of sand is applied over an organic soil layer.

The Mediterranean climate of the region, combined with almost constant summer winds, requires regular irrigation during summer. Frost control is also necessary during the sensitive spring months. Solid set irrigation is utilized in the beds.

New cranberry beds are typically planted between March and May, and require about three years to reach full production potential. The cranberry fruit cycle is 16 months long, with bud set occurring around June of year one, and harvest occurring in the fall of the following year. Bloom timing is protracted on the west coast, with the bloom period beginning as early as mid-May and lasting 4-6 weeks.

Photo Credit: Katie Murray

Cranberries are a perennial crop, with beds historically producing for several decades. Research points to the benefits of bed renovation every 10 years. However, given the expense of renovation, and the current state of the market, it is unlikely that a 10-year rotation will become a commonly adopted strategy.

Cranberries require pollination, and PNW growers typically rent hives for pollination services. Cranberries are harvested from September to November, with the majority of the fruit harvested by the end of October.

Integrated Pest Management Overview in Cranberry Production

The historical average for cranberry production in the Pacific Northwest is lower than other major U.S. growing areas. Reasons for this comparatively low production include off-type germplasm, and inordinately higher levels of pests, including weeds (which can reduce production by 15% or more), diseases, and insects. Some Pacific Northwest farms have lower yielding dry-harvested beds, low degree-day units/sunlight during the growing season, inclement weather during pollination, and a low percentage of renovated beds. Some factors affecting production, such as pest management, can be easily addressed through research and education efforts; other factors, such as weather, require a long-term genetic approach.

The West Coast cranberry industry is challenged by several insect pests, including cranberry tipworm, blackheaded fireworm, scale insects, and black vine weevil (BVW).

Cranberry tipworm, *Dasineura oxycoccana*, is a relatively recent pest to the PNW, so growers are still learning how to manage it. It currently is only a problem in WA and NW Oregon farms. The decision to apply an insecticide treatment against cranberry tipworm is based on monitoring and the concurrent absence of pollinators from the field. It has been difficult to identify efficacious nonsystemic insecticides.

Blackheaded fireworm, *Rhopobota naevana*, is the most common major insect pest. If left uncontrolled, this pest quickly devastates beds for several years of production. In Washington, approximately 30% of growers use pheromone trap counts to inform them of the optimal time for insecticide applications. While this pest is well controlled on conventional farms, management on organically managed farms has been an on-going challenge.

Two species of scale, brown soft scale (*Coccus hesperidum)* and greedy scale (*Hemiberlesia rapax*) have become problematic over the past decade in SW Oregon farms. Brown soft scale insects are relatively easy to control using an organic-approved chemistry with appropriate timing. Greedy scale insects, on the other hand, require a more precise approach. Currently, only properly timed organophosphate applications have been shown to be effective. Efforts to train and educate growers to scout for and properly identify greedy scale have been

successful and have decreased the number of spray applications and improved timing. Further work is needed to identify softer, target-specific chemistries that will be efficacious against greedy scale insects.

BVW has been difficult to control, and due to its high fecundity and ability to cause severe damage, remains a significant pest. However, because BVW larva are soil dwelling, they are susceptible to flooding and thus, diked beds, which are flooded periodically for harvest and hygiene practices, typically do not have BVW issues. But most dry harvest beds need effective management plans for BVW. A major thrust of research on BVW control has been directed towards entomopathogenic nematodes and fungi over the past three decade. While these management approaches can be effective, they remain cost-prohibitive for most growers. Controls that focus on traditional chemicals have had only marginal efficacy, and have also been a concern for pollinators. Identification of alternative management programs for BVW remains a critical need.

Fungal diseases include those that impact the vines themselves, as well as those that infect the fruit. All are managed through fungicide applications. Foliar diseases such as twig blight (*Lophodermium* spp.) have the greatest potential for loss in cranberries. While relatively easy to control with well-timed conventional fungicides, there are not effective OMRI registered fungicides for organic growers to use. Other foliar diseases, like rose bloom and red leaf spot, can be easily suppressed with well-timed fungicides.

Cranberry fruit rot is an important disease complex comprised of at least 15 different fungal pathogens that can occasionally cause a yield loss of 15-30%. The fungal population responsible for field and storage rot is a constantly changing variable due to a number of factors, including evolving weather patterns over the last decade toward a warmer climate, the renovation and re-planting of many cranberry beds with high-producing new hybrid cultivars, and changing fungicide use patterns with newly-registered materials. Growers in Oregon and Washington have encountered significantly higher fruit rot levels in the past decade, and fungicide use has increased as well, especially for those growers growing fruit for the fresh market. Continue use of single mode-of-action fungicides will make fungicide resistance management critical in the future.

Control of recalcitrant weed species is a major challenge for PNW cranberry growers. Registration of new herbicides over the past decade has contributed to a reduction in losses due to weeds, and improvements in grower returns.

Nevertheless, some perennial weeds, such as sheep sorrel, yellow loosestrife, lotus, and false lily-of-the-valley have remained extremely difficult to manage. Resistance management for herbicides will be critical going forward.

Finally, a market oversupply of cranberries has marginalized grower returns over the last decade, and the long-term market outlook is bleak. Effectively implementing cost-savings by minimizing inputs toward pest management will be a critical component of IPM over the next decade.

IPM Critical Needs

The following list of broad IPM needs were compiled based on input from meetings held in April and March, 2017, with IPMSP workgroup members and other representatives from the cranberry industry. At these meetings, participants were asked to summarize needs related to each of the following headings:

Increased Decision/Knowledge Support

- Need models to aid growers in pesticide selection, application and timing, that also take into account pest thresholds.
- Research on resistance management with commonly used products.
- Education to growers on resistance management best practices.
- Need pest management decision support tools that increase grower confidence in being able to minimize/eliminate use of certain pesticides, increase efficacy, and improve economics.
- Need continued funding and support for an applied research workforce addressing cranberry issues.
- Growers need increased access to IPM resources and education.
- More IPM consultants are needed to serve the cranberry industry.
- Increased financial support for current weather station programs (Agri-Met, Ag Weather Net).

Development of alternatives to agro-chemicals

- Conduct analysis on the economic feasibility of the use of certain products that includes pest thresholds.
- Develop and submit a formal position paper responding to the rule change regarding the conventional-organic-conventional rotation cycle. If only one of these rotation cycles is allowed, many unnecessary constraints to organic production are created by this rule.

Whole Farm/Area-Wide Management

- Develop research and education around cranberry whole-farm pollination ecology.
- Education about on-farm plantings and habitats that support native pollinators.
- Identify existing habitat and presence, and encourage communication and story telling about these successes.

Pollinator Protection:

- Need more effective tools for treating pests at bloom, including products with short enough residual times to be used at night, to protect managed and native pollinators.
- Develop a useable tool to assist growers in knowing exactly where managed hives are located in relation to their farm – should help minimize risk of non-target exposure to pesticide during bloom, since bees don't recognize farm boundaries.
- Need protection plan for native pollinators, which contribute to 30-40% of pollination in cranberry.
- Need strategies to support and grow native pollinator presence.
- More research on the impacts of commonly used fungicides on native and managed pollinators.
- Research and development of effective chemical and non-chemical controls for black-headed fireworm to reduce use of pyrethroids.
- Research overall pollinator health as related to the sequence of migratory pollinator usage among other crops to determine true impacts from cranberry production.

Protection of Beneficials and Natural Enemies:

- Collect data on the presence of beneficials and natural enemies in cranberry bogs.
- Research the use of natural predators for cranberry pest control (e.g. fireworm control).
- Research and register effective products for managing insect pests that do not impact beneficials and natural enemies.
- Research effects of prolonged use of organophosphates on populations of secondary pests, and interactions with beneficials with declining organophosphate usage.

