

**Pest Management Strategic Plan**  
for  
**Blueberries**  
in  
**Oregon and Washington**

**2011 Revision**



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## Work Group Members

### **Work Group Members in Attendance at Meeting:**

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Bob Martin, Virologist, USDA Agricultural Research Service  
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### **Work Group Members Not in Attendance at Meeting:**

Ryan Brown, Crop Consultant, Norpac Foods, Inc.  
Brian Cieslar, Agronomist, Enfield Farms, Inc.  
Jeff Flake, Crop Consultant, Pan-American Berry Growers  
Steve Gapp, Agronomist and Crop Consultant, Crop Protection Services  
Doug Kraemer, Grower, Berries Northwest  
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Steve Midboe, Crop Consultant, Whatcom Farmers Co-op  
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### **Others in Attendance:**

Kathy Blaustein, Human Health Risk Assessment Specialist, Oregon State University  
Joe DeFrancesco, PMSP Coordinator, Oregon State University  
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## Summary of the Most Critical Pest Management Needs in Oregon and Washington Blueberries

*The most critical priorities are listed below and must be addressed to maintain the long-term viability of the blueberry industry in Oregon and Washington. Additional priorities can be found throughout this document after each pest discussion.*

### RESEARCH:

- Continue research on the biology and management of spotted wing drosophila, and develop an IPM program for this pest.
- Develop efficacious bird management methods and techniques.
- Develop additional efficacious organic-compliant pesticides and strategies for managing insects (especially aphids and spotted wing drosophila), diseases (especially mummy berry and botrytis fruit rot/blight), and weeds (especially bindweed and Canada thistle).
- Identify and develop better tools for rodent management.
- Establish a monitoring program for invasive pest threats.
- Develop an effective fumigant and/or an alternative strategy for controlling soil pests, such as root weevil larvae, symphylans, and root rot.
- Develop a blueberry breeding program that addresses disease and insect issues, and continue the selection/cultivar evaluation program to assess for suitability to Pacific Northwest conditions.

### REGULATORY:

- Need more supportive regulations that allow growers to use noisemaker devices for bird control at the urban/rural interface.
- Seek international standardization of maximum residue levels (MRLs) for commonly used blueberry pesticides. (Examples can be found in the section titled “Growing Blueberries for the Export Market.”)
- Establish shorter post-harvest intervals (PHIs) for pesticide products such as spinosad and chlorothalonil.
- Expedite the registration of chlorantraniliprole (Altacor) for lepidopteran insects.

**EDUCATION:**

- Educate growers on the importance of bees and pollination, including IPM and bee conservation issues.
- Continue to educate growers on the importance of rotating pesticide chemistries and the principles of resistance management.
- Continue to educate growers on the importance of using proper pesticide rates and timing, of equipment calibration, and of good spray coverage for successful pest management.
- Better coordinate research efforts between the USDA Northwest Center for Small Fruits Research and the blueberry commodity commissions of Oregon, Washington, and British Columbia, Canada.
- Educate legislators and administrators on the importance of restoring full funding for extension and research programs at land-grant universities as well as programs at the USDA Northwest Center for Small Fruits Research facility. Recent budgetary cutbacks and personnel layoffs at the university level threaten the viability of IPM implementation and the dispersal of information between publicly funded agencies and the blueberry industry.

## Process for this Pest Management Strategic Plan

In a proactive effort to continue to identify pest management priorities and lay a foundation for future strategies, blueberry growers, commodity group representatives, pest control advisors, university specialists, and other technical experts from Oregon and Washington formed a work group to revise the original document issued in 2004. Members of the group met for a day in April 2011 in Troutdale, Oregon, where they discussed and revised the management tools, critical needs, general conclusions, activity timetables, and efficacy ratings of various management tools for specific pests in blueberry production. The resulting document has been reviewed by the work group, including those who were not present at the meeting. The final result, this document, is a revised, comprehensive strategic plan that addresses many pest-specific critical needs for the blueberry industry in Oregon and Washington.

The document begins with an overview of blueberry production, and that is followed by discussion of critical production aspects of this crop, including the use of integrated pest management (IPM) in blueberries and specific issues related to growing blueberries for export markets. The remainder of the document includes a listing and description of major pests commonly encountered during the production of blueberries, organized by pest type. (Note that individual pests are presented in alphabetical order and not in order of importance.) Key control measures and their alternatives (current and potential) are discussed, and critical needs are included for each pest where these were indicated by the work group members.

Each pest entry notes the crop stage during which cultural, chemical, and/or biological controls would be utilized and/or when damage from that pest occurs. Readers should note that many of the cultural and biological controls listed in the document are not stand-alone control measures but need to be integrated with other control measures in order to be effective.

Note that trade names for certain pesticide products are used throughout this document as an aid for the reader in identifying these products. The use of trade names in this document does not imply endorsement by the work group or any of the organizations represented.

## Regulatory Background

Blueberry growers and others associated with the industry recognize the importance of developing long-term strategies to meet their pest management needs. These strategies may include identifying critical pesticide uses, retaining critical uses, researching pest management methods with an emphasis on economically viable solutions, and understanding the impacts of pesticide cumulative risk. EPA has completed most of the risk assessments required under the Food Quality Protection Act of 1996 (FQPA) and continues its reregistration process. With the advent of the FQPA and the subsequent risk assessments, several pesticides have been cancelled or now have reduced or more-restrictive label uses.

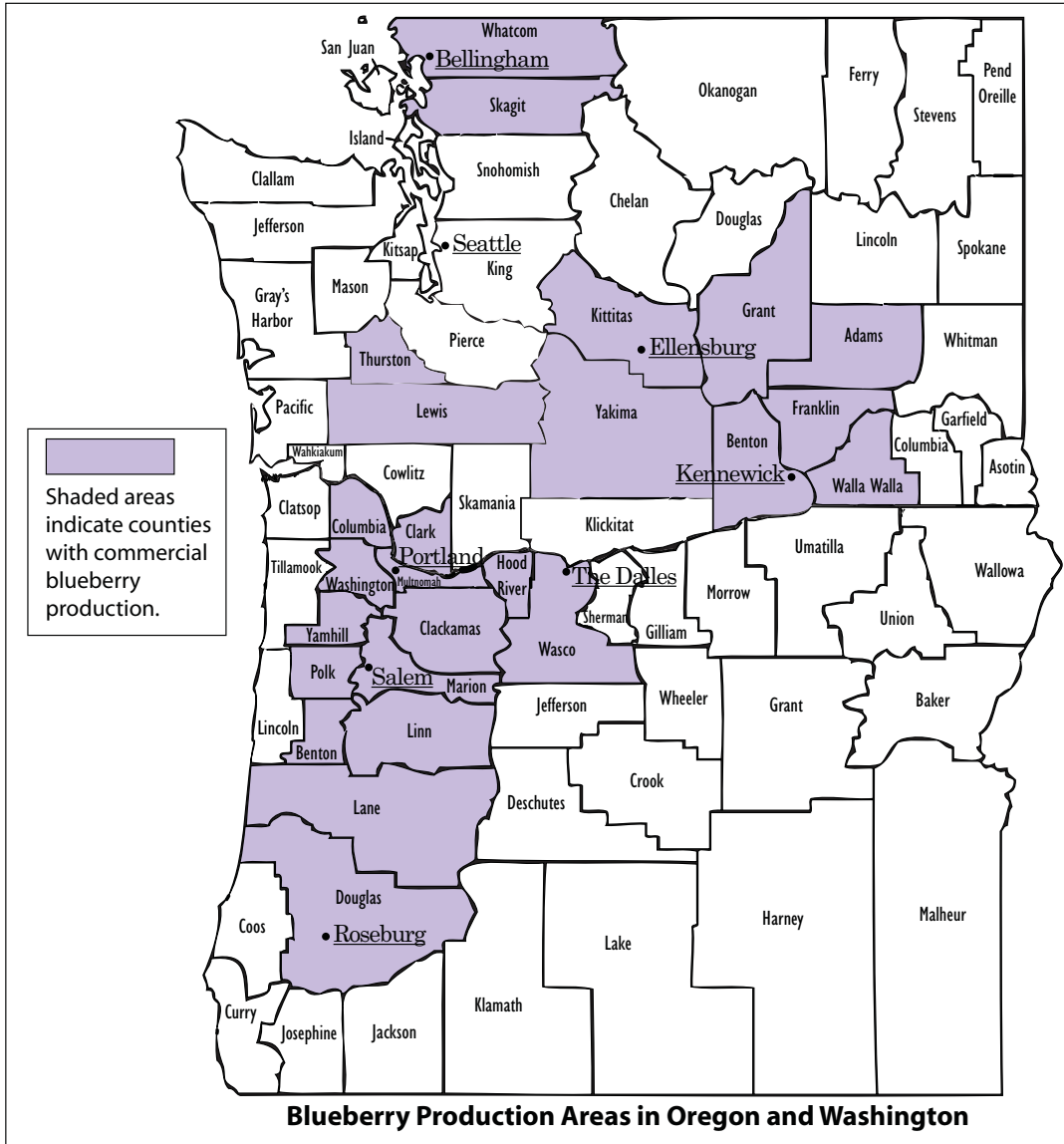
In addition to the risk assessments and reregistration efforts of EPA, the Endangered Species Act (ESA) may also impact the availability or restrict the use of certain pesticides. The ESA requires that any federal agency taking an action that may affect threatened or endangered species, including EPA, must consult with the National Oceanic and Atmospheric Administration (NOAA-Fisheries) or the U.S. Fish and Wildlife Service, as appropriate. Lawsuits have been filed against EPA alleging the Agency failed to complete this consultation process. One lawsuit resulted in the establishment of buffers for applications of certain pesticides around salmon-supporting waters in Washington, Oregon, and California. Salmon and other threatened and endangered species are located throughout the blueberry-growing regions of Oregon and Washington, and there are likely to be further requirements for the protection of these species. The buffer requirements not only affect management of pests within the buffer zone (which, if uncontrolled, can become problematic in the blueberry field), but they can also take many acres of blueberries out of production within a given planting. The total effects of FQPA and ESA are still transpiring.

