OREGON STATE UNIVERSITY EXTENSION SERVICE

An Integrated Pest Management Strategic Plan

For Oregon and Washington Cranberries

Photo: Lynn Ketchum, © Oregon State University

Two workers harvest cranberries on the Bussmann bogs near Bandon, Oregon.

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Introduction: Process for this Integrated Pest Management Strategic Plan ("IPMSP")

In a proactive effort to identify pest management priorities and lay a foundation for future strategies and increased use of Integrated Pest Management (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 publication, *Integrated Pest Management Strategic Plan for Oregon and Washington Cranberries*. Members of the group met for a day in March 2017 in Bandon, Oregon, and a day in April 2017 in Myrtle Point, Oregon, where they discussed and reached consensus about 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 result is a comprehensive strategic plan that addresses many IPM and pest-specific critical needs for the Oregon and Washington cranberry industry.

A list of top-priority critical needs was created, drawn from all of the needs appearing throughout the document, compiled from our March and April meetings. This list was based on a group voting process at the April meeting. A list of broader IPM needs was also developed based on input from both the March and April meetings, where attendees were asked to summarize needs for IPM-specific topics. Crop-stage-specific critical needs are also 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 described briefly, with links provided for more information about 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 that places practices within a simple IPM classification and to demonstrate areas where additional tools or practices may be needed. For more information on PAMS, see the appendix titled "Using PAMS Terminology" on page 48).

Trade names for certain pesticides are used as an aid to readers. 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
John Freitag, Friday Farms
Kevin Hatton, HB Cranberries, LLC
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Others in attendance

Paul Jepson, Integrated Plant Protection Center, Oregon State University
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Contributing work group members not in attendance at workshop

David Bellamy, Ocean Spray Cranberries, Inc., Washington
Dennis Bowman, Bowman Bogs
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Sarah Osborne, Peters Cranberries
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Photo: © Oregon State University

A cranberry harvest in full swing

Top-priority Critical Needs

The following critical needs were voted as the "top-priority" list of needs by the work group 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 topics

- Alternative and replacement chemistries for management of all major cranberry pests
- Expanded and increased decision-support tools for cranberry pest management
- Critical cranberry pests (including scale, sheep sorrel, lily of the valley) and best management practices that respond to critical needs
- Economic thresholds for major cranberry insects, diseases, and weeds
- Effective controls for black vine weevil, including chemical control and alternative tactics (currently registered chemical controls have not offered lasting control)
- Better understanding of the mechanism for frost protection using sprinklers (microclimatology for the coastal cranberry industry)
- Optimal timing for irrigation management and frost protection

Regulatory actions

- Establish formal communication with relevant parties regarding the challenges with maximum residue limits (MRLs) and exporting cranberries internationally.
- Maintain current registrations for commonly used pesticide products.
- Pursue registration of additional horticultural oils for use in cranberries against scale insects.

Education

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

An early morning harvest gets underway in Bandon, Oregon.

Cranberry Production Overview

The 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 Pacific Northwest since the 1880s.

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. Multiple varieties are grown, with the most popular being Stevens, Pilgrims, McFarlin, Grygleski 1, and Yellow River. Some growers are producing Crimson Queen, Mullica Queen, Demoraville, Welker, Haines, Hyred, and Sundance varieties. Farms average 10 to 20 acres in size, with some as large as 200 acres. Oregon and Washington production comprises an annual farm gate value of $18 to $25 million, accounting for roughly 9 percent of U.S. cranberry production.

A common misconception is that cranberries are grown in water, but this is not the case. 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 to 10 inches of sand over peat, muck, or topsoil), and the vines are set to a depth of 1 to 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-inch square pattern. As these vines take root, new shoots grow (referred to as "uprights"), 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 vines over several years.

Cranberries require acidic soils with a pH of 4.0 to 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 sprinkler irrigation is utilized in the beds.

New cranberry beds are typically planted between March and May, and require about 3 years to reach full production potential, reaching their peak after 4 to 6 years. The cranberry fruit cycle is 16 months long, with bud set occurring around June of year 1, and harvest occurring in the fall of the following year. Bloom timing is protracted on the West Coast, with bloom beginning as early as mid-May and lasting 4 to 6 weeks.

Cranberries are a perennial crop, and maintaining production requires the control of pests over the duration of the bed's life, which can be from 20 to more than 30 years. 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 in the Pacific Northwest.

Cranberries require pollination, and Pacific Northwest 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.

Cranberries are harvested by one of two methods. For processed fruit, the beds are "wet picked." In this scenario, the bed is flooded with water, and the berries are removed with a "beater" or harrow. The berries are then corralled in the water using a boom, and removed from the bed to an awaiting truck using an elevator or water pump. For fresh market fruit, beds are usually harvested using a "Furford" harvester. This is essentially a small combine about 2 feet wide, which scoops the fruit off the vines into "gunny sacks." The sacks, containing 30 to 50 pounds of fruit, are then removed from the bed, and the fruit is cleaned and sorted for the fresh market.

Integrated Pest Management Overview in Cranberry Production

The historical average cranberry yield in the Pacific Northwest is lower than other major U.S. growing areas. Reasons for this comparatively lower yield include weather, off-type germplasm, and inordinately higher levels of pests, including weeds (which can reduce production by 15 percent or more), diseases, and insects. Additionally, many Pacific Northwest farms were constructed more than 50 years ago, and bed placement was opportunistic, often following the natural lay of the land. As such, these older beds are often irregularly shaped and have engineering issues that impose limitations on production such as water holding capability and drainage. Although re-engineering cranberry beds of this nature would be beneficial, the cost would be prohibitive.