Certification Needs:

- Explore certification programs beyond just organic that could provide access to elite marketplaces (e.g. "bee safe" certification).
- Develop a marketing focus within the Oregon Cranberry Growers Association that can create a "brand" for PNW berries.
- Conduct a "Meeting the Standard" education program to provide information about how to best meet standards from various certifiers.

Human Health/Worker Protection:

- Need education for growers on new EPA worker protection standard.

Water Quality

- More effective education programs for growers needed to improve water quality.
- Research effective alternatives to products of concern (such as diazinon, chlorpyrifos).
- Establish water quality baseline and current water quality conditions to determine needs for additional water quality improvement.
- Work with pesticide registrants and IR-4 program on registration of new products for cranberry with low aquatic impact.
- Public education to correct misinformation about impacts to water quality from cranberry production.
- Better marketing materials that effectively convey the positives related to cranberry production and water quality.

Growing Cranberries for Export Markets

The harmonization of international Maximum Residue Levels (MRLs) is a high priority for the Oregon and Washington cranberry industry. The MRL for a specific pesticide is the maximum safe and legal amount of pesticide residue that is allowed in or on an agricultural commodity, such as cranberries. An MRL may exist in the United States but not in the importing country, or the MRL of the importing country may be set too low, so that use of the product on fruit grown for export is not feasible. These factors influence the pest management options a cranberry grower can use in the field.

Much of the PNW cranberry crop is used for the export market. The differential in returns to growers over fruit that can be sold export compared to domestic is significant enough that grower will avoid the use of a highly efficacious labeled pesticide if that pesticide doesn't have export MRLs. This development has increased the cranberry industry's exposure to economic losses due to the necessity to adhere to the MRL of the importing country. These economic risks take the form of:

- Having fruit rejected due to a pesticide residue being found that is legal in the United States but does not conform to the importing country's MRL standard.
- Limiting the control options that can be used on the cranberry crop so it will meet the customer's MRL standard, and by doing so, not being able to use a pesticide that might be more efficacious, less expensive, or needed for resistance management.

Often, establishment of an MRL in an export market is pending, but unless the MRL is established, cranberry growers are limited in their choice of pest management tools to use for controlling pests in their fields. The products lacking an MRL in the importing country are often those that are newly registered in the United States. They are often the products of choice because they are target-specific (fitting well into an IPM program), don't have negative mammalian or environmental ramifications, and are safe to pollinators and other beneficial organisms.

There are several pesticide products that are registered for use in Oregon and Washington but not allowed in certain export markets. For example, quinclorac has been registered for the past several years in Oregon and Washington, but it is rarely used because the MRL in the EU is two orders of magnitude lower than in the US (0.01 in the EU, effectively a non-detect level, vs. 1.5 ppm in the US).

Growers who use quinclorac are not qualified for export fruit for two years after its usage. Many other examples exist for other products in other export markets, like Korea and Japan.

Clearly, the harmonization of international MRLs is a global issue that affects both the availability of effective tools for IPM and the return that growers receive for their fruit. It a major issue impacting the pest management practices of Oregon and Washington cranberry growers, and often puts them at a disadvantage in the international marketplace.

Major Cranberry Pests

Insects and Nematodes:

Black-headed fireworm *(Rhopobota naevana)*
Black vine weevil *(Otiorhynchus sulcatus)*
Brown soft scale *(Coccus hesperidum)*
Cranberry fruitworm (*Acrobasus vaccinii)*
Cranberry girdler *(Chrysoteuchia topiaria)*
Cutworm (numerous species, see entry p. xx)
Greedy scale *(Hemiberlesia rapax)*
Tipworm (*Dasineura oxycoccana*)

Diseases and Pathogens:

Cottonball (*Monilinia oxycocci*)
Fruit rot (numerous fungi, see entry p. xx)
Lophodermium twig blight (*Lophodermium oxycocci*)
Phytophthora root rot (*Phytophthora* spp.)
Red leaf spot (*Exobasidium rostrupii)*
Rose bloom *(Exobasidium vaccinii)*
Upright dieback *(Diaporthe vaccinii)*

Weeds:

Annual bluegrass (*Poa annua*)
Arrowgrass (*Triglochin paulstris)*
Blackberry (*Rubus ameniacus, R. ursinus*)
Bog St Johnswort (*Hypericum anagalloides*)
Creeping bentgrass (*Agrostis stolonifera*)
Creeping buttercup (*Ranunculus repens*)
Horsetail (*Equisetum arvense*)
Lotus (*Lotus corniculatus*)
Moss
Nutsedge (*Cyperus* spp.)
Purple aster (*Aster subspicatus*)
Purple leaved willowherb (*Epilobium ciliatum*)
Salal
Sheep sorrel (sour dock) (*Rumex acetosella*)
Silverleaf (*Potentilla pacifica)*
Slough sedge (cutgrass) (*Carex obnupta*)
Smartweed (*Polygonum persicaria*)
Sweet vernal grass (*Anthoxanthum odoratum*)
Three-square (bulrush) (*Schoenoplectus americanus*)
Tussock (*Juncus effusus)*
Willow (*Salix* spp.)
Yellow loosestrife (*Lysimachia terrestris*)

Cranberry Pest Management Timing by Crop Stage

Dormancy-Bud-break (November-April)
Brown soft scale
Weeds: annual bluegrass, arrowgrass, blackberry, creeping bentgrass, creeping buttercup, horsetail, lotus, moss, purple aster, purple leaved willowherb, salal, sheep sorrel, silverleaf, slough sedge, smartweed, sweet vernal grass, tussock, willow, yellow loosestrife

Shoot elongation (April-May)
Black-headed fireworm
Black vine weevil
Greedy scale
Tipworm
Cottonball
Rose bloom
Upright dieback
Weeds: annual bluegrass, blackberry, Bog St Johnswort, creeping bentgrass, creeping buttercup, lotus, purple aster, silverleaf, slough sedge, smartweed, tussock, willow, yellow loosestrife

Bloom (May-July)
Black-headed fireworm
Black vine weevil
Cranberry fruitworm
Cranberry girdler
Cutworm
Greedy scale
Tipworm
Cottonball
Fruit rot
Red leaf spot
Rose bloom
Upright dieback
Weeds: annual bluegrass, blackberry, Bog St Johnswort, creeping bentgrass, lotus, purple aster, slough sedge, smartweed, tussock, willow, yellow loosestrife

Fruit set-fruit development (June-September)
Black-headed fireworm

Cranberry fruitworm
Cranberry girdler
Cranberry root weevil
Cutworm
Greedy scale
Tipworm
Lophodermium twig blight
Fruit rot
Red leaf spot
Weeds: annual bluegrass, blackberry, Bog St Johnswort, creeping bentgrass, lotus

Harvest (August-November)

Black vine weevil
Large weeds removed before harvest such as lotus, willow, alder, blackberry

Major Cranberry Insects and Diseases

INSECTS and NEMATODES

Black headed fireworm *(Rhopobota naevana)*

For pest description information, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-blackheaded-fireworm

First-brood larvae web and feed on new tip growth in late April or early May. Second-brood larvae web runner ends and damage berries and fruit buds for next year's crop. When injury is severe, vine tips look brown, as if scorched by fire, and berries shrivel. A third generation of moths may emerge in August and September. Moths of the second and third broods lay overwintering eggs. Control of the first larval hatch helps reduce likelihood of large subsequent hatches.

Cranberry root-weevil
Black vine weevil *(Otiorhynchus sulcatus)*
Strawberry root weevil *(O. ovatus)*

For pest description information, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-root-weevil

Adults are present in cranberry beds along coastal areas during most of the year but late May to late June is when they can start to be seen in large numbers. They begin egg laying in mid-June to early July. Larvae feed on plant roots. Damage from larval feeding is most apparent just before and during bloom. Edges of the cranberry bed and drier areas are most susceptible to weevil injury.