In addition, in 2011 EPA established new regulations and requirements for the use of soil fumigants. Items such as worker protection, handler training, site-specific fumigant management plans, buffer zones, and restrictions in application methods and rates are a few examples of the changes surrounding the use of soil fumigants. While these new mitigation measures are needed to reduce potential for direct human exposure to toxicants, they will surely impact the establishment, productivity, and possibly the profitability of newly established blueberry plantings.

Clearly, new pest management strategies will be necessary in the blueberry industry. The strategic plan the industry has produced will help them meet their pest management challenges now and in the future.

## Blueberry Production Overview

In 2010, the Pacific Northwest states of Oregon and Washington together produced about 22 percent of the total cultivated blueberry crop in the United States.



Oregon ranks third in U.S. blueberry production. In 2010, approximately 300 Oregon blueberry growers harvested about 50.8 million pounds of berries on 6,100 acres (1,400 nonbearing acres were also reported), with a farm gate value of \$59.4 million. Approximately 50 percent of the Oregon crop was harvested for the fresh market, with the other 50 percent harvested for processing (i.e., frozen, canned, jams, and juice).



While the typical farm size in Oregon is about 10 to 20 acres, there are many smaller farms (from 1 to 5 acres) as well as some that are more than 100 acres. Most of the blueberry production in Oregon occurs in the Willamette Valley, located on the west side of the Cascade Mountains in Benton, Clackamas, Columbia, Marion, Lane, Linn, Multnomah, Polk, Washington, and Yamhill counties. Some production also takes place in counties along the Pacific Coast, in the southwestern part of the state (Douglas County), and in the north-central part of the state along the Columbia River (Hood River and Wasco counties).

Washington ranks fifth nationally in blueberry production. In 2010, Washington growers harvested 42 million pounds of blueberries on 5,200 acres (1,000 nonbearing acres were also reported), with a farm gate value of \$54.6 million. Approximately 30 percent of Washington's crop was harvested for the fresh market, with the remaining 70 percent destined for processing.

Like Oregon, most of the blueberry production in Washington occurs west of the Cascade Mountains, with most of the production in the northwestern counties of Whatcom and Skagit. There is also blueberry production in Lewis, Clark, and Thurston counties in southwestern Washington and some acreage along the Pacific Coast. A new and growing region for blueberry production is east of the Cascade Mountains, mainly in Benton County, but there is also commercial acreage in Adams, Franklin, Grant, Kittitas, Walla Walla, and Yakima counties. These counties now account for about 25 percent of total blueberry acreage in the state of Washington.

Various species of blueberries are grown commercially in the United States. In Oregon and Washington, the most widely planted is the highbush blueberry (*Vaccinium corymbosum* L.); however, there are also a few plantings of rabbiteye blueberries (*Vaccinium ashei*).

Blueberries are perennial, long-lived, deciduous woody shrubs. They are shallow-rooted plants characterized by fibrous roots that lack root hairs. As such, they require an open, porous soil for ease of growth and are favored by conditions that keep the roots moist and cool. For large berry size and healthy plant growth, irrigation is necessary during the growing season. Overhead irrigation is common, but many newly established fields are now using drip irrigation, with a drip line placed on either side of the blueberry plant. Blueberries require acidic soil and do best in soils with a pH between 4.5 and 5.5. The soils and climate of western Oregon and Washington, where winters are mild and summers are moderate, are well suited to blueberry production. In eastern Washington, where the soils tend to be more alkaline and the climate is cold in the winter and very warm in the summer,

the addition of sulfur to acidify the soil to achieve the proper pH is necessary. Eastern Washington growers are faced with additional challenges to produce blueberries profitably.

Cultivars of the highbush blueberry are classified as early-season, mid-season, or late-season, each requiring from 120 to 160 growing degree-days to ripen fruit. The fruiting season in the Pacific Northwest extends from late June to October, and each cultivar ripens over a three- to five-week period. Many different blueberry cultivars are grown in Oregon and Washington. 'Duke' is the most widely planted cultivar. 'Aurora,' 'Bluecrop,' 'Bluegold,' 'Bluejay,' 'Draper,' 'Earliblue,' 'Elliot,' 'Jersey,' 'Liberty,' 'Reka,' and 'Rubel' are other common cultivars.

Well-maintained blueberry plants can remain productive for 50 or more years. Good site selection and proper soil preparation is imperative. Blueberries can be planted in either the fall or the spring, with springtime being more common. If soilborne pests are known to exist at the planting site, the soil may be fumigated prior to planting. Vertebrate pests can also be a problem at some sites. Fencing prior to planting to keep deer out is prudent. Perennial weeds are best controlled before the long-lived blueberries are planted.

Rows are spaced to accommodate farm equipment, usually about 10 to 11 feet apart. In-row plant spacing ranges from 30 to 48 inches. One- or 2-year-old plants are planted by hand into flat or raised beds that have been well disked, often with the addition and incorporation of sawdust or other organic matter to create a well-drained and loose growing medium for the plants. Sawdust mulch, about 2 to 4 inches thick, added to the plant row is commonly applied after planting to help keep the roots cool and moist and to aid in weed suppression. In the past couple of years, the use of a permeable fabric weed mat for weed control, placed under the plants in the plant row of newly established fields, has become quite common. The weed mat is often made of a nylon fabric and laid down prior to, or just after, planting. A good quality weed mat can last in the field for 8 to 10 years. Once the weed mat is no longer effective, sawdust is applied as a mulch in the plant row to suppress weeds. Although the long-term effects of weed mats are yet to be determined, the benefits, especially for organic producers, include no or reduced herbicide usage and/or hand weeding labor.



*Rows of blueberries spaced 10 feet apart,  
with sawdust in plant row and grass sod between rows.*

Depending on the cultivar, plants may be stripped of flowers or fruit for the first year or two that they are in the ground to allow them to grow vegetatively and develop a strong root system. New canes emerge each spring from the base of the plants. These shoots are vigorous and often are the renewal canes for subsequent years' production. Highbush blueberry plants usually require 6 to 8 years to reach full production. Some cultivars can grow up to 10 feet high or more, but they are pruned to maintain a reasonable height for harvest. Pruning during dormancy (winter months) not only controls plant height, but with the selective removal of canes, it helps to maintain plant vigor and productivity.

A field planted with different cultivars enables cross-pollination, which can increase fruit production, resulting in earlier fruiting and larger fruit size. The objective is to achieve as high a fruit set as possible, preferably 100 percent. Bees are required for good pollination and fruit set. Although native bees may provide adequate pollination in small plantings, most commercial growers place honeybee hives in the field at the start of bloom to ensure good pollination and optimum fruit set.

Blueberries produced in Oregon and Washington are destined both for processing (i.e., frozen, canned, jams, juice, purees) and the fresh market. Berries destined for processing are harvested with a mechanical harvester. The machine straddles the plant row, and vibrating bars shake the plant, causing ripe berries to fall onto a conveyor belt. Sorted berries fall into crates and are then taken to the processing plant. This operation requires little labor, consisting of the driver, two workers who sort the berries (discarding under-ripe or damaged fruit) as berries come across the sorting belt, and a worker to stack crates as they are filled. Fresh-market berries are

mostly hand-picked and require large harvest crews. The trend is toward cultivars suitable for the fresh market that can be machine-picked.



*Hand Harvesting*



*Mechanical Harvesting*

Blueberries grow in clusters or bunches, with the fruit within each cluster ripening at different rates over a period of 3 to 5 weeks. As such, the same plant is harvested three or four times during the harvest period. Installation of a two-wire trellis system to help keep mature, heavy, fruit-laden canes from bending and touching the ground is becoming common practice for many growers. In addition to damage by other pests, fruit damage and yield loss due to bird feeding is a major problem at harvest time for most growers.



*Blueberry plants with posts and trellis wires for support to help keep branches that are heavy with fruit at harvest from touching the ground.*

# Crop Stages and Field Activities for Oregon and Washington Blueberry Production

## I. Establishment: Newly Established Plantings (Pre-plant through Planting)

Blueberries are long-lived perennials; therefore, proper site selection and soil preparation is critical for long-term health, vigor, and productivity of the planting. Soil samples are often taken 1 to 3 years prior to planting to determine fertility levels and pH of the soil. The optimum pH range is 4.5 to 5.5. Sulfur can be applied prior to planting if the soil pH needs to be lowered. Phosphorous and other fertilizers can also be incorporated pre-plant. To improve soil tilth (i.e., structure and fertility of the soil), a cover crop may be planted and then disked into the soil prior to planting. Perennial weeds are oftentimes treated with a nonselective, systemic herbicide such as glyphosate prior to tillage. Pre-plant soil fumigation is a common practice in many regions where the soil is known to contain soil-dwelling insects, nematodes, diseases, and weeds. Soil fumigation helps control these pests so the planting is successfully established and can be productive for many years. Deer can feed on young plant material. In areas with known deer problems, the blueberry field is sometimes fenced prior to planting.

Blueberries are planted in either the fall or spring. Row spacing is generally 10 to 11 feet, and plant spacing ranges from 30 to 48 inches. In preparation for planting, tiling (installation of drainage tiles), deep tillage, and/or subsoiling are often performed to break up any existing hardpan that could impede drainage. Sawdust or other organic matter is often incorporated into the soil prior to planting to improve soil tilth, drainage, and root development. The soil is worked to produce a smooth surface. Some growers create raised beds to improve drainage and increase efficiency of mechanical harvesters. One- or 2-year-old plants are planted by hand into flat or raised beds. Two to 4 inches of sawdust mulch are commonly applied to the soil surface in the plant row after planting to help keep the roots cool and moist and to aid in weed suppression. Alternatively, a fabric weed mat is installed in the plant row for weed control. The field is irrigated immediately after planting. Some blueberries struggle to survive after planting, and in the absence of a specific disease or insect, it often appears to be a cultivar response to the specific soil and site environment. Growers want to learn more about this apparent cultivar-environment relationship through research and education.