Thus, some Pacific Northwest farms are producing on lower yielding dry-harvested beds, with low degree-day units and 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, black-headed fireworm, scale insects, and black vine weevil.

Cranberry tipworm, *Dasineura oxycoccana*, is a relatively recent pest to the Pacific Northwest, so growers are still learning how to manage it. It is currently only a problem in Washington and northwest 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.

Black-headed 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 percent of growers use pheromone trap counts to inform them of the optimal timing for insecticide applications. While this pest can be managed chemically on conventional farms, management on organically managed farms has been an ongoing challenge.

Two species of scale, for example, brown soft scale (*Coccus hesperidum)* and greedy scale (*Hemiberlesia rapax*), have become problematic over the past decade in southwest 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 shown to be effective. Efforts to train and educate growers to scout for and properly identify greedy scale have been successful and have improved their timing and decreased the number of insecticide applications. Further work is needed to identify softer, target-specific chemistries that will be efficacious against greedy scale insects.

Black vine weevil (*Otiorhynchus sulcatus*) has been difficult to control, and as a result of its high fecundity and ability to cause severe damage, it remains a significant pest. However, because the soil dwelling larvae are susceptible to flooding, pest issues can be avoided in diked beds, which are flooded periodically for harvest and hygiene practices. Most dry-harvested beds need effective management plans for black vine weevil.

A major thrust of research on black vine weevil control has been directed toward entomopathogenic nematodes and fungi over the past three decades. While these management approaches can be effective, they remain cost-prohibitive for most growers. Controls that focus on traditional chemicals have shown only marginal efficacy, and have also raised concerns regarding pollinators. Identification of alternative management programs for the insect remains a critical need.

Photo: Lynn Ketchum, © Oregon State University

A handful of cranberries still on the vine.

Fungal pathogens and 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 no effective organic-approved fungicides for use against this disease. 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 comprising at least 15 different fungal pathogens that can cause a yield loss of 15 to 30 percent in some cases. 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 replanting 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 preharvest fungicide use has increased as well, especially for fresh market growers. Continued 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 Pacific Northwest cranberry growers. Registration of new herbicides over the past decade has contributed to a reduction in losses from 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. Implementation of cost savings by minimizing pest management inputs will be a critical component of production over the next decade.

IPM Critical Needs

The following list of broad IPM needs was compiled based on input from meetings held in March and April 2017, with IPMSP work group members and other representatives from the cranberry industry in Oregon and Washington. This list is not pest- or crop-stage specific, but applies more generally to IPM development and IPM benefits across the cranberry industry. At these meetings, participants were asked to summarize needs related to each of the following headings.

Decision and knowledge support

- Develop models to aid growers in pesticide selection, application, and timing that also take into account pest thresholds.
- Increase research on resistance management with commonly used products.
- Continue education to growers on resistance management best practices.
- Develop pest management decision-support tools that increase grower confidence in being able to minimize or eliminate use of certain pesticides, increase efficacy, and improve economics.
- Seek funding and support for an applied research workforce that addresses cranberry issues.
- Provide growers with increased access to IPM resources and education.
- Encourage training and employment of more IPM consultants to serve the cranberry industry.
- Increase financial support for current weather station programs (Agri-Met, Ag Weather Net).

Development of alternatives to agro-chemicals

- Conduct analysis on the economic feasibility for using certain higher-cost alternative products, including 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 and area-wide management

- Develop research and education around whole-farm cranberry pollination ecology.
- Conduct education about on-farm plantings and habitats that support native pollinators.
- Identify existing pollinator and natural enemy habitat, and encourage communication and storytelling about these successes.

Pollinator protection

- Identify 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 to help minimize risk of nontarget exposure to pesticides during bloom.
- Develop a protection plan for native pollinators, which contribute 30 to 40 percent of pollination services in cranberry.
- Identify strategies to support and grow native pollinator populations.
- Research the impacts of commonly used fungicides on native and managed pollinators.

- Identification of effective chemical and nonchemical controls for black-headed fireworm to reduce use of pyrethroids.
- Increase research of overall pollinator health with respect to the sequence of migratory pollinator usage among other crops to determine true impacts from cranberry production.

Beneficial and natural enemy protection

- Collect data on the presence of beneficials and natural enemies in cranberry beds.
- Research the use of natural predators for cranberry pest control (such as 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 impacts to beneficials of declining organophosphate usage.

Certification needs

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

Human health and worker protection

- Educate growers on new EPA worker protection standard.

Water quality

- Conduct effective education programs for growers aimed at improving water quality.
- Research effective alternatives to products of concern (such as diazinon and chlorpyrifos).
- Establish a 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 impacts.
- Public education to correct misinformation about impacts to water quality from cranberry production.
- Create marketing materials that effectively convey the positives related to cranberry production and water quality.

Photo: Lynn Ketchum,

A worker uses a boom to collect cranberries.

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. An MRL may exist in the United States but not in the importing country, or the MRL of the importing country may be set so low 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 Pacific Northwest cranberry crop is used for the export market. The differential in returns to growers for fruit that can be sold for export compared to fruit sold for domestic consumption is significant enough that growers will avoid the use of a highly efficacious, labeled pesticide if that pesticide does not have export MRLs. The necessity of adhering to the MRLs of the importing country has increased the cranberry industry's exposure to economic losses. These economic risks take the form of:

- Having fruit rejected because a pesticide residue is found that, despite being legal in the United States, does not conform to the importing country's MRL standard.
- Limiting the control options that can be used on the cranberry crop to meet the customer's MRL standard. Export growers are unable to use a pesticide that might be more efficacious, less expensive, or required for resistance management.