Cranberry fruitworm (*Acrobasus vaccinii)*

For pest description information, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-cranberry-fruitworm

This pest overwinters as larvae. Moth emergence occurs during late June to early July. Eggs are laid on the fruit, and larvae enter the fruit immediately upon hatch. Each larva may consume five to six fruit during development.

Cranberry girdler *(Chrysoteuchia topiaria)*

For insect description, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-cranberry-girdler

Adult moths appear in May, June, and July. They feed on stems and runners, which can kill all or part of the plant. In Oregon, damage from larval feeding is first observed in late August and September. If beds are weedy, especially grassy, girdlers will be able to establish themselves before they move to cranberries. Newly hatched larvae like to burrow into the crowns of grass plants and feed.

Cranberry Tipworm (*Dasineura oxycoccana*)

For pest description information, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-cranberry-tipworm

Tipworm larvae feed on flower buds and shoot tips, causing distorted growth. Infestation from first generations does little crop damage, but subsequent generations can prevent the formation of mixed terminal buds required for next year's crop. Tipworm is not noted to be a serious pest in southern Oregon beds, but numerous Washington and northwest Oregon beds have suffered substantial crop loss from tipworm.

Cutworm
Numerous species

For pest description, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-cutworm

There are a number of moth species with larvae (cutworms) that have a wide range of colors, markings, and patterns. The foliage-feeding larvae generally feed at night, and clip off tips of uprights and runners.

Scale
Brown soft scale *(Coccus hesperidum)*
Greedy scale *(Hemiberlesia rapax)*

For pest description information, see: https://pnwhandbooks.org/insect/small-fruit/cranberry/cranberry-scale

Scale are sucking insects that infest vines and leaves of cranberry plants causing stunted, delayed vine growth and/or dead patches in beds. Scale presence can cause reduced fruit set on infested uprights.

DISEASES and PATHOGENS

Cotton Ball (*Monilinia oxycocci*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-cottonball

Caused by *Monilinia oxycocci*, a fungus that overwinters in mummified berries from the previous season, spores spread from these berries in the spring. Released spores infect new shoot growth in early spring, causing tip blight. In the tip-blight stage of the disease, young tips of new upright growth turn brown, curl over and wilt. Affected berries remain yellowish-tan rather than coloring normally, or in some cases, turn brown and shrivel before sizing up. Late in the season, fruits shrivel, harden and darken, and eventually mummify.

Fruit rot

Fruit rot can be caused by several fungi, including: *Phomopsis vaccinii*, viscid rot; *Botrytis* sp., yellow rot; *Allantophomopsis cytisporea* and *A. lycopodina*, black rot; *Gomerella cingulata* (asexual *Colletotrichum acutatum)*, bitter rot; *Coleophoma empetri*, ripe rot; *Botryosphaeria vaccinii*, berry speckle; and *Physalospora vaccinii*, blotch rot.

The following genera are all important in Oregon and Washington cranberry fruit rot: *Allantophomopsis, Coleophoma, Colletotrichum, Physalospora*, and *Fusicoccum*.

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-fruit-rots

Fungi that cause fruit rots are in the beds and can be troublesome especially when rainy conditions persist during bloom. The two types of rot are field rots that develop before harvest, and postharvest rots that form after harvest in fresh

fruit in refrigerated storage. Field rots have not been economically important in well-managed beds but levels are on the increase. Postharvest rots are important only for fresh fruit; fruit to be processed is frozen immediately after harvest and, thus, postharvest rot is not a problem. Control of fruit rots in the field near fruit set reduces decay when fresh berries are held in refrigerated storage.

***Phytophthora* root rot**

Although three *Phytophthora* spp. have been found in Oregon and Washington beds, *P. cinnamomi* is the most pathogenic.

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-phytophthora-root-runner-rot and: Polashock, et al., 2017. Compendium of Blueberry, Cranberry, and Lingonberry Diseases and Pests.

These microorganisms have spores that swim to healthy plants, enter them, and destroy roots and runners under flooded conditions. Most beds with root rot are wet picked, but root rot in dry-picked beds can occur in areas with poor drainage. Dead spots in the bed occur first in poorly drained areas and continue to expand to healthy areas. Lower (underground) runners have a red to olive-brown discoloration and lack feeder roots. Newly planted vines also die.

Red leaf spot (*Exobasidium rostrupii)*

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-red-leaf-spot

Symptoms of this disease may appear during rainy (misty), cloudy weather beginning in midsummer on the new growth. If severe, terminal growth of the uprights and runners dies due to a secondary pathogen, such as black spot fungus, (*Mycosphaerella nigro-maculans),* and the subsequent crop is reduced.

Rose bloom *(Exobasidium vaccinii)*

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-rose-bloom

This disease has a 1-year life cycle. Thus, infections in spring do not develop symptoms until the following spring. The fungus normally attacks only the

axillary buds, causing them to produce abnormal branches with thickened, hypertrophied, rose-colored leaves that resemble miniature roses-hence the name. The fungus occasionally attacks terminal buds and blossoms. Infected blossoms are deformed and usually enlarged. Affected berries are deformed. Yield on infected fruiting uprights can be reduced by a third.

Twig blight (*Lophodermium oxycocci*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-twig-blight

Fungi overwinter as mycelium in last season's leaves and are dispersed by wind. New growth can be infected between late June and mid-August. This disease can slow the establishment of new beds, and may be severe the year after planting. Yield on infected uprights is lowered by one-third, and the following year's crop is also impacted as infected uprights are less likely to set a mixed bud for the next crop year.

Upright dieback *(Diaporthe vaccinii)*

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/cranberry-vaccinium-macrocarpon-upright-dieback

Current-year, spring growth is the most susceptible growth stage, although plants can be infected throughout the season if wounded. Infected uprights generally die before bloom. Diseased and healthy uprights may be on the same runner. Vegetative and fruiting uprights are both affected. As many as 25% of the uprights may be affected in certain beds.

WEEDS

Successful weed management in cranberries requires a comprehensive, year-round approach that alternates a combination of weed control practices over several years. Developing these strategies requires knowledge of each weed and weed control practice. A combination of products alternated with each other and with other weed control practices is necessary to reduce the chance of developing resistant species or biotypes. Removing weeds (especially perennial weeds) and seed heads by hand is often necessary. Specific weed challenges are discussed in more detail in the crop stage sections.

VERTEBRATE PESTS

Several vertebrate pests can be problematic in cranberry. Voles (*Microtus* spp.) create trails, or runs, that are used so often that they become visible in the bed. They sever cranberry uprights at the base, creating pockets of dead vines. Vole control is a constant issue, as it is in other cropping systems. Growers can use bait stations placed outside the cranberry beds. Cultural control methods that serve to reduce potential habitat around the beds, such as mowing dikes and removing idle irrigation pipe can be helpful. Many growers create raptor perches and other nest structures to encourage raptor presence as another means of control.

Deer and elk are also a constant pressure in cranberry bogs. Some farms have the financial means and the physical layout that enables them to build deer- and elk-resistant fencing. Others do not have that capability. Elk, given their size, can be very damaging to beds, irrigation systems, and fencing.

Bears are another occasional vertebrate pest and can forage on ripe berries and cause damage from digging in beds.

Cranberry Pests and Management Activities

Dormancy-Bud-break (November-April)

Cranberry vines are dormant after harvest in the fall. Major management activities during this timeframe include removal of field debris from harvest (leaves, stems, diseased fruit etc.), pruning, (removal of excessive vegetative growth), and sanding (adding a thin layer of sand on top of vines to promote rooting and bury disease inoculum).