After planting (and possibly the following year) some cultivars are stripped of flowers or fruit to allow the plants to grow vegetatively and develop a strong root system. During the planting year, and in any other years during which the bushes

are stripped of flowers and fruits, the planting is considered “nonbearing.” During this time period certain pesticides, especially some herbicides, can be used that are not allowed during production (bearing) years. For the most part, except where noted, cultural practices and pesticide applications that occur in an established (bearing) planting will also occur during the nonbearing years.

**Field activities that may occur during ESTABLISHMENT (pre-plant through planting):**

- Sampling soil for nutrients, pH, nematodes, and soil insects
- Scouting for weeds and insects
- Planting a pre-plant cover crop
- Removing cover crop (herbicide or tillage) prior to planting
- Soil fumigation or solarizing the soil
- Broad spectrum weed control during field preparation
- Applying weed mat to the plant row
- Tile installation (for drainage)
- Soil tillage
- Addition of organic matter for incorporation into the soil in the plant row
- Creating raised beds
- Planting young blueberry plants
- Fertilizing (pre- or post-plant)
- Mulching in the plant row with organic matter
- Applying pre-emergence herbicide after planting
- Establishing a permanent cover crop or permanent grass sod between the rows
- Installing irrigation system
- Irrigation

**II. Bud Break through Bloom**

(Depending on cultivar and weather, generally from early-March through late-April.)

In early spring, usually sometime in March, buds on plants that have been dormant will begin to open. Plants in the nonbearing phase will also begin to open buds at this time but are often stripped of flowers to allow the plant to grow vegetatively and develop a strong root system. Exactly when a plant will break dormancy, and thus when it will flower and produce fruit, is weather- and cultivar-dependent.

Flower buds are located at the terminal end of a blueberry cane. Buds lower down on the cane are vegetative, producing leaves and branches. Flower buds develop before the vegetative buds, and a plant can be in full bloom while leaves are still beginning to expand. Flowers open about 2 to 3 weeks after bud break, and full

bloom occurs about 2 weeks after that. Petal drop (when flowers fall off the plant at the end of the bloom period) begins about 5 to 6 weeks after bud break.

**Field activities that may occur during BUD BREAK through BLOOM:**

Cover crop removal (herbicide or tillage)  
 Scouting for insects, diseases, and weeds  
 Fertilization  
 Herbicide application (pre- or post-emergent)  
 Fungicide application  
 Insecticide application  
 Irrigation  
 Stripping blossoms from young plants (nonbearing phase)  
 Bringing in bee hives for pollination  
 Frost control (e.g., sprinkler irrigation)  
 Establishing sod between rows  
 Managing row middles (mowing, herbicide application, disking)  
 Scouting for vertebrate pests (adding fencing if necessary)  
 Establishing trellis system  
 Tissue testing (also done before or after harvest; some growers sample more than once per season)

**III. Post-Bloom through Harvest**

(Generally early-May through late-July. Some cultivars produce fruit until late-September.)

After blossoms have dropped, small green fruits begin to develop. Depending on the cultivar, the period of post-bloom (petal fall) to harvest lasts about 5 to 6 weeks. During this time the berries increase in size and begin to change color from green to pink-blue to blue as the berry matures. Once they are fully blue in color and sugar content is adequate, the berries are harvested.

Harvest season is cultivar-dependent. Some cultivars are ready for harvest at the end of June or in early July, while some aren't ready until the end of August, bearing fruit until the end of September. Blueberry fruits grow in clusters, and although some cultivars have a concentrated ripening period, most cultivars ripen over a period of 3 to 5 weeks. Only the ripe fruit is harvested, which necessitates harvesting the same plant three or four times during the harvest period.

The majority of blueberries grown in Oregon and Washington is machine-harvested and destined for processing. The remainder are harvested by hand and sold fresh. The percentage of the crop that is processed or sold fresh varies from year to year,

depending on price, fruit quality, and the availability of harvest crews. Generally, 50 to 70 percent of the harvested crop is processed. As fruit load becomes heavy prior to harvest, use of farm equipment in the fields is limited in order to avoid damaging fruit or knocking it off the plants. If insecticides or fungicides are applied prior to harvest, they are oftentimes applied by airplane or helicopter.

**Field activities that may occur during POST-BLOOM through HARVEST:**

Scouting for insects, diseases, and weeds  
 Fertilization (foliar feeding and soil applied)  
 Post-emergent herbicide application, including spot-spraying  
 Hand weeding in plant row  
 Fungicide application  
 Insecticide application  
 Irrigation  
 Mowing or cultivating row middles  
 Hand harvesting  
 Machine harvesting  
 Removing bee hives from the field  
 Vertebrate control  
 Tissue testing (also done before or after harvest; some growers sample more than once per season)  
 Fruit thinning (for young plantings)  
 Applying fruit-maturing agents

**IV. Post-Harvest through Dormancy**

(Generally occurs from August through late-February.)

Irrigation continues post-harvest but is discontinued as the days get shorter and cooler and moist weather begins (usually sometime in October). After harvest, the blueberry plant continues to grow until late fall/early winter, when leaves drop and dormancy begins. Dormancy lasts until early the following spring, when the soil and air warm and buds begin to swell and open. A major activity during the latter part of dormancy is pruning, usually done by work crews with hand pruners. Old or diseased branches are removed, and a plant height of about 5 or 6 feet is maintained. Prunings are removed from the field and burned, composted, or shredded with a mower to reduce spread of disease.



**Field activities that may occur during POST-HARVEST through DORMANCY:**

Scouting for insects, diseases, and weeds

Herbicide application (pre- or post-emergence)

Hand weeding in the plant row

Fungicide application (e.g., copper sprays)

Insecticide application

Irrigation until fall rains begin

Mowing or cultivating row middles

Pruning during dormancy

Soil fumigation prior to planting a new field

Taking soil and tissue samples for nutrient testing (tissue testing also done before or after harvest)

Vertebrate control

## Blueberry Pests Listed by Crop Stage

The following outline of the general crop stages involved in Oregon and Washington blueberry production includes each pest in the stage (or stages) during which the pest, if present, is generally controlled.

### I. Establishment (pre-plant through planting)

- a. *Insects*
  - i. Garden symphylan
  - ii. Root weevil
  - iii. Wireworm
- b. *Diseases and Viruses*
  - i. Phytophthora root rot
  - ii. Viruses
- c. *Nematodes*

### II. Bud Break through Bloom

- a. *Insects*
  - i. Aphids
  - ii. Blueberry gall midge
  - iii. Leafroller
  - iv. Winter moth/Bruce spanworm
- b. *Diseases and Viruses*
  - i. Anthracnose ripe rot
  - ii. Bacterial canker/bacterial blight
  - iii. Botrytis blossom blight
  - iv. Botrytis fruit rot
  - v. Fusicoccum/Godronia canker
  - vi. Mummy berry
  - vii. Phomopsis twig blight
  - viii. Phytophthora root rot
  - ix. Viruses

### III. Post-bloom through Harvest

- a. *Insects*
  - i. Aphid
  - ii. Boxelder bug

- iii. Brown marmorated stink bug (a potential pest)
- iv. Leafroller
- v. Scale
- vi. Root weevil
- vii. Spotted wing drosophila (SWD)
- b. *Diseases and Viruses*
  - i. Alternaria fruit rot
  - ii. Anthracnose ripe rot
  - iii. Botrytis fruit rot
  - iv. Fusicoccum/Godronia canker
  - v. Viruses

#### **IV. Post-harvest through Dormancy**

- a. *Insects*
  - i. Aphid
  - ii. Root weevil
  - iii. Scale
  - iv. Winter moth
- b. *Diseases*
  - i. Bacterial canker
  - ii. Fusicoccum/Godronia canker
- c. *Nematodes*

Note: Control for weeds, vertebrate pests, and slugs occurs on and off throughout the year.

## **Integrated Pest Management (IPM) Strategies in Blueberry Production**

Integrated pest management (IPM) is a decision-making approach to pest management that involves knowledge of the crop, the pest, the ecosystem, and the relationships among these components. Practically all blueberry growers in Oregon and Washington use some IPM practices in their operation to control diseases, nematodes, insects, vertebrate pests, and weeds. The ultimate goal of IPM in blueberries is to ensure the production of an abundant, high-quality crop in an environmentally and economically sound manner. The use of IPM practices avoids calendar-based pesticide sprays and instead relies on field scouting, proper pest identification, prevention, cultural and biological practices, and the judicious use of pesticides that are the least toxic to the environment and beneficial organisms.

IPM practices for disease control include use of resistant or tolerant cultivars, scouting to identify a problem in its early stages of development, sanitation, plant spacing, proper pruning, and weed control. For example, opening up the plant canopy with proper pruning and removing weeds at the base of the plants allows for good air circulation and reduces the moisture that most disease organisms need to survive and multiply.

For insect control, scouting, sanitation, judicious use of pest-specific pesticides, and preservation of habitat for beneficial arthropods are widely used IPM practices. Field scouting and accurate pest identification allow for early detection of the insect pest, when control methods are usually more effective. Often, beneficial insects are present and help control the pest population, especially when the pest population is still low. If a pesticide treatment is deemed necessary, growers use the pesticide at the optimum time for control (i.e., the stage that the pest is most vulnerable) and choose a pesticide that is pest-specific rather than broad-spectrum to help protect beneficial arthropods that may be present.

IPM practices used by blueberry growers for good weed control include scouting, cultivation, proper weed identification, and surface mulch or a weed mat. Early detection of weed problems through scouting, and not letting weeds go to seed, help growers manage weeds more efficiently. Surface mulch not only helps keep the blueberry plant roots moist and cool but also helps smother and prevent emergence of weed seedlings.

When applying pesticides, blueberry growers and commercial applicators regularly calibrate application equipment to ensure proper and accurate delivery in order to avoid injury to the applicator, the environment, and the blueberry plants.