Although an MRL may be pending in an export market, it cannot be applied until it is established. This situation often limits the choice of pest management tools in the cranberry grower's 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 and fit well within an IPM program; do not have negative mammalian or environmental impacts; and are safe to pollinators and other beneficial organisms.

There are currently several pesticide products 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 European Union is two orders of magnitude lower than in the United States (0.01 ppm in the EU, effectively a nondetect level, vs. 1.5 ppm in the United States). Growers who use quinclorac are not qualified to export fruit for 2 years after its use. Many examples exist for products in other export markets, such as 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 is a major issue that impacts the pest management practices of Oregon and Washington cranberry growers, and often places them at a disadvantage in the international marketplace.

List of Major Cranberry Pests

(listed alphabetically)

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. 15)
Greedy scale *(Hemiberlesia rapax)*
Tipworm (*Dasineura oxycoccana*)

Diseases and Pathogens

Cottonball (*Monilinia oxycocci*)
Fruit rot (numerous fungi, see entry p. 15)
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 armeniacus, 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 (*Gaultheria shallon)*
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 Pests by Crop Stage

Dormancy to bud-break (November–April)

Insects: 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)

Insects: Black-headed fireworm, black vine weevil, greedy scale, tipworm
Diseases: 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)

Insects: Black-headed fireworm, black vine weevil, cranberry fruitworm, cranberry girdler, cutworm, greedy scale, tipworm
Diseases: 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)

Insects: Black-headed fireworm, cranberry fruitworm, cranberry girdler, cranberry root weevil, cutworm, greedy scale, tipworm
Diseases: Lophodermium twig blight, fruit rot, red leaf spot
Weeds: Annual bluegrass, blackberry, Bog St. Johnswort, creeping bentgrass, lotus

Harvest (August–November)

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

Major Cranberry Pest Descriptions

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. With severe injury, vine tips look brown as if scorched by fire, and berries shrivel. A third generation of moths may emerge in late summer. 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-weevils

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 pest numbers grow. 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 fruits during development.

Cranberry girdler (*Chrysoteuchia topiaria*)

For pest description information, 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 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 the first generation 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.

Cutworms

Numerous species

For pest description information, 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 the tips of uprights and runners.

Scale insects

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 or dead patches in beds. Scale presence can cause reduced fruit set on infested uprights.

Diseases and Pathogens

Cottonball (*Monilinia oxycocci*)

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

This disease is 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

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

Fruit rot can be caused by several fungi, including *Phomopsis vaccinii*, viscid rot; *Botrytis* spp., 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.

Important genera in Oregon and Washington cranberry fruit rots are *Allantophomopsis*, *Coleophoma*, *Colletotrichum*, *Physalospora*, and *Fusicoccum*.

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, so 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; infections in one 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 upright shoots 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 percent of the uprights may be affected in certain beds.

Weeds

Overall, cranberry crop losses due to weeds are estimated to be 25 percent, and are among the highest of any agricultural commodity. However, for certain weed species, losses can be 100 percent. The most problematic weeds for cranberry crop loss are herbaceous perennials, such as lotus, sheep sorrel, bentgrass, yellow loose strife, and marsh arrowgrass, which have high fecundity and are difficult to control with registered herbicides. Many cranberry weeds are hard-to-control wetland and upland weeds. Common cranberry weeds include:

Annual bluegrass (*Poa annua*)
Arrowgrass (*Triglochin paulstris*)
Blackberry (*Rubus armeniacus, 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 (*Gaultheria shallon*)
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*)

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 means of control.

Deer and elk are also a constant pressure in cranberry beds. 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 even fencing.

Bears are another occasional vertebrate pest and can forage on ripe berries and cause damage from digging in beds. Bears can also cause damage to hive boxes, which can lead to additional expense for growers having to protect hives with electric and conventional fencing systems.

Cranberry Pest Management by Crop Stage

Dormancy to 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 and repairs of irrigation and drainage systems, dikes and roads, and equipment.

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

Pesticides in Pacific Northwest cranberry beds are most often applied through irrigation systems (chemigation), not boom sprayers. Granular herbicides are applied with air spreaders, drop spreaders, or "belly grinders."

Field activities and pest management decisions that occur during dormancy to bud-break

Sanding
Pruning
Sanitation
Algae, liverwort, moss control—early fungicide application
Drainage improvement
Tree removal if shade is an issue on bed
Frost control
Preemergent herbicides (for horsetail and other weeds)
Scout for scale
Management for brown soft scale

PAMS[1] practice	Dormancy to bud-break pest management activities	Target pest(s)
Prevention	Sand application	Cranberry girdler, weevil, weeds, moss
	Prune	Fruit rot, twig blight
	Drainage, maintenance, and improvement	Weeds, fruit/root rot
	Sanitation: remove harvest debris	Disease control
Avoidance	Fence fields	Ungulate and goose management
Monitoring	Scout fields	Brown soft scale, greedy scale, voles, moss, fireworm eggs, twig blight
	Bait stations set on dikes near beds	Voles
	Weed maps	Weeds
Suppression	Resand beds for cranberry girdler control	Cranberry girdler
	Apply iron/copper	Mosses
	Flooding	Weeds, insects: scale, weevil, fruit rot, twig blight
	Set up raptor perches and other bird or bat boxes	Rodent control, insect control
	Herbicide applications: ▪ 2,4D (in WA; Weedar 64 in OR; granular only; used with Section 24c labels in OR and WA for wiping trees and brush and winter biennial control) ▪ Clethodim (Select) (for grass weeds only) ▪ Clopyralid (Stinger) ▪ Copper or iron (for moss) ▪ Dichlobenil (Casoron) ▪ Glyphosate (Roundup) ▪ Napropramide (Devrinol) ▪ Norflurazon (Evital) ▪ Quinclorac (Quinstar) ▪ Sethoxydim (Poast; Volunteer in WA) for grass weeds only	Weeds
	Insecticidal soap (M-pede)	Brown soft scale
	Disease suppression applications: Lime sulfur Copper sulfate	Disease spore suppression
	Hazing or hunting with approval	Ungulate and goose management

[1] See appendix “Using PAMS Terminology,” page 48.