Pruning is usually done annually, while sanding is done more infrequently (every 4 to 8 years). Other farm maintenance done during this time includes improvement/repairs of irrigation and drainage systems, dikes and roads, and equipment.

Pest management priorities during this stage include control of brown soft scale, and weed control (broadleaves, grasses), which includes pulling of perennial weeds, and application of pre-emergence herbicides.

As spring approaches, buds swell and begin to lose their cold tolerance, and frost protection becomes crucial for growers. This is done entirely through sprinkler irrigation.

Pesticide applications in most PNW cranberry beds are most often applied through irrigation systems (chemigation), not booms. Granular herbicides are applied with drop spreaders or belly grinders. Granular fertilizers are applied with throw spreaders and belly grinders; foliar fertilizers are applied via irrigation systems.

Field activities/pest management decisions that occur during Dormancy-Bud-break:

- Sanding
- Pruning
- Sanitation
- Algae, liverwort, moss control – early fungicide app
- Drainage improvement
- Tree removal if shade is an issue on bed
- Frost control

- Pre-emergent herbicides (for horsetail and other weeds)
- Scout for scale
- Management for brown soft scale

PAMS[1] Practice	Dormancy-Bud-break Pest Management Activities	Target Pest(s)
Prevention	Sanding	Cranberry girdler, weevil, weeds, moss
	Pruning	Fruit rot, twig blight
	Drainage, maintenance, and improvement	Weeds, fruit/root rot
	Sanitation: removing harvest debris	Disease control
Avoidance	Fencing	Ungulate and geese management
Monitoring	Scouting	Brown soft scale, greedy scale, voles, moss, fireworm eggs, twig blight
	Bait stations set on dikes near beds	Voles
	Weed mapping	weeds
Suppression	Re-sanding beds for cranberry girdler control	
	Iron/copper applications	mosses
	Flooding	Weeds, (insects: scale, weevil, fruit rot, twig blight)
	Raptor perches and other bird/bat boxes	Rodent control, insect control
	Herbicide applications: • 2, 4D (Weedar) • Clethodim (Select) (for grass weeds only) • Clopyralid (Stinger) • Copper or iron (for moss) • Dichlobenil (Casoron) • Glyphosate (Roundup) • Napropramide (Devrinol)	Weeds

[1] See Appendix document on Using PAMS Terminology.

	• Norflurazon (Evital) • Quinclorac (Quinstar) • Sethoxydim (Poast; Volunteer in WA) for grass weeds only	
	Insecticidal soap (M-pede)	Brown soft scale
	Disease suppression applications: Lime sulfur Copper sulfate	Disease spore suppression
	Hazing/hunting with approval	Ungulate and geese management

Critical Needs for Dormancy-Bud-break Pest Management:

Research:

- Research effective rodent management options including chemical options.
- Establish economic/treatment thresholds for major pests, including economic thresholds for weed control/drainage, etc.
- Research the efficacy of dormant season treatments for greedy scale.
- Research the efficacy of using pyriproxyfen (Esteem) for greedy scale control.

Regulatory:

- Continued support and communication to resolve issues with MRLs in export countries (e.g., quinclorac and other products).
- Pursue registration and label for pyriproxyfen (Esteem) for greedy scale control.

Education:

- Clarify for growers the currently registered rodent management options.
- Education to growers on pruning: frequency and intensity for best management.
- Education/clarification to growers regarding the use of pyriproxyfen (Esteem) for cranberry pests under supplemental label.

Shoot Elongation (April – May)

Shoot elongation is the most critical time of the year for frost protection, as new growth is extremely tender to temperatures less than 32 degrees Fahrenheit. Frost protection can be ongoing all night for many successive nights, which can

make beds excessively wet. As soils warm, weed growth and insect emergence begin to be noted.

Early post-emergent weed control is common during this period. Blackheaded fireworm, tipworm, black vine weevil, and scale all require management during this time period. Some foliar diseases, including rose bloom, cottonball, and twig blight, would need to be treated if the outbreak is severe.

Growers are also applying their first applications of fertilizer during this time, a blend of nitrogen, phosphorous, and potassium.

Field activities/pest management decisions that may occur during Shoot Elongation:

- Post-emergent herbicide – weed scouting
- Scout for black vine weevil
- Scout for twig blight infestations
- Cottonball preventative fungicide app, if present previously
- Scout for rose bloom, treat if necessary
- Adjust frost protection for growth stage
- Fireworm monitoring & treatment
- Tipworm monitoring & treatment
- Fertilization decisions based on soil/tissue tests, to add nutrients for upright initiation in new beds
- Mowing dikes/spraying ditches
- Maintaining irrigation and frost control systems

PAMS Practice	Shoot Elongation Pest Management Activities:	Target Pest(s)
Prevention	Drainage after frost control [irrigating for frost control limits capacity to apply pesticides]	Disease control
Avoidance	Covering new beds with vines; aided with nutrient management	Weed suppression
Monitoring	Monitoring	Fireworm larvae, tipworm
	Pheromone traps	Fireworm, girdler
	Sampling for adult root weevil larvae	
	Scouting	Black vine weevil, twig blight
	Sticky traps (provides monitoring and	Tipworm

	suppression)	
Suppression	Spring flooding prior to egg hatch	Fireworm larvae
	Mowing dikes/spraying ditches	Weed control
	Herbicides: • Chlorimuron ethyl (Curio) • Mesotrione (Callisto) • Quinclorac (Quinstar) Grass Herbicides: • Clethodim (Select) • Glyphosate (Roundup) [hand wiping] • Sethoxydim (Poast, Volunteer in WA)	
	Insecticides: • Acephate (Orthene) • Carbaryl (Sevin) for tipworm, fireworm • Chlorantraniliprole (Altacor) for fireworm • Chlorpyrifos (Lorsban) • Diazinon • Horticultural oils • Indoxacarb (Avaunt) • Insecticidal soaps (M-pede) • Methoxyfenozide (Intrepid) for fireworm • Spinetoram (Delegate)	
	Copper application (Nucop, Kocide) for disease control	Rose bloom and other diseases

Critical Needs for Shoot Elongation Pest Management:

Research:

- Research the pest biology and life cycle of cranberry tipworm.
- Research effective controls for cranberry tipworm.
- Develop best management practices for cranberry tipworm.
- Research effective products for blackheaded fireworm control, especially relative to bloom timing, and also for organic growers.
- Develop area-wide monitoring and mapping program for black-headed fireworm.
- Research on blackheaded fireworm to determine level of correlation between pheromone trap counts and economic damage.
- Develop phenology model for blackheaded fireworm.
- Establish management thresholds for blackheaded fireworm.

- Research on best management timing for greedy scale.
- Research on effective products for greedy scale control, especially alternatives to diazinon.
- Research on economic impacts for certain cranberry pests, such as greedy scale and tipworm (e.g. how big of an economic impact are these pests; what damage do they cause).
- Research effective management strategies for cranberry girdler.
- Research effective alternatives to quinclorac (Quinstar) for weed management.
- Research effective organic-approved products for weed control.
- Develop a program for weed resistance monitoring.
- Research effective alternatives to glyphosate (Roundup).
- Research effective controls for black vine weevil (other products have not offered lasting control).
- Protection plan for native pollinators during early, middle, and late season pesticide applications

Regulatory:

- Resolve MRL issues related to critical pesticides (e.g. quinclorac, chlorothalonil).
- Register additional horticultural oils for use in cranberries (this could be a manufacturer label change).

Education:

- Education on pest biology, life cycle, and best management practices for cranberry tipworm, once researched.
- Educate growers on importance of scouting and monitoring for black-headed fireworm.
- Educate growers on best management timing for greedy scale.
- Education to community and landowners regarding the impacts of uncontrolled habitat (e.g. abandoned bogs) on black-headed fireworm population levels.
- Increase awareness and management/enhancement of native bee/pollinator populations.
- Increase awareness/management of beneficials.