## Growing Blueberries for Export Markets

The standardization of international Maximum Residue Levels (MRLs) is a high priority for the Oregon and Washington blueberry 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 blueberries. An MRL may exist in the United States but not in the importing country, which will influence the pest management options a blueberry grower can use in the field.

Over the last few years, an increasing percentage of the Oregon and Washington blueberry crop is being sold into export markets. This development has increased the blueberry 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 blueberry 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, Oregon and Washington blueberry 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, bifenthrin, clopyralid, methoxyfenozide, and spinetoram have been registered and used for the past several years in Oregon and Washington, but they do not have an MRL established in Japan, which is one of the major export markets for Oregon and Washington blueberries. Other examples exist for other products in other export markets.

Clearly, the standardization of international MRLs is a global issue, but it is one that very much impacts the pest management practices of Oregon and Washington blueberry growers and often puts them at a disadvantage in the international marketplace.

# Blueberry Pests and Management Options

## I. Insects

For any given insect pest, although there might appear to be many chemical options for control, the choice of pesticide products is often limited for many different reasons. For example, some insecticide products can be used only once per season (e.g., diazinon); some restrict application timing to a certain time of the season (e.g., esfenvalerate); some are not acceptable in export markets (e.g., bifenthrin in Japan); some claim efficacy, but experience shows otherwise; and yet others are not used due to their negative effects on pollinators, workers, and the environment. All these factors limit and influence the choices a grower has for pest management.

### Aphid

The green peach aphid (*Myzus persicae*) and *Ericaphis scammelli* (no common name) can be found on succulent new growth in early spring. They are light green to dark green in color. Feeding by large numbers of aphids causes leaves to yellow and become stunted and distorted. Growth of young plants is reduced. Chronic infestations can lead to reduced yield and fruit quality. Aphids have also been identified as the vector of blueberry scorch virus, which can cause plant death.

Aphids may be present after vegetative bud break to post-harvest. They are more problematic and require control in areas where viruses are present and the aphid acts as a vector of those diseases, such as British Columbia, Canada and areas in northwestern Washington. Honeydew secreted by the aphid can cause fruit to be contaminated and lower quality. A “clean-up spray” (i.e., a pesticide application made just prior to harvest to disperse or kill any insects and spiders that may contaminate the harvested fruit) for other insects should control any aphid problem as well.

Since aphids can vector serious plant viruses and the honeydew they secrete can reduce fruit quality, satisfactory aphid control is important in blueberry production.

#### *Chemical control:*

- Acetamiprid (Assail): 1-day PHI. Good to excellent for vector control. Bee toxicity.

- Azadirachtin (Neemix, Aza-Direct): 0-day PHI. Not much efficacy information available. Expensive. Approved for organic production.
- Bifenthrin (Brigade): 1-day PHI. Bee toxicity. Controls other insects as well, but sometimes not used due to lack of established international MRLs in some importing countries.
- Diazinon: 7-day PHI. Although effective against aphids, cannot be used when blooms are present because of bee toxicity. Not widely used for aphids due to label changes limiting rate and number of applications.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production. Very effective for some organic growers. Expensive.
- Imidacloprid (Provado 1.6F [foliar], 3-day PHI; Admire Pro [soil], 7-day PHI): Provides good aphid control, widely used. Bee toxicity.
- Malathion: 1-day PHI. Effective but toxic to bees.
- Methomyl (Lannate): 3-day PHI. Not very effective. Toxic to bees and is also a bee repellent.
- Oils: Applied during dormancy or at early bud break to control eggs. Fair to good efficacy. Approved for organic production.
- Pyrethrin (Pyganic): 0-day PHI. Approved for organic production. May cause spotting on fruit. Bee toxicity.
- Soaps (M-Pede): 0-day PHI. Effective when coverage is good (must contact the aphid directly). Approved for organic production.
- Thiamethoxam (Actara [foliar], 3-day PHI; Platinum [soil], 75-day PHI). Widely used for vector control. Bee toxicity.

***Cultural control:***

- None known.

***Biological control:***

- Release of predatory arthropods (such as ladybird beetles) or creating/enhancing habitat for beneficial insects can be helpful but are not common practices. If and when they are practiced, however, they are not stand-alone management options.

**Critical Needs for Aphid Management:**

**Research:**

- Conduct survey and mapping of current location and spread of blueberry scorch virus.
- Conduct an assessment of damage versus economic loss to determine need for treatment.



**Regulatory:**

- Develop standardized international MRLs for effective and commonly used chemistries to control aphids (and other blueberry pests).

**Education:**

- Educate growers on identification and controlling the spread of blueberry scorch virus.
- Educate growers, especially fresh-market growers, on the importance of aphid control to reduce honeydew contamination on the fruit.

**Blueberry Gall Midge** (*Dasineura oxycoccana*)

This is a fairly new potential pest in blueberries. It is present in almost all blueberry fields, but the extent of damage to yield has not yet been established in the Pacific Northwest. The adult blueberry gall midge is a very small fly, about 1 to 3 millimeters long and reddish in color. The female midge lays eggs in developing vegetative buds after bud break. Eggs hatch into larvae, which are white to orange in color, very small, located within the bud, and difficult to see with the naked eye. Within a few days, they begin feeding within the blueberry leaf bud. After a week's time, the bud is damaged and has a dry and blackened appearance, which is often confused with boron deficiency. The damage to developing shoot tips coincides with each new flush of shoot growth. There have been no documented incidences of floral bud damage in the Pacific Northwest. Blueberry gall midge could reduce yields by destroying developing shoot tips, thereby affecting bud set. There may be 3 to 5 generations per year in a blueberry field.

In mature fields, midges are generally not regarded as a serious pest, but they can be a problem in young plantings. The midge can feed on and destroy the dominant growing tip, which can lead to stunted or distorted shoot growth and a short, stunted bush.

Midge larvae may be present and need to be controlled after bud break. Late season treatments to allow the plants to develop a strong branching structure are sometimes needed.

***Chemical control:***

Note: Blueberry gall midge is not listed on any pesticide label, but use is legal.

- Acetamiprid (Assail): 1-day PHI. Bee toxicity.
- Diazinon: 7-day PHI. Bee toxicity.
- Esfenvalerate (Asana XL): 14-day PHI. Bee toxicity.

- Imidacloprid (Provado 1.6F): 3-day PHI. Bee toxicity.
- Malathion: 1-day PHI. Efficacy unknown; research needed. Bee toxicity.
- Methomyl (Lannate): 3-day PHI. Bee toxicity.
- Novaluron (Rimon): 8-day PHI. New registration; little grower experience.
- Phosmet (Imidan): 3-day PHI. Bee toxicity
- Spinetoram (Delegate): 3-day PHI. Bee toxicity.
- Spinosad (Success and Entrust): 3-day PHI. Entrust is approved for organic production. Poor efficacy against this pest. Bee toxicity.

***Cultural control:***

- None known.

***Biological control:***

- None known.

**Critical Needs for Blueberry Gall Midge Management:**

**Research:**

- Conduct an assessment of damage versus economic loss to determine need for treatment.

**Regulatory:**

- None at this time.

**Education:**

- To avoid over-treatment based on obvious symptoms, educate growers that visible damage does not always correlate with economic damage.

**Boxelder Bug** (*Leptocoris trivittatus*)

Boxelder bug is an occasional pest of blueberry. In some years, they are seemingly everywhere, colonizing on many different types of plant material. They lay their eggs in the calyx end of the blueberry fruit, contaminating the fruit at harvest and reducing its value.

***Chemical Control:***

- There are no specific chemical controls for boxelder bug, but if necessary it can be controlled by a broad spectrum “clean-up spray,” such as zeta-cypermethrin, or Oxidate or Pyganic for organic growers.

***Cultural Control:***

- None used.

***Biological Control:***

- None used.

**Critical Needs for Boxelder Bug Management:****Research:**

- None at this time.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**Brown Marmorated Stink Bug (*Halyomorpha halys*)**

The brown marmorated stink bug is not currently a pest in Oregon and Washington blueberries, but it is a potentially serious pest due to its growing presence in these states and its wide host range. This insect is native to eastern Asia and was first discovered in the United States in Pennsylvania in 1996. In Oregon, it was first discovered in 2004 in the Portland metropolitan area, and by 2010 had spread to other regions of the state. Wherever it is established, it is a major pest of horticultural and agronomic crops, with a broad host range including fruits, vegetables, soybeans, and ornamentals.

The adult brown marmorated stink bug is approximately ½-inch long, with a shield-shaped body. It is generally mottled-brown to gray in color, and the margins of the shoulders are smooth without any toothed edges. The antennae, legs, and abdomen have dark and light bands. It also has patches of copper or blue-metallic colored punctures on the head and shoulders. It is a sucking insect that uses its proboscis to pierce the host plant to feed. It secretes saliva then sucks up the plant juices, leaving a necrotic area at the feeding site.

Thus far, this stink bug has shown high adaptability to different climates in the United States and appears to resist commonly used pesticides.

### Critical Needs for Brown Marmorated Stink Bug Management:

#### Research:

- Research biology and management of brown marmorated stink bug.
- Research potential for the management of brown marmorated stink bug within a successful IPM program for blueberries.

#### Regulatory:

- None at this time.

#### Education:

- None at this time.

### Garden Symphylan (*Scutigera immaculata*)

Symphylans are tiny, white, centipede-like insects, 1/8- to 1/4-inch long, that live in the soil and feed on fine roots. They are exceptionally injurious to young plants (i.e., plants lose vigor and in severe cases can die). The symptoms of low vigor and weak growth usually appear sometime between April and June.

Symphylans are generally not a common or widespread problem in blueberry production, except in heavy soils. If necessary, they would usually be controlled prior to planting when the soil is fumigated for other soilborne pests. Dazomet can be used in an established planting as a “spot treatment” when an affected plant is removed and a new nonbearing plant is planted in its place.

#### **Chemical control:**

(Note: pre-plant soil fumigation has not been shown to be very effective.)