Critical needs for dormancy to bud-break pest management

Research topics

- Effective rodent management options including chemical options.
- Economic and treatment thresholds for major pests, including economic thresholds for weed control, drainage, etc.
- Efficacy of dormant-season treatments for greedy scale.
- Efficacy of using pyriproxyfen (Esteem) for greedy scale control.

Regulatory actions

- Maintain continued support and communication to resolve issues with maximum residue limits (MRLs) in export countries (for quinclorac and other products).

Education

- Clarify for growers the currently registered rodent management options.
- Educate growers on pruning frequency and intensity for best management.
- Educate and clarify to growers regarding the use of pyriproxyfen (Knack) for cranberry pests under supplemental label.

Photo: Lynn Ketchum, © Oregon State University

Cranberry bushes prior to harvesting.

Shoot elongation (April–May)

Shoot elongation is the most critical time of the year for frost protection, as new growth is extremely sensitive to temperatures less than 32 degrees Fahrenheit. Frost protection can be necessary 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 postemergent weed control is common during this period. Black-headed fireworm, tipworm, black vine weevil, and scale all require management during this time period. Some foliar diseases, including rose bloom and cottonball, would need to be treated if the outbreak is severe. Twig blight can also be a problem at this time, but there is no known treatment for this timing.

Growers are also applying their first applications of fertilizer during this period, a blend of nitrogen, phosphorous, and potassium. Granular fertilizers are applied with air or throw spreaders and belly grinders; foliar fertilizers are applied via irrigation systems.

Field activities and pest management decisions that may occur during shoot elongation

Weed scouting
Postemergent herbicide applications
Scouting for black vine weevil
Scouting for twig blight infestations
Cottonball preventative fungicide application, if present previously
Scouting for rose bloom, treatment if necessary
Adjust frost protection for growth stage
Fireworm monitoring and treatment
Tipworm monitoring and treatment
Fertilization decisions based on soil and tissue tests, to add nutrients for upright initiation in new beds
Mowing dikes and 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	Cover new beds with vines; aided with nutrient management	Weed suppression
Monitoring	Monitor fields	Fireworm larvae, tipworm
	Pheromone traps	Fireworm, girdler
	Sample for adult root weevil larvae	Root weevil
	Scout fields	Black vine weevil, twig blight
	Place sticky traps for monitoring and suppression	Tipworm
Suppression	Flood in the spring prior to egg hatch	Fireworm larvae
	Mow dikes and 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)	Weeds
	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)	Insects
	Copper application (Nucop, Kocide) for disease control	Rose bloom and other diseases

Critical needs for shoot elongation pest management

Research topics

- Pest biology and life cycle of cranberry tipworm.
- Effective controls for cranberry tipworm.
- Best management practices for cranberry tipworm.
- Effective products for black-headed fireworm control, especially relative to bloom timing, and also for organic growers.
- Area-wide monitoring and mapping program for black-headed fireworm.
- Black-headed fireworm to determine level of correlation between pheromone trap counts and economic damage.
- Phenology model for black-headed fireworm.
- Management thresholds for black-headed fireworm.
- Best management timing for greedy scale.
- Effective products for greedy scale control, especially alternatives to diazinon.
- Economic impacts for certain cranberry pests, such as greedy scale and tipworm. How big of an economic impact, and what damage do these pests cause?
- Effective management strategies for cranberry girdler.
- Determine if translaminar materials (such as azoxystrobin) are efficacious this time of year against twig blight (*Lophodermium*).
- Effective alternatives to quinclorac (Quinstar) for weed management.
- Effective organic-approved products for weed control.
- Program development for weed resistance monitoring.
- Effective alternatives to glyphosate (Roundup).
- Effective controls for black vine weevil (chemical and nonchemical), as current chemical controls have not offered lasting control.
- Protection plan for native pollinators during early-, middle-, and late-season pesticide applications

Regulatory actions

- Resolve maximum residue limit (MRL) issues related to pesticides considered critical (like quinclorac and chlorothalonil).
- Register additional horticultural oils for use in cranberries (potentially through manufacturer label change).

Education

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

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 ongoing fertilization. Anywhere from one to four colonies of bees per acre are used for a 4- to 6-week 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 management of 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 and 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	Manage dikes	Weeds, insects, voles
	Use a high uniformity irrigation system for chemigation and frost protection	Impacts disease management
	Manage vegetation and airflow, especially around field edges	Disease prevention
Avoidance	Avoid excess nitrogen to limit overgrowth	Fruit rot, tipworm,
	Optimize fertilizer timing depending on vines, soil type, end market (fresh vs. processed, etc.)	All pests
	Manage irrigation timing (best in morning, to reduce leaf wetness overnight)	Disease control
	Fence fields	Ungulate and geese management
Monitoring	Sample for adult emergence	Black vine weevil
	Set pheromone traps	Cranberry fruitworm, girdler, fireworm
	Monitor through visual inspection, sticky traps, counting	Tipworm, fireworm
	Monitor fields	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 is best achieved with products with long residual	Insects
	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)	Diseases
	Herbicides (mainly spot treatment or hand spraying of grass herbicides): ▪ Chlorimuron ethyl (Curio) ▪ Clethodim (Select) ▪ Glyphosate (Roundup) (applied via wiper applicator) ▪ Mesotrione (Callisto) ▪ Sethoxydim (Poast/Volunteer)	Weeds
	Haze and hunt with approval	Ungulate and geese management
	Use cages or electric fencing, platforms, hardware cloth around hives to protect bees	Bears