Bloom (May - July)

Depending on variety, cranberries can begin blooming as early as May, and some can still be in bloom as late as July.

Continued frost protection is critical during this stage, as is pollination management and on-going fertilization. Anywhere from one to four colonies of bees per acre are used for a 4 to 6 week time period during bloom. Insecticide selection and use during this time period requires consideration of on-farm pollinator presence.

Pest management priorities during this stage include black-headed fireworm, tipworm, black vine weevil, cranberry fruitworm, cranberry girdler, cutworm, greedy scale, cottonball, fruit rot, red leaf spot, rose bloom, upright dieback, and weeds. Scouting and pheromone trapping for fireworm and cranberry girdler are important. Some fungicides are applied during bloom to prevent fruit rot.

Field activities/pest management decisions that may occur during Bloom:

- Place hives for pollination
- Pollinator management and treatment timing
- Pheromone traps for fireworm and girdler/monitoring
- Fireworm control
- Black vine weevil monitoring
- Fungicide treatments: fruit rot, twig blight, rose bloom
- Frost protection (very important at this stage)
- Fertilizer management
- Drainage and irrigation management
- Dike and ditch management –mowing, flailing, improving drainage, spraying ditches
- Rodent control (raptor poles)

PAMS Practice	Bloom Pest Management Activities:	Target Pest(s)
Prevention	Dike management	Weeds, insects, voles
	Precision surrounding irrigation management/frost control	Impacts disease management
	Vegetation/airflow management, especially around field edges	Disease prevention
Avoidance	Avoiding excess nitrogen to limit overgrowth	Fruit rot,

		tipworm,
	Optimizing fertilizer timing depending on vines, soil type, end market (fresh vs. processed, etc.)	?
	Timing of irrigation (best in morning, to reduce leaf wetness overnight)	Disease control
	Fencing	Ungulate and geese management
Monitoring	Sampling for adult emergence	Black vine weevil
	Pheromone traps	Cranberry fruitworm, girdler, fireworm
	Monitoring-visual inspection, sticky traps, counting	Tipworm, fireworm
	Monitoring	Bears (for bee protection)
Suppression	Insecticides: • Bt (Dipel) [Not used/ low efficacy] • Chlorantraniliprole (Altacor) • Indoxacarb (Avaunt) for weevil emergence mid to late bloom • Methoxyfenozine (Intrepid) • Pyrethrins for organic growers • Spinosad (Entrust) for organic growers Note: Cranberry fruitworm control best achieved with products with long residual	
	Fungicides: • Azoxystrobin (Abound) • Chlorothalonil (Bravo) • Copper (Nucop, Kocide) • Fenbuconazole (Indar) • Ferbam for rose bloom control; used as late as first bloom; can also be used for fairy ring disease • Mancozeb (Dithane F45, Manzate) • Prothioconazole (Proline)	
	Herbicides (mainly spot treatment/hand spraying of grass herbicides): • Chlorimuron ethyl (Curio)	

	• Clethodim (Select) • Glyphosate (Roundup) (used for hand wiping) • Mesotrione (Callisto) • Sethoxydim (Poast/Volunteer)	
	Hazing and hunting with approval	Ungulate and geese management
	Cages or electric fencing, platforms, hardware cloth around hives to protect bees	Bears

Critical Needs for Bloom Pest Management:

Research:

- Research effective management strategies for twig blight, including organic approved products.
- Develop area-wide monitoring and data sharing/communication program for twig blight, as well as other insect and disease pests. Anonymous alerts could be sent with trap count data, etc.
- Research critical timings for application of broad-spectrum products for best scale and fireworm control that balances judicious use to protect pollinators and beneficials.
- Research options for fireworm control that also account for need for greedy scale management.
- Develop support programs for transitioning away from cancelled products and also from broad spectrum to more selective products to reduce exacerbation of pest impacts.
- Research beneficial insect occurrence and timing.
- Develop affordable technologies to support automated irrigation systems; wireless sensors to detect cold spots
- Research on duration of frost management/frost management cycling and best timing to reduce impacts on pest management.
- Better understanding of mechanism for frost protection using sprinkling (micro-climatology for coastal cranberry industry).
- Explore various classes of fungicide to support pollinator protection and resistance management.

Regulatory:

- Communicate with regulatory agencies regarding the potential for pest management challenges if insecticides and fungicides become regulated during bloom.
- Develop a pollinator management plan that accounts for protection during bloom and also accomplishes needed pest management during this stage.
- Continued industry engagement on MRL issues: support for industry members working on these issues, and continued funding and research.
- Currently, Indoxacarb (Avaunt) and Spinosad (Entrust) are the only products available for use during bloom. If regulated out of use during bloom, no alternatives available. Indoxacarb is used for emerging weevil control and applied at night for mitigation.

Education:

- Education on the importance of monitoring for twig blight to aid in pesticide application decision-making.
- Communication and better control strategies for derelict bogs.
- Education on available tools (e.g. leaf wetness model, ET monitoring for irrigation scheduling, value of various sensor systems, etc.).
- Resistance management education for all classes: fungicides, insecticides, and herbicides.
- Education on best management practices for pollinator protection.
- Continued education on proper use and timing of commonly used products; encourage use of new, safer products; provide education in a form that makes it possible for growers to consider new and different options.

Fruit Set-Development (June-September)

During this stage, managed pollinators are removed from beds. Once fruit set has occurred, growers need to minimize foot traffic on the beds.

Pest management priorities during this stage include black-headed fireworm, cranberry fruitworm, cranberry girdler, cranberry root weevil, cutworm, tipworm, greedy scale, fruit rot, twig blight, red leaf spot, and weeds.

Scouting for cranberry fruitworm, and proper timing of insecticide applications to control this pest, is critical during this stage. Fungicide controls for twig blight are critical at this timing if this pest is present. Wiping of tall perennial weeds extending above the canopy with glyphosate is common during this stage.

Irrigation management and maintenance of soil moisture is critical, and fertilization continues through this stage.

Field activities/pest management decisions that may occur during Fruit Set-Development:

- Irrigation, heat control
- Tissue/soil sampling
- Weed mapping
- PURs reports (for contractual obligations)
- Fertilization
- Continued maintenance of dikes, borders, etc.
- Ungulate management
- Insect and disease control
- Frost control if needed late in this stage
- Monitoring bud set for fertilization decisions

PAMS Practice	Fruit-Set-Development Pest Management Activities:	Target Pest(s)
Prevention	Sanitation of equipment (fertilizer spreaders) to avoid spread of pests	Insects, diseases, and weeds
	Heat control	Rot prevention
	Dike management; management of adjacent habitat if possible to avoid windblown seed	Weed/disease
Avoidance		
	Avoiding excess fertilization by monitoring bud set and plant condition	
	Grass control	Weevil infestation
	Irrigation control—avoid over-and under-irrigation	Weeds, diseases
Monitoring	Monitoring	Fireworm, deer, elk, geese, bears
	Heat monitoring	
	Water/irrigation monitoring	
Suppression	Short floods (1-2 days)	Cranberry girdler
	Insecticides: • Acephate (Orthene) [if meets pre-harvest intervals, but MRL issues limit use at this	

	stage] • Acetamiprid (Assail) • Chlorantraniliprole (Altacor) • Chlorpyrifos (Lorsban) [if meets pre-harvest intervals, but MRL issues limit use at this stage] • Diazinon • Indoxacarb (Avaunt) • Methoxyfenozide (Intrepid) • Pyrethrins	
	Beneficial nematodes	Weevil, girdler
	Herbicides: • Chlorimuron ethyl (Curio) • Clethodim (Select) • Glyphosate (Roundup) for hand wiping • Mesotrione (Callisto) • Quinclorac (Quinstar) • Sethoxydim (Poast/Volunteer)	
	Fungicides: • Chlorothalonil (Bravo) • Copper hydroxide + mancozeb (Dithane F45, Manzate)	
	Seed head removal	Weeds
	Hand weeding of young trees (willows, alders)	

Critical Needs for Fruit Set-Development Pest Management:

Research:

- Research effective management options for fireworm during the fruit set and development stage to prevent and treat late outbreaks, which can be problematic during this timeframe.
- Research on optimal timing for irrigation management and frost protection.
- Research alternative chemistries and best management practices for cranberry fruitworm, including prediction and treatment regimes that include early monitoring; this pest is particularly problematic if pest pressures arise at this stage.