- 1,3-dichloropropene (Telone II): Often combined with chloropicrin (e.g., Telone C-17 or C-35).

#### **Cultural control:**

- Pre-plant sampling in heavy soil is important to diagnose symphylan presence.
- Tillage helps but is not a stand-alone method.
- Growers avoid rotating to crops such as corn that are known hosts for symphylans.

#### **Biological control:**

- Biostimulants are available, but efficacy is unknown.

### Critical Needs for Garden Symphylan Management:

#### Research:

- Develop better scouting tools for symphylan.
- Identify and evaluate efficacious controls for established plantings (as opposed to solely pre-plant control).

#### Regulatory:

- None at this time.

#### Education:

- Educate growers on how to scout for symphylans once better scouting tools are developed.

#### Leafroller

Obliquebanded leafroller (*Choristoneura rosaceana*)

Orange tortrix leafroller (*Argyrotaenia franciscana*)

Others

The orange tortrix leafroller and the obliquebanded leafroller are the most common leafrollers found in blueberry fields. However, leafrollers are only a minor problem in Oregon. They are more common in Washington, especially the obliquebanded leafroller.

The adult orange tortrix moth is orangish-tan, about ½- to ¾-inch long, and bell-shaped when at rest. Larvae are tan when small, changing to pale green with tan heads as they mature. The orange tortrix has two to three generations per year.

The adult obliquebanded leafroller moth is about ¾-inch long, bell-shaped when at rest, and has diagonal bands across its forewings. The larvae are tan when small, changing to leaf-green with black heads as they mature. There are two generations a year.

The larvae of both species feed on developing buds and leaves and can subsequently reduce yields. Later generations feed directly on berries and can be a harvest contaminant. Leafroller larvae overwinter on canes in the field, and although it is not common, if the winter is warm they can remain active and will feed on cane buds.

Leafroller larvae may be present and need to be controlled after bud break through harvest.

***Chemical control:***

- Acetamiprid (Assail): 1-day PHI. New registration. Sometimes used. Bee toxicity.
- Azadirachtin (Neemix, Aza-Direct): 0-day PHI. Expensive and ineffective; not widely used. Approved for organic production.
- *Bacillus thuringiensis* (Bt): This product is the preferred one for leafroller control and is most effective when larvae are young and small. Bt has the advantages of a 0-day PHI, and since it is safe to bees, it can be used when blooms are present. Bt is commonly used if leafrollers are present during bloom by both organic and conventional growers. Approved for organic production.
- Bifenthrin (Brigade): 1-day PHI. Bee toxicity. Could be effective on this pest, but growers consider it a better tool for later use to control other insects such as spotted wing drosophila or root weevil adults.
- Carbaryl (Sevin): 7-day PHI. Fairly effective; used early in the spring when weather is still cool. Bee toxicity.
- Diazinon: 7-day PHI. Very effective, but because only one use per year is allowed, most growers reserve diazinon for later use to control other insect pests. Bee toxicity.
- Esfenvalerate (Asana XL): 14-day PHI. Very good control, especially in cold weather. Widely used by blueberry growers due to good efficacy in a wide range of environmental conditions and due to its being inexpensive. Bee toxicity.
- Fenpropathrin (Danitol): 3-day PHI. Bee toxicity.
- Indoxacarb (Avaunt): 7-day PHI. Bee toxicity.
- Malathion: 1-day PHI. Fair to good efficacy. Bee toxicity.
- Methomyl (Lannate): 3-day PHI. Excellent efficacy but toxic to bees; cannot be used when blooms are present.
- Methoxyfenozide (Intrepid): 7-day PHI.
- Novaluron (Rimon): 8-day PHI. New registration; no grower experience. May be toxic to some beneficials.
- Oils: Oils applied during dormancy for other insects may help reduce overwintering leafroller populations.
- Phosmet (Imidan): 3-day PHI. Fair to good efficacy but toxic to bees and cannot be used when blooms are present.
- Pyriproxifen (Esteem): 7-day PHI. Avoid direct application or spray drift to beehives.
- Spinetoram (Delegate): 3-day PHI. Bee toxicity.

- Spinosad (Success, Entrust): 3-day PHI. Good efficacy. Entrust is approved for organic production. Bee toxicity.
- Zeta-cypermethrin (Mustang): 1-day PHI. Excellent efficacy but toxic to bees and cannot be used when blooms are present.

***Cultural control:***

- Pheromone traps are used to monitor male moth flight for each species, which helps determine if and when an insecticide application would be most effective.

***Biological control:***

- Naturally occurring predators and parasitoids exist, but they alone do not keep leafroller populations under control, nor do they prevent contamination of harvested fruit.

**Critical Needs for Leafroller Management:**

**Research:**

- None at this time.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**Root Weevil**

Black vine weevil (*Otiorhynchus sulcatus*)

Obscure root weevil (*Sciopithes obscurus*)

Rough strawberry root weevil (*O. rugosostriatus*)

Strawberry root weevil (*O. ovatus*)

Root weevil larvae overwinter 2 to 8 inches deep in the soil and can be found in fields prior to planting. They are ¼- to ½-inch long, are white with tan heads, and have no legs. They feed on roots during fall, winter, and early spring and can quickly reduce plant vigor or cause plant death in young plantings.

Adult root weevils are snout-nosed beetles, and depending on species, are about ½- to ¾-inch long and black to brown in color. They are nocturnal and feed on leaves. The adults emerge from the soil and appear in fields, generally after bloom in June,

July, and August. They feed for about 4 weeks and then begin laying eggs on the soil surface near the crown of the plant. These eggs hatch into young larvae that move down into the soil and feed along the roots. If undetected and left uncontrolled, populations can build that will be problematic the following year. Adult root weevils may still be present and lay eggs after harvest, especially if the blueberries are an early-season cultivar. Although it is not a common problem for blueberry growers, adults can cause serious economic losses as a contaminant in harvested fruit if they are present.

Root weevil adults may be present and need to be controlled post-bloom through harvest. Larvae are generally treated post-harvest in the fall.

***Chemical control:***

Larval stage:

- Imidacloprid (Admire Pro): 7-day PHI. Not widely used; efficacy is marginal.
- Thiamethoxam (Platinum): Although root weevils don't appear on the label, a soil application of Platinum has been shown to provide larval control when applied in the early fall when larvae are young and small. Commonly used. Spring applications work well also, with attention paid to the 75-day PHI. Bee toxicity.

Adults:

- Azadirachtin (Neemix, Aza-Direct): 0-day PHI. Not effective; expensive. Approved for organic production.
- Bifenthrin (Brigade): 1-day PHI. Bee toxicity.
- Cryolite Bait: 3-day PHI. Product is registered, but availability from the manufacturer is uncertain. 24(c) registration.
- Esfenvalerate (Asana XL): 14-day PHI. Fair to good control. Bee toxicity.
- Malathion: 1-day PHI. Efficacy is unknown. Bee toxicity.
- Phosmet (Imidan). 3-day PHI. Bee toxicity.
- Thiamethoxam (Actara): 3-day PHI. Good control. Bee toxicity.
- Zeta-cypermethrin (Mustang): 1-day PHI. Good control. Bee toxicity.

***Cultural control:***

- Tillage helps reduce weevil populations by crushing the soft-bodied larvae, but is not a stand-alone method.
- Scouting for adults to determine population levels and best time for treatment applications.
- Adult weevils don't fly, so adjacent area management often aids in reducing in-field populations.



**Biological control:**

- Entomopathogenic nematodes are available but expensive. They can be applied to soil for control of larvae. Such treatment is usually done after harvest. Efficacy depends on soil temperature and moisture but has been erratic or poor. It is difficult to obtain consistent results.

**Critical Needs for Root Weevil Management:****Research:**

- Evaluate the efficacy of *Metarhizium* (a fungal organism) for controlling root weevil.
- Develop an aggregate pheromone for improved root weevil monitoring.
- Develop improved root weevil scouting methodologies.

**Regulatory:**

- Expedite the registration of chlorantraniliprole (Altacor) for leafroller insects.

**Education:**

- Educate growers on proper scouting methods for root weevils.
- In an effort to avoid over-treatment (particularly with leaf notching damage, which does not always require treatment), educate growers that visible damage symptoms do not always correlate with economic loss.

**Scale**

Lecanium scale (*Lecanium* spp.)

Azalea bark scale (*Eriococcus azaleae*)

Lecanium scales appear as small, yellowish-brown, helmet-shaped “bumps” on blueberry stems and branches during winter dormancy. The “bump” is actually a shell-like covering that protects the scale eggs, which will hatch into “crawlers” the following spring and summer.

Azalea bark scales can also be found during dormancy and appear as small, white, felt-like patches on stems and branches. The felt-like patch is a covering that protects the red-colored eggs within. In spring and summer the eggs hatch into reddish “crawlers.”

Immature scale insects (“crawlers”) of both scale species leave their protective covering on the blueberry stems prior to harvest and crawl to leaves where they begin to feed. Feeding can stunt and distort shoot growth, cause witch’s broom, and

reduce fruit yield. Unsightly honeydew and sooty mold (a black fungus that grows in the honeydew excreted by the scale crawlers as they feed) reduce the quality of the harvested fruit and can result in further economic loss.

The immature scale insects are spread by wind, birds, harvest machinery, and human activity. The “crawlers” may be present and need to be controlled any time after bud break and up to harvest. Adults are treated during dormancy.

***Chemical control:***

Crawler Stage:

- Bifenthrin (Brigade): 1-day PHI. Bee toxicity.
- Pyriproxyfen (Esteem): 7-day PHI. Bee toxicity. Effective and often used.
- Soaps (M-Pede): 0-day PHI. Efficacy unknown. Approved for organic production.

Eggs (dormancy):

- Azadirachtin (Neemix, Aza-Direct): 0-day PHI. Not effective; expensive. Approved for organic production.
- Oils: Oil suffocates the scale insects. Effective and often used.
- Pyriproxyfen (Esteem): 7-day PHI. Can be used alone or tank-mixed with oil.