Critical needs for bloom pest management

Research topics

- Effective management strategies for twig blight, including organic approved products.
- Area-wide monitoring, data sharing and communication program for twig blight, as well as other insect and disease pests. Anonymous alerts could be sent with trap-count data, etc.
- Critical timing for application of broad-spectrum products for effective scale and fireworm control that is balanced with judicious use to protect pollinators and beneficials.
- Fireworm management that also takes into account needs for greedy scale.
- Support programs for transitioning away from cancelled products and also from broad-spectrum to more selective products to reduce exacerbation of pest impacts.
- Beneficial insect occurrence and timing.
- Affordable technologies to support automated irrigation systems, such as wireless sensors to detect cold spots.
- Duration of frost management and frost-management cycling and best timing to reduce impacts on pest management.
- Understanding the mechanism for frost protection using sprinkling (microclimatology for coastal cranberry industry).
- Various classes of fungicide to support pollinator protection and resistance management.

Regulatory actions

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

Education

- Educate growers on the importance of monitoring for twig blight to aid in pesticide application decision-making.
- Communicate to growers about better management strategies for derelict beds.
- Educate growers on available decision-support tools (including leaf wetness model, evapotranspiration monitoring for irrigation scheduling, and value of various sensor systems).
- Educate growers on resistance management for all classes: fungicides, insecticides, and herbicides.
- Educate growers on best management practices for pollinator protection.
- Educate growers 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 management for 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, are critical during this stage. Fungicide controls for twig blight are critical at this timing if this pest is present. Control of tall perennial weeds extending above the canopy with glyphosate using a wiper applicator is common during this stage.

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

Field activities and pest management decisions that may occur during fruit set-development

Irrigation, heat control
Tissue and soil sampling
Weed mapping
Pesticide Use Reports (PURs) 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	Sanitize equipment (fertilizer spreaders) to avoid spread of pests	Insects, diseases, and weeds
	Use heat control	Rot prevention
	Manage dikes and adjacent habitat if possible to avoid windblown seed	Weed/disease
Avoidance	Avoid excess fertilization by monitoring bud set and plant condition	All pests
	Grass control	Weevil, girdler infestation
	Irrigation control—avoid over- and under-irrigation	Weeds, diseases
Monitoring	Monitor fields	Fireworm, deer, elk, geese, bears
	Monitor heat on the fields	
	Monitor water and irrigation of the fields	
Suppression	Create short floods (1 to 2 days)	Cranberry girdler
	Insecticides: ▪ Acephate (Orthene) [if meets preharvest intervals, but MRL issues limit use at this stage] ▪ Acetamiprid (Assail) (not used due to pollinator and maximum residue limit [MRL] issues) ▪ Chlorantraniliprole (Altacor) ▪ Chlorpyrifos (Lorsban) [if meets preharvest intervals, but MRL issues limit use at this stage] ▪ Diazinon ▪ Indoxacarb (Avaunt) ▪ Methoxyfenozide (Intrepid) ▪ Pyrethrins	Insects
	Beneficial nematodes	Weevil, girdler
	Herbicides: ▪ Chlorimuron ethyl (Curio) ▪ Clethodim (Select) ▪ Glyphosate (Roundup) (hand wiping) ▪ Mesotrione (Callisto) ▪ Quinclorac (Quinstar) ▪ Sethoxydim (Poast/Volunteer)	Weeds
	Fungicides: ▪ Chlorothalonil (Bravo) ▪ Copper hydroxide + mancozeb (Dithane F45, Manzate)	Diseases
	Seed head removal	Weeds
	Hand weed young trees (willows, alders)	

Critical needs for fruit set—development pest management

Research topics

- 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.
- Optimal timing for irrigation management and frost protection.
- Alternative chemistries and best management practices for cranberry fruitworm, including prediction and treatment regimes that include early monitoring; this pest is particularly problematic if pressures arise at this stage.

Regulatory actions

- 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 the 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 vertebrate pest management.

Education

- None that are specific to this stage at this time.

Harvest (August–November)

Some varieties of cranberry can be ready for harvest as early as August, and some as late as November. Early ripening and rot-prone varieties need to be picked first to avoid issues with rot. During this stage, equipment used for cleaning, sorting, and hauling is readied for harvest. Tall weeds that can make harvest difficult are removed. For dry harvesting, harvest is coordinated with packer and shipper demands. For wet harvesting, beds are flooded and then fruit is removed.

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 just prior to harvest, and after harvest for early harvested beds.

Field activities and pest management decisions that may occur during harvest

Irrigation management
Sprinkler head removal
Cleaning harvest equipment
Flooding
Beating
Harvest

Photo: Lynn Ketchum, © Oregon State University

Some cranberries are ready for harvest as early as August while others are picked as late as November.