Regulatory:

- Continued industry engagement on MRL issues: support for industry members working on these issues, and continued funding and research.
- Communication and engagement with regulatory agencies impacting availability of water from the stage of fruit set through harvest.
- Communication and engagement with regulatory agencies about the importance of acquiring game management permits during fruit set, as this is a critical timing for game management.

Education:

- None at this time.

Harvest (August-November)

Some varieties of cranberry can be ready for harvest as early as August, and as late as November. During this stage, cleaning, sorting, and hauling equipment is readied for harvest. Tall weeds that can make harvest difficult are removed with weed-eaters. For dry harvesting, harvest is coordinated with packer/shipper demands. For wet harvesting, beds are flooded, beaten, and harvested.

Sprinkler heads are typically removed prior to harvest and must be reinstalled afterward. Growers may also hold harvest water to assist with pest control and allow harvest debris (vines, leaves removed by harvester) to float to the edge of the bed for removal.

Irrigation scheduling remains important during harvest.

Field activities/pest management decisions that may occur during Harvest:

- Irrigation management
- Sprinkler head removal
- Cleaning harvest equipment
- Flooding
- Beating
- Harvest

PAMS Practice	Harvest Pest Management Activities:	Target Pest(s)
Prevention	Rotation cycles of early flooding at harvest	Insects

	Cleaning harvest equipment	Weeds
	Remove harvest debris	All pests
Avoidance	Selection of harvested fields and care with flood waters to avoid transfer of seed-infested water between bogs	Weeds
	Sequencing of harvest with early preference to rot-prone varieties and new bogs first	Rot
Monitoring	Flooding for 2 to 3 weeks immediately after harvest to kill root weevil larvae	Root weevil
Suppression	Weed-eating	Weeds
	Post-emergent weed control immediately after harvest and before dormancy: • 2, 4-D (Weedar) • Clethodim (Select) • Glyphosate (Roundup) for hand wiping • Sethoxydim (Poast/Volunteer)	Weeds
	Selective hand weeding (e.g., lotus)	Weeds

Critical Needs for Harvest Pest Management:

Research:

- Research on best harvesting/handling equipment with respect to fruit damage; particularly important for dry-harvested beds.
- Research on optimal duration of flooding, including float time and impacts to fruit quality, temperature considerations, etc.
- Research on best management of aquatic weeds in irrigation ponds.
- Research on the potential for transfer of chemical residues through fruit cleaning, improper fruit separation, chemigation equipment, and/or shared floodwaters at harvest (e.g., quinclorac might be used in some bogs but not others, but if harvest flood water is shared, does that also transfer residues to non-treated fruit?).

Regulatory:

- Continued industry engagement on MRL issues: support for industry members working on these issues, and continued funding and research.

Education:

- None at this time.

Other:

- Lack of consultants for this crop in this region limits response times for, and impacts on, pest management and the ability to learn about and adopt new practices.
- Because of the geographic isolation of the industry, certification can become a cost burden in the absence of access to support for the administrative processes associated with it.
- Labor shortage at harvest impacts growers' ability to achieve full value of crop.

Invasive and Emerging Pests

INSECTS
None identified at this time.

DISEASES

Blueberry shock virus was first detected in Wisconsin beds in 2014, and has since been identified in Oregon, as well as in Massachusetts, New Jersey, and British Columbia Fruit scarring is the usual symptom that is observed, although it remains unknown as to whether infected vines always exhibit this symptom. Little is known about the disease cycle, mode of transmission, or persistence of symptoms. Research is ongoing.

Tobacco streak virus (TSV) is another potential concern, having been identified in beds in Wisconsin, Massachusetts, and New Jersey. It has not been observed in beds in Oregon or Washington yet, but PNW growers often purchase vines from Wisconsin, which increases the risk of TSV occurring here. TSV symptoms include fruit scarring; nearly all the fruit on a plant will exhibit symptoms. TSV is known to infect 80+ different plant species. One mode of transmission is believed to be via pollinators, however, there is still much to learn. To minimize risk of exposure to TSV in PNW beds, plants used for propagation and breeding should be tested for TSV.

WEEDS
None identified at this time.

Critical Needs for Invasives and Emerging Pests:

None identified at this time.

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5. Polashock, et al., 2017. Compendium of Blueberry, Cranberry, and Lingonberry Diseases and Pests, Second Edition.

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Activity Tables for Cranberries in OR and WA

~Field Activities (other than pest management)~

Note: An activity may occur at any time during the designated time period but generally not continually during that time period.

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Drainage	x	x	x	x	x						x	x
Fertilization					x	x	x	x				
Flooding (for harvest)									x	x	x	
Frost control			x	x	x	x			x	x		
Harvest									x	x	x	
Irrigation					x	x	x	x	x			
Maintenance of irrigation and frost control systems	x	x	x	x							x	x
Pruning	x	x	x								x	x
Sanding	x	x	x								x	x

~Pest Management Activities~

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Fungicide applications					x	x	x	x				
Hand weeding*	x	x	x	x	x	x	x	x			x	x
Herbicide post-emergent applications*	x	x	x	x	x	x	x	x			x	x
Herbicide pre-emergent applications		x	x	x	x						x	
Insecticide applications					x	x	x	x				
Mowing			x	x	x	x	x	x	x	x	x	
Scouting/monitoring				x	x	x	x	x	x			

*Note: hand weeding/spot treating for weeds can take place most of the year

Seasonal Pest Management for Cranberries in OR

Note: "X" = times when pest management strategies are applied to control these pests, not all times when pest is present.

Insects	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Black vine weevil							X	X				
Black-headed fireworm				X	XX	X	X	XX	X			
Cranberry girdler							X	X				
Greedy scale					X	X	X	X				
Soft scale			X	X								
Cutworm					X	X	X					
Diseases and Viruses	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Fruit rot					X	X	X	X				
Lophodermium twig blight						X	X	X				
Phytophthora rot				X	X							
Red leaf spot				X	X							
Rose bloom				X	X							
Upright dieback						X	X	X				
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Broadleaves												
Annual				X	X	X	X	X	X			
Perennial			X	X	X	X	X	X	X			
Grasses												
Annual			X	X	X							
Perennial			X	X	X							
Rushes	X	X	X	X	X	X	X	X	X			X
Sedges	X	X	X	X	X	X	X	X	X			X
Woody Species	X	X	X	X	X	X	X	X	X			X

Seasonal Pest Management for Cranberries in WA

Notes:
1. "X" = times when pest management strategies are applied to control these pests, not all times when pest is present.