***Cultural control:***

- Good pruning practices (pruning canes older than 4 years) can prevent scale infestation.
- Burn winter prunings.

***Biological control:***

- None known.

**Critical Needs for Scale Management:**

**Research:**

- Conduct an assessment of damage versus economic loss to determine need for treatment.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**Spotted Wing Drosophila (SWD)** (*Drosophila suzukii*)

The spotted wing drosophila (SWD) is a new and exotic pest that attacks a wide variety of fruits. Adult SWD flies resemble common vinegar flies, but unlike common vinegar flies, SWD flies prefer ripe to overripe fruit still hanging on the plant. In the 2 years that the pest has been present in Oregon and Washington agricultural crops, the most damage from the fly appears to be on late-maturing fruit. In blueberries, this would be cultivars that ripen in August and September.

Adult flies are 2 to 3 millimeters in length and have red eyes and a yellowish-brown amber-colored body. Males have a black spot (sometimes dark, sometimes faded) near the leading top edge of each wing. (Females do not have wing spots.) The females have a prominent, saw-like ovipositor on the posterior end that is used to insert eggs into fruit. Several dark continuous bands are visible around the female's abdomen.

A female SWD lays one to three eggs in each fruit, and a single female can lay several hundred eggs in her lifetime (which is an average of 3 to 4 weeks). The small white larvae feed inside the fruit for about 5 to 7 days until they are ready to pupate. The brownish-yellow pupa is a non-feeding stage, lasting 4 to 5 days. Pupae often remain inside fruit, with their respiratory horns sticking out of the fruit for breathing purposes until the adult fly emerges. The adult fly will then mate and begin a new generation. It has been estimated that three to nine generations might occur in Oregon and Washington, depending on environmental conditions. Adult flies are monitored with apple cider vinegar traps placed in the field. Freshly harvested fruit can be checked for larval and pupal infestation with a salt extraction method or a fruit dunk flotation method using sugar water. Some growers and fruit processor quality assurance labs report the salt extraction method to be more effective than the sugar water flotation method.

Egg laying by the female damages and scars the fruit skin. Fruit also softens, collapsing and/or bruising at the damage site.

***Chemical Control:***

The products listed below target the adult stage of SWD. Treatment is recommended when flies are present and fruit begins to color. Treatment may continue until the end of harvest. Post-harvest treatments (after the final harvest of the season) are not recommended.

Synthetic pyrethroids:

- Bifenthrin (Brigade and other brands). 1-day PHI. Bee toxicity.
- Esfenvalerate (Asana XL): 14-day PHI. Esfenvalerate can act like a bee repellent; do not apply within 7 days of pollination.
- Fenpropathrin (Danitol): 3-day PHI. Bee toxicity.
- Zeta-cypermethrin (Mustang Max). 1-day PHI. Widely used because of its long residual effect (approximately 14 days), short PHI, and acceptance in the Japanese market. Bee toxicity.

Organophosphates:

- Diazinon (various formulations): 7-day PHI. Bee toxicity.
- Malathion (several brands). 1-day PHI. Widely used because of its long residual effect (approximately 10 days) and short PHI. Bee toxicity.
- Phosmet (Imidan). 3-day PHI. Bee toxicity.

Spinosyns:

- Spinetoram (Delegate). 3-day PHI. Bee toxicity.
- Spinosad (Success or Entrust): 3-day PHI. Entrust is approved for organic production and widely used by organic growers. Success is often used in rotation with a synthetic pyrethroid and an organophosphate to reduce likelihood of resistance. Bee toxicity.

Others:

- Azadirachtin (Neemix, Aza-Direct): Although approved for organic production, not widely used due to poor efficacy and expense. 0-day PHI.
- Carbaryl (Sevin and other brands): 7-day PHI. Bee toxicity.
- Horticultural oil (various formulations): Provides some control of SWD but has no residual activity; hence, it is not widely used. May cause spotting on fruit. Many brands of oil are approved for organic production.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Some organic growers report good efficacy. Approved for organic production.
- Imidacloprid (Provado 1.6F): 3-day PHI. Bee toxicity. Slow-acting.
- Methomyl (Lannate). 3-day PHI. Bee toxicity.
- Pyrethrin (various formulations): 0-day PHI. Good control but has no residual activity. Pyganic brand is approved for organic production. In organic systems, Pyganic is often used in rotation with Entrust (spinosad) to reduce likelihood of resistance to spinosad, which is the main organic tool used for SWD. Bee toxicity.
- Thiamethoxam (Actara): 3-day PHI. Slow-acting. Bee toxicity.

***Cultural Control***

- Harvest in a timely manner: Pick fruit at regular intervals to prevent egg-laying opportunities. Avoid overripe fruit on plants.
- Clean up infested fruit: To avoid SWD's populations from building, remove and dispose of leftover, fallen, and infested fruit.
- Reduce amount of alternate hosts from surrounding areas: Potential perimeter and wild land hosts for SWD may include snowberry, dogwood, Himalayan blackberry, wild rose, flowering cherry, crab apple, salmonberry, thimbleberry, wild cherry, and other plant species.

***Biological control***

- Anecdotal observations suggest that predaceous bugs (e.g., minute pirate bugs, big-eyed bugs), parasitic wasps, and lacewing larvae may be important biological control agents. Pesticides are used judiciously to protect natural enemies.

**Critical Needs for Spotted Wing *Drosophila* Management:****Research:**

- Develop a new formulation for GF-120 (an organic-approved bait formulation of spinosad) that is attractive to SWD.
- Identify and evaluate other attract-and kill technology to control SWD.
- Evaluate feeding enhancements to be used with attract-and-kill technologies so that "softer" chemistries can be used.
- Identify over-wintering sites for SWD.
- Research the benefits of perimeter sprays (i.e., perimeter of field) on contributing to control of SWD.
- Improve sprayer technology to ensure good coverage.
- Improve trellising for better access to fields for spray application coverage.
- Evaluate the efficacy of chemigation and fogging/misting.
- Integrate SWD management into an IPM program.
- Research efficacy of sanitation practices in controlling SWD.
- Identify additional organic options for SWD control.
- Identify options for treating fruit left on the ground after harvest.
- Improve monitoring techniques (e.g., traps, timing).
- Develop economic threshold (i.e., population levels that necessitate control measures).

**Regulatory:**

- Seek resolution to MRL issues (i.e., standardization of international MRLs), due to the need for close treatment-to-harvest timing to control SWD.

**Education:**

- Educate growers on importance of improved sanitation practices.

**Winter Moth/Bruce Spanworm** (*Operophtera brumata*, *O. bruceata*)

Adults are mottled brown moths about 1 inch long that emerge from the soil in the early fall from pupal cases. Female moths are wingless. Adults are active during the winter months, when females deposit eggs in the cracks and crevices of the blueberry canes.

Larvae hatch in early spring and feed on newly opening flower and leaf buds. Feeding damage to fruit buds by larvae can significantly reduce yields. Larvae can balloon into fields from neighboring trees and shrubs.

Control strategies are targeted at the young larvae at bud swell and bud break, but the eggs can also be controlled during the dormant period.

***Chemical control:*****Larvae:**

Note: When treating earlier in the season, bees are not yet present and active; therefore, bee toxicity is not as much of a consideration.

- Acetamiprid (Assail): 1-day PHI. Good to excellent control. Bee toxicity.
- *Bacillus thuringiensis* (Bt): Poor to fair efficacy; lower rates mixed into each bloom spray increases efficacy. 0-day PHI.
- Bifenthrin (Brigade): 1-day PHI. Bee toxicity.
- Diazinon: 7-day PHI. Efficacious and often used for winter moth and Bruce spanworm control. Some areas of northwestern Washington report that the current labeled rate (0.5 lb a.i./A) is not effective and thus not widely used. Bee toxicity.
- Esfenvalerate (Asana XL): 14-day PHI. Good to excellent control. Bee toxicity.
- Fenpropathrin (Danitol): 3-day PHI. Bee toxicity.
- Indoxacarb (Avaunt): 7-day PHI. Bee toxicity.
- Methomyl (Lannate): 3-day PHI. Very effective and widely used. Bee toxicity.
- Methoxyfenozide (Intrepid): 7-day PHI. Slow acting.
- Novaluron (Rimon): 8-day PHI. New registration; little grower experience.
- Phosmet (Imidan): 3-day PHI. Bee toxicity.
- Spinetoram (Delegate): 3-day PHI. Bee toxicity.

- Spinosad (Success, Entrust): 3-day PHI. Entrust is approved for organic production. Bee toxicity.
- Zeta-cypermethrin (Mustang): 1-day PHI. Good control. Bee toxicity.

Eggs:

- Dormant oil: Oil applied during dormancy suffocates the eggs and reduces the number of eggs that will hatch into larvae.

***Cultural control:***

- Growers trim trees around field borders, as trees are also a preferred habitat of the winter moth and spanworm.
- Growers monitor for egg hatch and larval feeding in March or just prior to bud break by inspecting buds for silk, frass, and feeding damage.

***Biological control:***

- Naturally occurring predators and parasitoids exist but alone do not keep populations under control.
- Pheromones are commercially available for monitoring adult male flight, but due to the difficulty of synthesizing the winter moth/spanworm pheromones, purchasing from a reliable source can be difficult. Also, pest pressure may not be high enough to justify deploying traps due to the expense.

**Critical Needs for Winter Moth/Bruce Spanworm Management:**

**Research:**

- Conduct an assessment of damage versus economic loss to determine need for treatment.
- Determine the importance of alternate hosts and the impact of habitat modification to reduce infestations.

**Regulatory:**

- Expedite the registration of chlorantraniliprole (Altacor) for leafroller insects.

**Education:**

- None at this time.

**Wireworms (*Limoniusspp.*)**

These worms can be found in the soil prior to planting blueberries. Chemical controls for these insect pests are the same as those for the garden symphytan (see entry for garden symphytan, above).