PAMS practice	Harvest pest management activities	Target pest(s)
Prevention	Use rotation cycles of early flooding at harvest	Insects
	Clean harvest equipment	Weeds
	Remove harvest debris	All pests
Avoidance	Select harvested fields and use care with flood waters to avoid transfer of seed-infested water between beds	Weeds
	Sequence harvest with early preference to rot-prone varieties and new beds first	Rot
Monitoring	None at this time	
Suppression	Trim handheld string	Weeds
	Flood the field for 2 to 3 weeks immediately after harvest to kill root weevil larvae	Root weevil
	Postemergent weed control immediately after harvest and before dormancy: ▪ 2,4-D (Weedar) ▪ Clethodim (Select) ▪ Glyphosate (Roundup) (hand wiping) ▪ Sethoxydim (Poast/Volunteer)	Weeds
	Selective weed by hand (e.g., lotus)	Weeds

Critical needs for harvest pest management

Research topics

- Best harvesting and handling equipment with respect to fruit damage and subsequent impact on fruit quality and storage rot. This is particularly important for dry-harvested beds that are used to produce fruit for the fresh market.
- Optimal duration of flooding, including float time and impacts to fruit quality, temperature considerations, etc.
- Best management of aquatic weeds in irrigation ponds.
- Potential for transfer of chemical residues through fruit cleaning, improper fruit separation, chemigation equipment, or shared floodwaters at harvest. (For example, quinclorac might be used in some beds but not others, but if harvest floodwater is shared between beds, does that transfer residues to nontreated fruit?)

Regulatory actions

- Continued industry engagement on maximum residue limit (MRL) issues: support for industry members working on these issues, and continued funding and research.
- Work to avoid labor shortage at harvest, which impacts growers' ability to achieve full value for the crop.

Education

- None specific to this growth stage, 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.

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 Pacific Northwest 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 more than 80 different plant species. One mode of transmission is believed to be via pollinators; however, there is still much to learn. To minimize the risk of exposure to TSV in Pacific Northwest 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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Appendix

Activity Tables for Cranberries in OR and WA

Field Activities (other than pest management)

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 postemergent applications*	X	X	X	X	X	X	X	X			X	X
Herbicide preemergent 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			

*Notes:

- Hand weeding and spot treating for weeds can take place most of the year.
- An activity may occur at any time during the designated time period but generally not continually during that time period.

Seasonal Pest Management for Cranberries in Oregon

Insects	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Black vine weevil							X	X				
Black-headed fireworm				X	X	X	X	X	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

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

Seasonal Pest Management for Cranberries in Washington

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
Grasses												
Annual			X	X	X							
Perennial	X	X	X	X	X	X	X	X	X	X	X	X

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

Cranberry Pesticide Risk Management Table

The letters below represent four categories of nontarget risk potentially affected by pesticide use. Where risks are indicated, mitigations can be applied (BMPs) to reduce risks to aquatic life, terrestrial wildlife, pollinators, and bystanders.[2]

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: e.g., a child standing at the edge of the field
ND = Means no data is available for this product
— = Means that risks are not anticipated for this product

Pesticides	Risks requiring mitigation	Dormancy–bud-break (November–April)	Shoot elongation (April–May)	Bloom (May–June)	Fruit set–development (June–September)	Harvest (August–November)	Target Pest(s)	Comments
Insecticides		**If used, average number of applications per crop stage**						
Acephate (Orthene)	T, P		1		1		Fireworm, girdler	Not commonly used in OR, go-to product in WA; only one use per year
Acetamiprid (Assail)	A		1				If used, weevil, fireworm	Not used; pollinator and MRL issues
Azadirachtin (Aza-direct, Neemix)	—							Not used; not effective
Bt (DiPel)	—						fireworm	Used occasionally by organic; not considered effective
Carbaryl (Sevin)	A, T, P		2		1		Tipworm	Go-to product; up to five applications allowed
Chlorantraniliprole (Altacor)	—		1	1	1		Fireworm, girdler	Go-to product
Chlorpyrifos (Lorsban)	A, T, P, B		1		1		Adult weevil and scale	Occasional use for critical management only
Chromobacterium subtsugae (Grandevo)	ND						Tipworm, fireworm	Not used; not effective
Clothianidin (Belay)	A, P				1		Black vine weevil	Would be go-to product, but MRL issues limit use

[2] This analysis is based on the Oregon State University Integrated Plant Protection Center's state-of-the-science risk assessment tool ipmPRiME, a risk model that identifies moderate to high (10% or greater) risk (Jepson et al., 2014; Sustainable Agriculture Network, 2017). These data are a supplement to product labels, and do not substitute for any mitigations required on the label. For more information, see "Pesticide Risk Classification," in the appendix on page 50.

Pesticides	**Risks requiring mitigation**	**Dormancy–bud-break (November–April)**	**Shoot elongation (April–May)**	**Bloom (May–June)**	**Fruit set–development (June–September)**	**Harvest (August–November)**	**Target Pest(s)**	**Comments**
Diazinon	A, T, P, B		1		1		Fireworm, fruitworm, greedy scale	Go-to product
Dinotefuran (Scorpion)	A, P				1			Go-to product; but MRL issues limit use
Imidacloprid (Admire Pro)	A, P				1		Greedy scale	Used postbloom; not used often, not effective
Indoxacarb (Avaunt)	P		1	1	1		Black vine weevil	Go-to product
Insecticidal soap (M-Pede)	ND	1					Soft scale	Not often used
Methoxyfenozide (Intrepid)	—			2			fireworm	Go-to product during bloom
Phosmet (Imidan 70W)	A, T, P		1		1		Fireworm, fruitworm	
Pyrethrin (Pyrenone)	P		1	1	1		fireworm	
Sodium flualuminate (Cryolite 50 Dust)	—	1		1			fruitworm	Rarely used; not available
Spinetoram (Delegate WG)	—		1	1	1		fireworm	
Spinosad (Entrust)	P		1	1	1		fireworm	Only effective insecticide for organic growers
Thiamethoxam (Actara)	A, P				1		weevil	
Tebufenozide (Confirm 2F)	—			1			Fireworm, fruitworm, spanworm	Not commonly used anymore
Fungicides								
Aluminum tris (Aliette)	ND						Phytopthora root rot	Not used
Azoxystrobin (Abound)	A			2			Fruit rot, lophodermium, phytophthora root rot	Resistance management critical when used; go-to product for fruit rot