Insects	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Black headed fireworm				X	X	X	X	X				
Black vine weevil					X	X	X	X	X	X		
Cranberry girdler						X	X	X				
Fruitworm						X	X					
Tipworm					X	X	X					
Diseases and Viruses	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Fruit rot					X	X	X					
Leaf spot					X	X	X	X				
Rose bloom					X	X						
Twig blight							X					
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Broadleaves												
Annual				X	X	X	X	X	X			
Perennial	X	X	X	X	X	X	X	X	X	X	X	X
Woody Species	X	X	X	X	X	X	X	X	X	X	X	X

Cranberry Pesticide Risk Management Table

The icons below represent four categories of non-target risk potentially affected by pesticide use. If an icon is used, it indicates that mitigation is needed at commonly used application rates in order to reduce risk. Risks were calculated using the risk assessment tool IPM PRiME, and do not substitute for any mitigations required by the product label.

A= Risks to aquatics: invertebrates and fish **T**= Risks to terrestrial wildlife: birds and mammals

P= Risks to pollinators: risk of hive loss **B**= Risks to bystanders: child standing at edge of field

Any product highlighted in yellow is classified as a "highly hazardous pesticide" (HHP) by the World Health Organization and the Food and Agriculture Organization of the United Nations. These products may pose significant risks to human health or the environment, and risk reduction measures may not be effective in mitigating these risks.

Pesticides	Risks requiring mitigation	Dormancy-Bud-break (November-April)	Shoot elongation (April-May)	Bloom (May-June)	Fruit set-fruit development (June-September)	Harvest (August-November)	Target Pest(s)	Comments
Insecticides Products marked with an "A" are go-to products, those marked with an "*" are considered critical to the industry		**If used, average number of Applications per Crop Stage** "A" Indicates critical use timing						
Acephate (Orthene)	T, P		1		1		fireworm	Not commonly used in OR, go-to product in WA; only one use/year
Acetamiprid (Assail)	A		1					Not commonly used; used before pollinators present
Azadirachtin (Aza-direct, Neemix)								Not used
Bt (DiPel)							fireworm	Used by organic, not considered effective
Carbaryl (Sevin)	A, T, P		2		1		Tipworm	Go-to product; up to 5 applications allowed
Chlorantraniliprole (Altacor)			1	1	1			Go-to product
Chlorpyrifos (Lorsban)	A, T, P, B		1		1		Adult weevil and scale	Occasional use for critical management only
Chromobacterium subtsugae (Grandevo)								Not used
Clothianidin (Belay)	A, P				1			Would be go-to product; but MRL issues limit use
Diazinon	A, T, P, B		1		1			Go-to product
Dinotefuran (Scorpion)	A, P				1			Go-to product; but MRL issues limit use
Imidacloprid (Admire Pro)	A, P				1			Used post-bloom
Indoxacarb (Avaunt)	P		1	1	1		Black vine weevil	Go-to product
Insecticidal soap (M-Pede)		1						Not often used
Methoxyfenozide (Intrepid)				2				Go-to product during bloom
Phosmet (Imidan 70W)	A, T, P		1		1			
Pyrethrin (Pyrenone)	P		1	1	1			
Sodium flualuminate (Cryolite 50 Dust)		1		1				Rarely used; not available
Spinetoram (Delegate WG)			1	1	1			
Spinosad (Entrust)	P		1	1	1			Only effective insecticide for organic growers

Pesticides	Risks requiring mitigation	Dormancy-Bud-break (November-April)	Shoot elongation (April-May)	Bloom (May-June)	Fruit set-fruit development (June-September)	Harvest (August-November)	Target Pest(s)	Comments
Thiamethoxam (Actara)	A, P				1			
Tebufenozide (Confirm 2F)				1				Not commonly used anymore
Fungicides								
Aluminum tris (Aliette)								Not used
Azoxystrobin (Abound)	A			2				Resistance management critical when used; go-to product for fruit rot
Chlorothanlonil (Bravo)	A, T		1	1	1			Go-to fungicide, important to use as last for resistance management
Copper diammonia diacetate (Copper-Count-N)								Not used
Copper hydroxide (Nucop, Kocide)	A		1	1				
Copper hydroxide + Mancozeb, (Mankocide)	A			1	1			
Copper sulfate, lime (Bordeaux)	A, T, P	2						
Copper sulfate + sulfur (Top Cop w/Sulfur)	A, T, P							Not used
Fenbuconazole (Indar)				2				Go-to product for fruit rot
Ferbam (Ferbam Granuflo)	A, P, B		1					Not available for purchase on the west coast in small units; pallets only
Mancozeb (Dithane F45, Manzate)	T		1	1	1			Go-to fungicide, important to use as last for resistance management
Mefenoxam (Ridomil Gold SL)								Not used
Mono- and dibasic sodium, potassium, and ammonium phosphates (Phostrol)								Not used
Mono- and dipotassium salts of phosphoric acid (Rampart)								Not used
Polyoxin D zinc salt (OSO, Ph-D)				2				
Potassium phosphite (Prophyt)								
Propiconazole (Orbit)				1				
Prothioconazole (Proline 480 SC)				2				Go-to product for fruit rot
Herbicides								
2,4-D (Weedar 64)		1	1	1	1	1		Spot treatment year-round
Chlorimuron ethyl (Curio)		1	1	1				SLN, requires waiver of liability signature
Clethodim (Select)		1	1	1	1	1		Spot treatment year-round
Clopyralid (Stinger)		2	1					Spot treatment year-round
Dichlobenil (Casoron 46)	T	1						
Glyphosate (Roundup)		1	1	1	1	1		Hand applied as spot treatment year-round
Mesotrione (Callisto)			1	1	1			2 applications only
Napropamide (Devrinol)	T	1						
Norflurazon (Evital 5G)	A, T	1						
Quinclorac (QuinStar 4L)			2		1			
Sethoxydim (Poast)		1	1	1	1			

Efficacy Ratings for INSECT Management Tools in Cranberry

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (< 70% control); **?** = efficacy unknown in [crop] management system—more research needed; ***** = used but not a stand-alone management tool; **NU** = not used for this pest; chemistry or practice known to be ineffective.

MANAGEMENT TOOLS	Blackheaded fireworm	Black vine weevil	Brown soft scale	Cranberry fruitworm	Cranberry girdler	Cranefly/leatherjacket	Cutworm	Greedy scale	Tipworm	COMMENTS
Registered Chemistries										
Acephate (Orthene)	E				G			?		
Acetamiprid (Assail)										
Azadirachtin (Aza-direct, Neemix)										Not effective
Bt (DiPel)										Not effective
Carbaryl (Sevin)										
Chlorantraniliprole (Altacor)	E				G					Favored product
Chlorpyrifos (Lorsban)	E	F	G					G		Reserved for critical use
Chromobacterium subtsugae (Grandevo)										Not effective
Clothianidin (Belay)										Pollinator concerns
Diazinon	E			G				F		Product is critical to industry
Dinotefuran (Scorpion)										MRL and pollinator concerns
Imidacloprid (Admire Pro)	E	G								Pollinator concerns, doesn't work on organic soils
Indoxacarb (Avaunt)	G	E								Only effective tool available for adult black vine weevil
Insecticidal soap (M-Pede)			G							Requires multiple applications
Methoxyfenozide (Intrepid)	F									Go to insecticide during bloom
Phosmet (Imidan 70W)										Used by organic growers
Pyrethrin (Pyrenone)	F									Requires multiple applications to be effective
Sodium flualuminate (Cryolite 50 Dust)		G								Not commonly used anymore
Spinetoram (Delegate WG)	G	G								
Spinosad (Entrust)										Used by organic growers
Thiamethoxam (Actara)										Pollinator concerns
Tebufenozide (Confirm 2F)										Use replaced by Intrepid
Unregistered/New Chemistries										
Biological										
Cultural/Non-Chemical										

Comment [MM1]: Please note important non-chemical practices

Efficacy Ratings for DISEASE and PATHOGEN Management Tools in Cranberry

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (< 70% control); **?** = efficacy unknown, more research needed; **NU** = not used for this pest; ***** = used but not a stand-alone management tool.