**Critical Needs for Wireworm Management:**

**Research:**

- None at this time.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.



## II. Diseases

Negative effects on plant growth and productivity due to soil pH or irrigation management are sometimes confused with and attributed to disease organisms. Educating growers to differentiate between symptoms due to pH or irrigation and those due to diseases is a general educational need that has been identified in this pest management strategic plan. Also, it is important for readers to note that biologically based pesticide products, such as Serenade (*Bacillus subtilis*) and *Streptomyces lydicus* (Actinovate AG), are listed under chemical controls and not in the biological control section.

In addition to the diseases listed below, minor diseases that are either sporadic or are not widespread may also occur in Oregon and Washington blueberry fields. Those minor diseases include: armillaria root rot (*Armillaria mellea*), crown gall (*Rhizobium radiobacter*), stem canker (*Botryosphaeria corticis*), and witches' broom rust (*Pucciniastrum goeppertianum*).

### **Alternaria Fruit Rot** (*Alternaria tenuissima*)

This fungal organism infects blueberry plants beginning at the end of bloom and continuing throughout the fruit development stage up until harvest. Infections remain latent until the fruit ripens. Infected fruits exhibit a shriveling or caving-in of the side of the berry and can become watery in storage. Skins are weak and break open easily. Dark green fungal spores may appear on the fruit. This disease is problematic in most blueberry-growing regions on the west side of the Cascade Mountains in Oregon and Washington and is especially serious in northwestern Washington.

#### ***Chemical control:***

- Azoxystrobin (Abound): 0-day PHI. Good efficacy; commonly used.
- *Bacillus subtilis* (Serenade): 0-day PHI. Little grower experience; efficacy unknown. Approved for organic production.
- Boscalid + pyraclostrobin (Pristine): 0-day PHI. Good efficacy.
- Captan: Good efficacy. 0-day PHI.
- Cyprodinil + fludioxonil (Switch): 0-day PHI.
- Fenbuconazole (Indar): 30-day PHI.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production. No residual effects. Unknown efficacy in the Pacific Northwest.
- Pyraclostrobin (Cabrio): 0-day PHI. Good efficacy; commonly used.

- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Approved for organic production. Unknown efficacy.
- Ziram (Ziram Granuflo): Label restriction does not allow use after 3 weeks from full bloom.

***Cultural control:***

- Avoid wounding or bruising fruit during harvest.
- Harvest promptly to avoid overripe fruit.
- Do not pick or handle fruit when it is wet.
- Cool berries rapidly after harvest.
- Avoid overhead irrigation if possible.
- Clean plant debris frequently from picking buckets, packing lines, and inspection belts.

***Biological control:***

- None known.

**Critical Needs for Alternaria Fruit Rot Management:**

**Research:**

- Evaluate efficacy of products currently registered to control alternaria fruit rot.
- Develop better disease risk modeling to more accurately determine proper treatment timing.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**(Anthracnose) Ripe Rot** (*Colletotrichum gloeosporoides* and *C. acutatum*)

This fungal disease appears on fruit before harvest and as a post-harvest rot, but control tactics are implemented during the bloom period and during the fruit development stage. (Infection remains latent until the fruit is nearly mature.) It can also cause shoot tips to become blighted and flowers to turn brown or black. Under warm and rainy conditions, orange-colored spore masses may appear on the fruit. This disease is problematic in most blueberry-growing regions on the west side of

the Cascade Mountains in Oregon and Washington and is especially serious in northwestern Washington.

***Chemical control:***

- Azoxystrobin (Abound): 0-day PHI. Effective; commonly used.
- *Bacillus subtilis* (Serenade): 0-day PHI. Little grower experience, but there may be some potential for control. Approved for organic production. The active ingredient is a protein from *Bacillus subtilis* strain QST 713.
- Boscalid + pyraclostrobin (Pristine): 0-day PHI. Good to excellent control, but not used when anthracnose is the main target. If targeting anthracnose, pyraclostrobin (Cabrio) is used instead.
- Captan: 0-day PHI. Effective but not widely used, as some markets prefer no captan use and other registered products are just as effective.
- Captan + fenhexamid (Captevate): 0-day PHI.
- Chlorothalonil (Bravo, Echo): Not used. Long PHI (42 days) limits its use to early bloom only. Not effective during prebloom or bloom. Performance in the Pacific Northwest is variable and mostly ineffective.
- Cyprodinil+ fludioxonil (Switch): 0-day PHI. Effective; commonly used.
- Fluazinam (Omega): 30-day PHI. New registration with little grower experience.
- Fosetyl-al (Aliette): 0-day PHI. Not widely used. Not effective in the Pacific Northwest during prebloom or bloom.
- Pyraclostrobin (Cabrio): 0-day PHI. Good efficacy; commonly used.
- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Approved for organic production; efficacy is unknown.
- Ziram: Effective but last application allowed is 3 weeks after full bloom, which minimizes its usefulness.

***Cultural control:***

- Avoid overhead irrigation or apply such that plants are not wet for extended periods of time.
- Lower the temperature of harvested fruit to 32°F as soon as possible after picking.
- Prune bushes for adequate airflow and to reduce drying time after bushes become wet.

***Biological control:***

- None known.

### Critical Needs for Anthracnose Ripe Rot Management:

#### Research:

- Develop better organic methods for controlling anthracnose and other blueberry diseases.
- Develop better disease risk modeling to more accurately determine proper treatment timing.

#### Regulatory:

- None at this time.

#### Education:

- Educate growers about resistance management programs for ripe rot.

### **Bacterial Canker/Bacterial Blight** (*Pseudomonas syringae* pv. *syringae*)

This disease is caused by a bacterium that multiplies on the stem surface but enters the plant through wounds and natural openings. Wood that is 1 year old or older is affected. Symptoms seem to be more severe after a hard freeze during the winter. Cankers can kill buds, and if a canker girdles the stem, the stem portion above the canker dies. Leaves turn orange (or black) and wilt after buds have leafed out.

#### *Chemical control:*

- *Bacillus subtilis* (Serenade): 0-day PHI. Little grower experience, but there may be some potential for control. Efficacy in the Pacific Northwest is unknown. Approved for organic production.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production.
- Fixed coppers (various formulations): Some strains of the bacterium may be resistant to coppers. No PHI is indicated on labels. Some copper products are approved for organic production.

#### *Cultural control:*

- Scouting and monitoring for the disease helps identify early infection.
- Prune out diseased wood as soon as it is noticed.
- Avoid over-fertilization and late-season fertilization.

#### *Biological control:*

- None known.

**Critical Needs for Bacterial Canker/Blight Management:****Research:**

- Identify and evaluate alternative control methods for controlling bacterial canker.
- Evaluate, in a side-by-side study, the efficacy of copper product formulations.
- Research proper treatment timing.

**Regulatory:**

- None at this time.

**Education:**

- Educate growers on proper treatment timing based on research.

**Botrytis Blossom Blight and Fruit Rot** (*Botrytis cinerea*)

This fungus overwinters and survives on dead twigs from prunings and dead organic matter. In spring, spores are released and spread by wind or splashing water. Infected blossoms take on a water-soaked appearance and die. Pale brown lesions may form on young leaves. Infected succulent twigs turn brown or black, later bleaching to tan or grey. Blossoms as well as fruit and fruit clusters at harvest are sometimes covered with a dense mass of grey powdery spores.

In the case of fruit rot caused by *Botrytis*, the infection occurs during bloom and remains latent until the fruit is ripe, and control tactics are implemented during the bloom and fruit development periods.

***Chemical control:***

Note: Application of chemical controls begins at 5 percent bloom, and if weather is conducive to disease development it can continue up until harvest.

- *Bacillus subtilis* (Serenade): 0-day PHI. Little grower experience, but there may be some potential for control. Approved for organic production
- Boscalid + pyraclostrobin (Pristine): 0-day PHI. Very effective; commonly used.
- Captan: 0-day PHI. Effective; commonly used early in the bloom period.
- Captan + fenhexamid (Captevate): 0-day PHI.
- Cyprodinil + fludioxonil (Switch): 0-day PHI. Very effective; commonly used.
- Fenhexamid (Elevate): 0-day PHI. Very effective; commonly used.
- Fluazinam (Omega): 30-day PHI.

- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production.
- Iprodione: 0-day PHI. Excellent control if there is no resistance.
- *Reynoutria sachalinensis* (Regalia): 0-day PHI. Efficacy unknown. Little grower experience. Approved for organic production.
- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Efficacy unknown. Little grower experience. Approved for organic production.
- Ziram: Not widely used. Efficacy has been poor to moderate. Label restriction does not allow use after 3 weeks from full bloom.

**Cultural control:**

- Space plants for good air circulation and quick drying.
- Prune during dormancy to open the canopy for good air circulation.
- Practice good weed control to reduce moisture in the planting.
- Use of drip irrigation instead of overhead sprinklers, if possible. If overhead sprinklers are used, irrigate when water has time to evaporate quickly.
- Adjust timing and/or frequency of overhead irrigation to keep aboveground portions of the plant dry.
- Harvest fruit at appropriate stage of maturity and move to cold storage as soon as possible.
- Avoid late-season fertilization.

**Biological control:**

- None known.

**Critical Needs for Botrytis Blossom Blight and Fruit Rot Management:**

**Research:**

- Develop better disease risk modeling to more accurately determine proper timing of treatment application.
- Identify and develop efficacious organic-compliant pesticides and strategies.
- Evaluate efficacy of currently registered organic-approved products, such as *Bacillus subtilis* (Serenade), *Streptomyces lydicus* (Actinovate AG), *Reynoutria sachalinensis* (Regalia), and others. Also, determine longevity of such products in the field.
- Develop a spray program for organic-approved products.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**Fusicoccum Canker/Godronia Canker**

(*Godronia cassandrae* [asexual: *Fusicoccum putrefaciens*])

This is a serious disease of blueberry, especially in young plants. The fungus overwinters in cankers on infected bushes. Only new wood can be infected. New infections appear as small reddish-brown areas around buds and wounds. As cankers enlarge, their centers turn gray and their margins remain reddish to dark brown. Cankers become larger each year. The stem wilts and dies when the canker girdles the stem. Spores are dispersed by splashing water, rain, and overhead irrigation. Infection can occur any time between late spring and early fall.