Pesticides	Risks requiring mitigation	Dormancy–bud-break (November–April)	Shoot elongation (April–May)	Bloom (May–June)	Fruit set–development (June–September)	Harvest (August–November)	Target Pest(s)	Comments
Chlorothanlonil (Bravo)	A, T		1	1	1		Fruit rot, twig blight, general disease management	Go-to fungicide; important to use last for resistance management
Copper hydroxide (Nucop, Kocide)	A		1	1			Rose bloom, red leaf spot	
Copper hydroxide + Mancozeb (Mankocide)	A			1	1			General disease management
Copper sulfate, lime (Bordeaux)	A, T, P	2						Not used
Copper sulfate + sulfur (Top Cop w/Sulfur)	A, T, P							Not used
Fenbuconazole (Indar)	—			2			Fruit rot	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		Fruit rot, general disease management	Go-to fungicide; important to use last for resistance management
Mefenoxam (Ridomil Gold SL)	—						Phytopthora root rot	Not used
Mono- and dibasic sodium, potassium, and ammonium phosphates (Phostrol)	ND						Phytopthora root rot	Not used
Mono- and dipotassium salts of phosphoric acid (Rampart)	ND							Not used
Polyoxin D zinc salt (OSO, Ph-D)	—			2			Fruit rot	Poor efficacy
Potassium phosphite (Prophyt)	—							Not used
Propiconazole (Orbit)	—			1			cottonball	Not widely used
Prothioconazole (Proline 480 SC)	—			2			Fruit rot, lophodermium	Go-to product for fruit rot

Pesticides	Risks requiring mitigation	Dormancy–bud-break (November–April)	Shoot elongation (April–May)	Bloom (May–June)	Fruit set–development (June–September)	Harvest (August–November)	Target Pest(s)	Comments
Herbicides								
2,4-D (Weedar 64 in OR)	—	1	1	1	1	1	Woody/ herbaceous perennials, rushes, sedges	Weedar 64 wipe only; spot treatment year-round; 2,4-D granular in spring; may be broadcast
Chlorimuron ethyl (Curio)	—	1	1	1			Creeping buttercup, herbaceous perennials, bog rush	SLN, requires waiver of liability signature
Clethodim (Select)	—	1	1	1	1	1	Annual, perennial grasses	Spot treatment year-round
Clopyralid (Stinger)	—	2	1				Lotus, sheep sorrel, asters, clovers	Spot treatment year-round
Dichlobenil (Casoron 46)	T	1					Annual broadleaves, equisetum, sedge, small willows	
Glyphosate (Roundup)	—	1	1	1	1	1	Misc. tall weeds, sedges	Hand applied as spot treatment year-round
Mesotrione (Callisto)	—		1	1	1		Lotus, small willows	Two applications only
Napropamide (Devrinol)	T	1					lotus	
Norflurazon (Evital 5G)	A, T	1					Sedges, rushes, grasses	
Quinclorac (QuinStar 4L)	—		2		1		Yellow loosestrife, cudweed	
Sethoxydim (Poast)	—	1	1	1	1		grasses	

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, more research needed

Management tools	Black-headed fireworm	Black vine weevil	Brown soft scale	Cranberry fruitworm	Cranberry girdler	Cranefly/leatherjacket	Cutworm	Greedy scale	Tipworm	Comments
Registered chemistries										
Acephate (Orthene)	E				G			P		
Acetamiprid (Assail)										Not used; pollinator and MRL issues
Azadirachtin (Aza-direct, Neemix)										Not effective
Bt (DiPel)										Not effective
Carbaryl (Sevin)									E	
Chlorantraniliprole (Altacor)	E				G					Favored product
Chlorpyrifos (Lorsban)	E	F	G					F		Reserved for critical use
Chromobacterium subtsugae (Grandevo)	F								P	Not effective on most PNW cranberry insect pests
Clothianidin (Belay)										Pollinator concerns
Diazinon	E			G				F		Product is critical to industry
Dinotefuran (Scorpion)										MRL and pollinator concerns
Imidacloprid (Admire Pro)	E	G							P	Pollinator concerns; does not work on organic soils
Indoxacarb (Avaunt)	G	E								Only effective tool available for adult black vine weevil
Insecticidal soap (M-Pede)			G					P		Requires multiple applications
Methoxyfenozide (Intrepid)	F									Go to insecticide during bloom
Phosmet (Imidan 70W)	?									
Pyrethrin (Pyrenone)	F									Requires multiple applications to be effective
Pyriproxifen								F		Looks promising, more data needed
Sodium flualuminate (Cryolite 50 Dust)		G								Not commonly used anymore
Spinetoram (Delegate WG)	G	G								Effective, but costly; used by organic growers
Spinosad (Entrust)	G			F	P		G			Used by organic growers
Thiamethoxam (Actara)										Pollinator concerns
Tebufenozide (Confirm 2F)										Use replaced by Intrepid