MANAGEMENT TOOLS	Cottonball	False blossom	Fruit rot	Lophodermium twig blight	Phytophthora root rot	Red leaf spot	Red shoot	Rose bloom	Upright dieback	COMMENTS
Registered Chemistries										
Aluminum tris (Aliette)										Not used
Azoxystrobin (Abound)			G-E	G	G				F	Efficacy with Fenbuconazole
Chlorothanlonil (Bravo)	E	E	E	E	E	E	E	E	E	Expensive product; go-to product, requires 2-3 applications
Copper diammonia diacetate (Copper-Count-N)										Not used
Copper hydroxide (Nucop, Kocide)						E		G-E		
Copper hydroxide + mancozeb (Mankocide)	G	G	G-E	G	G	G-E	G	G	G	
Copper sulfate + lime (Bordeaux)										Not used
Copper sulfate + sulfur (Top Cop w/Sulfur)										Not used
Fenbuconazole (Indar)			E							Efficacy with Azoxystrobin
Ferbam (Ferbam Granuflo)			G	F				E		
Mancozeb (Dithane F45, Manzate)	G	G	G-E	G-E	G	G	G	G	G	
Mefenoxam (Ridomil Gold SL)										Not used
Mono- and dibasic sodium, potassium, and ammonium phosphates (Phostrol)										Not used
Mono- and dipotassium salts of phosphoric acid (Rampart)										Not used
Polyoxin D zinc salt (OSO, Ph-D)			P							Not widely used
Potassium phosphite (Prophyt)										Not used
Propiconazole (Orbit)	G									Not widely used
Prothioconazole (Proline 480 SC)			E	E						Cost-prohibitive; Efficacy with azoxystrobin
Unregistered/New Chemistries										
Biological										
Cultural/Non-Chemical										
Drainage				E	E				E	Important for all pests
Sanding										
Pruning										

Efficacy Ratings for WEED Management Tools in Cranberry

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (<70% control); **?** = efficacy unknown—more research needed; **—** = not used for this pest; ***** = used but not a standalone management tool. Note**:** Weed size or stage of growth is an important consideration with most post-emergence herbicides.

In "Type" column, Pre = soil-active against pre-emerged weeds; Post = foliar-active against emerged weeds.

MANAGEMENT TOOLS	Type (Pre or Post)	Kudweed	Annual rushes	Yellow loosestrife	Lotus	Sheep sorrel	Lily of the valley	Creeping bentgrass	sedges	COMMENTS
Registered Chemistries										
2,4-D (Weedar 64)		P	P	P	P	P	P	P	P	Rush control; Alders, willows, salal, blackberry-E
Chlorimuron ethyl (Curio)		P	E	F	F	P	P	P	P	E for buttercup
Clethodim (Select)								G-E		Needs multiple apps to be effective
Clopyralid (Stinger)		P	P	P	F-E	P-F	P	P	P	Asters, clovers—E; Needs two applications
Dichlobenil (Casoron 46)		F	G	F	P	F-G	P	P	P	Annuals, perennials go-to-G ; Horsetail, fireweed—go-to product;
Glyphosate (Roundup)				F	F				G	Go-to "G" for woody species;
Mesotrione (Callisto)				P-F	F-G					G for small willows; Requires multiple apps for lotus
Napropamide (Devrinol)		F	F		F-E					
Norflurazon (Evital 5G)			G					G	F-G	G for grasses
Quinclorac (QuinStar 4L)		E	P	E	F-G					Purple aster, goldenrod –G; E for young willows; G for horsetail
Sethoxydim (Poast)								G-E		Needs multiple applications
Unregistered / New Chemistries										
Cultural/Non-chemical										

USING PAMS TERMINOLOGY

This system of terminology for IPM was developed for use by US Federal agencies seeking to support adoption of IPM by farmers. The table below summarizes common tactics used in agricultural IPM using a "Prevention, Avoidance, Monitoring, Suppression" (PAMS) classification. It also defines (in *italicized* CAPS) the ecological purpose that lies behind a particular practice. The PAMS tables throughout the text provide a simple basis for surveying practices that are used at different crop growth stages in terms of their contribution to a comprehensive IPM program.

Summarizing integrated pest, disease and weed management (IPM) tactics using PAMS terminology Paul Jepson, IPPC Oregon State University; paul.jepson@oregonstate.edu	
PREVENTION	
PREVENT INTRODUCTION TO THE FARM	
Pest-free seeds, transplants	
PREVENT RESERVOIRS ON THE FARM	
Sanitation procedures	
Eliminating alternative hosts	
Eliminating favorable sites in and off crop	
PREVENT PEST SPREAD BETWEEN FIELDS ON THE FARM	
Cleaning equipment between fields	
PREVENT PESTS DEVELOPING WITHIN FIELDS ON THE FARM	
Irrigation scheduling to prevent disease development	
Preventing weed reproduction	
Preventing pest-susceptible perennial crops by avoiding high risk locations	
AVOIDANCE	
AVOIDING HOST CROPS FOR THE PEST	
Crop rotation	
AVOID PEST-SUSCEPTIBLE CROPS	
Choosing genetically resistant cultivars	
Choose cultivars with growth and harvest dates that avoid the pest	
Place annual crops away from high-risk sites for pest development (even parts of a field)	
AVOID CROP BEING THE MOST ATTRACTIVE HOST	
Trap cropping	
Use of pheromones	
Using crop nutrition to promote rapid crop development	
AVOID MAKING THE CROP EXCESSIVELY NUTRITIOUS	
Use nutrition to promote rapid crop development	
Avoiding excessive nutrients that benefit the pest	
AVOID PRACTICES THAT INCREASE THE POTENTIAL FOR PEST LOSSES	
Narrow row spacing	
Optimized in-row plant populations	
No-till or strip till	
MONITORING	
COLLECT PESTS	

Summarizing integrated pest, disease and weed management (IPM) tactics using PAMS terminology Paul Jepson, IPPC Oregon State University; paul.jepson@oregonstate.edu	
Scouting and survey approaches	
Traps	
IDENTIFY PESTS	
Use of identification guides, diagnostic tools and diagnostic laboratories	
IDENTIFY PERIODS OR LOCATIONS OF HIGH PEST RISK	
Use weather-based pest-development and risk models	
Use soil and plant nutrient testing	
DETERMINE STATUS AND TRENDS IN PEST RISKS AND CLASSIFY PEST SEVERITY	
Maintain pest records over time for each field	
MINIMIZE PEST RISKS OVER TIME	
Plan an appropriate PAMS IPM strategy, based upon pest status and trends	
DETERMINE INTERVENTIONS BASED UPON RISKS AND ECONOMICS	
Use of decision support tools, economic thresholds	
SUPPRESSION	
CULTURAL	
OUT-COMPETE THE PEST WITH OTHER PLANTS	
Cover crops	
SUPPRESS PEST GROWTH	
Mulches	
SUPPRESS PEST WITH CHEMICALS FROM CROPS OR OTHER PLANTINGS	
Bio-fumigant crops	
PHYSICAL	
PHYSICALLY INJURE PEST OR DISRUPT PEST GROWTH	
Cultivation	
Mowing	
Flaming	
Temperature management	
Exclusion devices	
PHYSICALLY REMOVE PESTS	
Mass trapping	
BIOLOGICAL	
SUPPRESS PEST REPRODUCTION	
Pheromones	
INCREASE PEST MORTALITY FROM PREDATORS, PARASITES AND PATHOGENS	
Conservation biological control	
Inundative release and classical biological control	
Use of pest antagonists	
CHEMICAL	
USE OF LEAST-RISK, HIGHEST-EFFICACY PESTICIDES	
Use economic thresholds to determine that pesticide use is economically justified	
Using pesticides as a last resort, as part of a PAMS IPM strategy	