Management tools	Black-headed fireworm	Black vine weevil	Brown soft scale	Cranberry fruitworm	Cranberry girdler	Cranefly/leatherjacket	Cutworm	Greedy scale	Tipworm	Comments
Unregistered/new chemistries										
Biological										
Entomopathogenic nematodes (*Steinernema Carpocapsa*, or *Heterorhabditis bacteriophora*)		F			F					Used occasionally; spotty efficacy
Cultural/nonchemical										
Flooding	G	G								Not an option for many beds; difficult on large farms

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

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		Not easily available on West Coast
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										

Management tools	Cottonball	False blossom	Fruit rot	Lophodermium twig blight	Phytophthora root rot	Red leaf spot	Red shoot	Rose bloom	Upright dieback	Comments
Cultural/nonchemical										
Drainage				E	E				E	Important for all pests
Sanding			F		E					Important for all pests
Pruning										Important for all pests

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

Management tools	Cudweed	Annual rushes	Yellow loosestrife	Lotus	Sheep sorrel	Lily of the valley	Creeping bentgrass	Sedges	Comments
Registered chemistries									
2,4-D (Weedar 64 in OR)	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 product; 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									
Rimsulfuron (currently in IR-4 testing)		E	P					E	Ratings based on trial data
Cultural/nonchemical									
Flooding							?		Possibly some control of grasses
Hand weeding and string trimming	F	F	P	P	P–F	P	P	P	Most critical in new plantings to prevent the early establishment of weeds

Note:
Weed size or stage of growth is an important consideration with most postemergence herbicides.

Using PAMS Terminology

This system of terminology for IPM was developed for use by U.S. 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. We also define (*italicized* headings) 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
Use pest-free seeds, transplants
Prevent reservoirs on the farm
Follow sanitation procedures
Eliminate alternative hosts
Eliminate favorable sites in and off crop
Prevent pest spread between fields on the farm
Clean equipment between fields
Prevent pest development within fields on the farm
Use irrigation scheduling to prevent disease development
Prevent weed reproduction
Prevent pest-susceptible perennial crops by avoiding high-risk locations
AVOIDANCE
Avoid host crops for the pest
Rotate crops
Avoid pest-susceptible crops
Choose 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
Plant trap crops
Use pheromones
Optimize crop nutrition to promote rapid crop development
Avoid making the crop excessively nutritious
Optimize crop nutrition to promote rapid crop development
Avoid excessive nutrients that benefit the pest
Avoid practices that increase the potential for pest losses
Use narrow row spacing
Optimize in-row plant populations
Use no-till or strip till

Continued on next page

Summarizing Integrated Pest, Disease, and Weed Management (IPM) Tactics using PAMS Terminology
Paul Jepson, IPPC, Oregon State University: paul.jepson@oregonstate.edu
MONITORING
Collect pests
Use scouting and surveys
Use traps
Identify pests
Use identification guides, diagnostic tools, and diagnostic laboratories
Identify periods or locations of high pest risk
Use weather-based pest-development and risk models
Test soil and plant nutrients
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 decision support tools, economic thresholds
SUPPRESSION
CULTURAL
Out-compete the pest with other plants
Plant cover crops
Suppress pest growth
Mulch
Suppress pest with chemicals from crops or other plantings
Plant biofumigant crops
PHYSICAL
Physically injure the pest or disrupt pest growth
Cultivate
Mow
Flame
Manage temperature
Use exclusion devices
Physically remove pests
Use mass trapping
Hand weeding
BIOLOGICAL
Suppress pest reproduction
Use pheromones

Continued on next page

Summarizing Integrated Pest, Disease, and Weed Management (IPM) Tactics using PAMS Terminology Paul Jepson, IPPC, Oregon State University: paul.jepson@oregonstate.edu
Increase pest mortality from predators, parasites, and pathogens
Use conservation biological control
Use inundative release and classical biological control
Use pest antagonists
CHEMICAL
Use least-risk, highest-efficacy pesticides
Use economic thresholds to determine that pesticide use is economically justified
Apply pesticides as a last resort, as part of a PAMS IPM strategy

Pesticide Risk Classification

Paul Jepson, Oregon State University

The pesticide risk analysis is based on the Oregon State University Integrated Plant Protection Center's state-of-the-science risk assessment tool ipmPRiME, a risk model that identifies moderate to high (10% or greater) risk (Jepson et al. 2014; Sustainable Agriculture Network, 2017). We analyzed a total of 800 pesticides, and 168 of these posed risks to human workers/bystanders, aquatic life, wildlife, and pollinators. The analysis is intended to provide guidance that is supplementary to the label, which is the primary source of risk management information and mandatory practices.

1. Risk to aquatic life

Pesticides qualified for this risk category if one or more ipmPRiME aquatic risk models (aquatic algae, aquatic invertebrates, or fish chronic risk) exhibited high risk at a typical application rate.

2. Risk to terrestrial wildlife

Pesticides qualified for this risk category if one or more ipmPRiME terrestrial risk models (avian reproductive, avian acute, or small mammal risk) exhibited high risk at a typical application rate.

3. Risk to pollinators

Pesticides were selected based on a widely used hazard quotient (HQ) resulting of pesticide application rate in g a.i./ha (grams active ingredient per hectare), and contact LD50 for the honey bee (*Apis mellifera*). Values of HQ <50 have been validated as low risk in the European Union, and monitoring indicates that products with an HQ >2,500 are associated with a high risk of hive loss. The HQ value used by IPPC is >350, corresponding to a 15 percent risk of hive loss. The quotient includes a correction for systemic pesticides, where risks to bees are amplified.

4. Inhalation risk

Inhalation risk to bystanders was calculated using the ipmPRiME model for inhalation toxicity (Jepson et al., 2014) calculated on the basis of child exposure and susceptibility. This index is protective for workers who may enter fields during or after application, and also bystanders.

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