This disease has not been a major problem in Oregon and Washington, but it has become a major issue in British Columbia, Canada on certain cultivars, impacting more than 10 percent of fields.

***Chemical control:***

- No fungicides are currently registered for this disease, but Captan appears to have some activity against the fungus.

***Cultural control:***

- Purchase healthy planting material and/or do not use plants with injured branches.
- Plant resistant cultivars. (Field observations have found 'Rubel' and 'Rancocas' resistant, while 'Berkeley,' 'Bluecrop,' 'Earliblue,' 'Jersey,' and 'Pemberton' are highly susceptible.)
- Use drip irrigation instead of overhead sprinklers, if possible.
- Pruning out and destroying (burning) cankered branches can remove infected wood but is not a stand-alone solution. Growers with infected prunings can obtain a permit from local fire districts to burn prunings. (Pruning not only removes infected wood on which spores are produced, but it also opens up the plant canopy to speed drying of the stems and leaves during the growing season.)

***Biological control:***

- None known.

**Critical Needs for *Fusicoccum*/*Godronia* Canker Management:****Research:**

- Gather existing information about efficacy trials that may have been conducted.

- Develop better diagnostic tools for fusisporium/godronia canker.
- Conduct a mapping assessment to determine current geographical regions of infection.
- Research proper treatment timing for fusisporium/godronia canker.

**Regulatory:**

- None at this time.

**Education:**

- None at this time.

**Mummy Berry** (*Monilinia vaccinii-corymbosi*)

This fungus overwinters in fruit mummies on the ground. In early spring as buds are opening, spores are released from apothecia (spore cups) on the mummies, infecting the newly emerging leaves and flowers. Leaf and shoot growth expanding from newly opened buds is blackened and eventually wilts and dies. The ascospores from the fruiting cups infect the new leaves and flowers (primary infection). This infection, in turn, releases conidia spores, which infect flower clusters (secondary infection), which causes blighted flowers covered with brownish gray spores. Mummy berry is one of the more serious diseases to affect blueberries and can cause nearly 100 percent yield loss if infection is widespread. If left uncontrolled, it can affect the following year's crop. Mummy berry can be a particularly difficult problem to manage for organic growers.

***Chemical control:***

Note: Some pre-emergent herbicides (e.g., simazine) are known to destroy the apothecia (spore cups).

- Azoxystrobin (Abound): 0-day PHI. Efficacy unknown; more research needed.
- Azoxystrobin + propiconazole (Quilt Xcel): 30-day PHI.
- *Bacillus subtilis* (Serenade): 0-day PHI. Poor control. Approved for organic production.
- Boscalid + pyraclostrobin (Pristine): Widely used; 0-day PHI.
- Captan: 0-day PHI. Efficacy is poor to fair.
- Captan + fenhexamid (Captivate): 0-day PHI. Efficacy is poor to fair.
- Chlorothalonil (Bravo, Echo): 42-day PHI. Provides suppression only. Fruit russeting will occur.
- Cyprodinil + fludioxonil (Switch): 0-day PHI. Efficacy is poor.



- Fenbuconazole (Indar): 30-day PHI. Excellent efficacy; widely used.
- Lime sulfur: Applied to soil to destroy apothecia (spore cups) as they are developing. Approved for organic production. Efficacy is fair.
- Propiconazole (Orbit, Tilt, and other formulations): 30-day PHI.
- Pyraclostrobin (Cabrio): 0-day PHI. Provides suppression only.
- *Reynoutria sachalinensis* (Regalia): 0-day PHI. Efficacy unknown; little grower experience. Approved for organic production.
- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Efficacy unknown; little grower experience. Approved for organic production.
- Ziram: Little used for this disease; efficacy is poor. Label restriction does not allow use after 3 weeks from full bloom.

**Cultural control:**

- Destroy developing apothecia (spore cups) by disrupting the soil under the plants and in alleyways by raking, mulching, or cultivating.
- Some growers apply a powdered formulation of urea fertilizer, which helps to burn the apothecia, while other growers, especially organic growers, flame the ground underneath the blueberry plants for the same purpose.
- Sanitation measures include destruction of cull piles near fields, controlling weeds to reduce moisture near the ground, and letting birds feed on the mummified fruit after harvest.

**Biological control:**

- None known.

**Critical Needs for Mummy Berry Management:**

**Research:**

- Identify and evaluate alternative organic-approved options for mummy berry control.
- Evaluate efficacy of mulching products for burying apothecia.
- Develop new and more efficacious controls for mummy berry.
- Develop better disease risk modeling to more accurately determine proper timing of treatment application.

**Regulatory:**

- None at this time.

**Education:**

- Educate growers about resistance management programs for mummy berry.

**Phomopsis Twig Blight** (*Phomopsis vaccinii*)

This fungus overwinters on infected plant debris. Infection occurs through flower buds and wounds from bud break to bloom, causing twig, flower, or shoot dieback. Twig blight is not very common in Oregon and Washington but has been found in certain areas, including the Skagit Valley in northwestern Washington. Growers usually don't treat for this disease.

***Chemical control:***

- Azoxystrobin (Abound): 0-day PHI.
- Azoxystrobin + propiconazole (Quilt Xcel): 30-day PHI.
- Boscalid + pyraclostrobin (Pristine): 0-day PHI.
- Captan: 0-day PHI.
- Cyprodinil + fludioxonil (Switch): 0-day PHI. Efficacy is poor.
- Fenbuconazole (Indar): 30-day PHI.
- Fluazinam (Omega): 30-day PHI.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production.
- Pyraclostrobin (Cabrio): 0-day PHI.
- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Approved for organic production. Efficacy unknown.
- Ziram: Label restriction does not allow use after 3 weeks from full bloom.

***Cultural control:***

- Purchase healthy planting material and/or do not use plants with injured branches.
- Prune out, remove, and destroy infected and dead branches.
- Avoid wounding or injuring plants, especially when pruning.
- Encourage plants to harden off in winter to avoid frost damage.
- Avoid late fertilization.

***Biological control:***

- None known.

**Critical Needs for Phomopsis Twig Blight Management:****Research:**

- Develop better diagnostic tools for field identification of phomopsis twig blight.

**Regulatory:**

- None at this time.

**Education:**

- Educate growers on proper disease diagnosis.

**Phytophthora Root Rot** (*Phytophthora* spp.)

This fungal disease is commonly found in areas where the soils are heavy or where drainage is poor. The fungus resides in the soil and can be transported via water or soil. Once established in the soil, it remains indefinitely. Infection can move from the roots to the crown and stems. The rot is firm, not soft. Infected roots transport water and nutrients poorly, causing small, reddened leaves and overall plant stunting. Smaller roots, then larger ones, die as the disease progresses. Young plants with small root systems may die within a year of infection. Mature plants show a decline in vigor over several years and may eventually die. Yields are poor on infected plants.

***Chemical control:*****Soil applied:**

- Mefenoxam (Ridomil Gold): 0-day PHI. Commonly used but resistance has been documented.

**Foliar applications:**

- Fosetyl-al (Aliette): 0-day PHI. Effective.
- Hydrogen Dioxide (Oxidate): 0-day PHI. Approved for organic production.
- Phosphorous acid (various formulations): Effective. No PHI given on labels.
- *Streptomyces lydicus* (Actinovate AG): 0-day PHI. Approved for organic production. Efficacy unknown.

***Cultural control:***

- Pre-plant options: Avoid planting in poorly drained fields or improve drainage by installing drainage tiles, planting on raised beds, incorporating gypsum, and/or amending soil with organic matter (which also improves soil tilth).
- Avoid overwatering.
- Plant only healthy, disease-free stock.
- Some growers have discovered that soil solarization (covering the soil surface with plastic for several weeks during warm temperatures) prior to planting can delay onset of the disease for 2 years.

- Subsoiling during dormancy improves drainage and can help reduce the effects of *Phytophthora* (which affects plants during the active growing season).
- Avoid planting susceptible cultivars. (The highbush cultivar 'Toro' and the rabbiteye cultivar 'Powderblue' are very susceptible.)

**Biological control:**

- Biostimulants are available and used on a limited basis, but efficacy is unknown.

**Critical Needs for Phytophthora Root Rot Management:**

**Research:**

- Develop efficacy data for biostimulant and biofumigant products for controlling *Phytophthora*.
- Evaluate efficacy of composted hardwood bark versus sawdust as a mulch to help suppress disease.
- Evaluate extent to which *Phytophthora* is spread through irrigation water.
- Determine efficacy of currently available foliar phosphorous acid products.

**Regulatory:**

- Disallow use of mefenoxam in blueberry nurseries so that growers do not purchase plants with delayed symptom development.

**Education:**

- None at this time.

### III. Viruses

Blueberry scorch virus (BIScV)  
 Blueberry shock virus (BIShV)  
 Tomato ringspot virus (ToRSV)  
 Blueberry fruit drop disease

In plants infected with blueberry scorch virus (BIScV) the flower clusters blight just as the petals are opening. Young shoots may blight also, turning grayish black. Blighted tissues may remain on the twig, but this is not a reliable symptom. Once infected with BIScV, plants do not recover. Yields decline over time, and blight symptoms appear year after year. BIScV is vectored by aphids. There are multiple strains of BIScV. As far as is known at this time, all strains infect all cultivars of blueberry that have been tested. Some strains cause symptoms in most cultivars, with the exception of 'Jersey,' while others do not cause symptoms in many cultivars or may cause a slight leaf yellowing but no necrosis of the blooms. Keeping vectors such as aphids under control helps reduce the likelihood of scorch virus infection.

In plants infected with blueberry shock virus (BIShV) flowers and young leaves suddenly die when plants are in early to full bloom (shock reaction). The entire bush may be blighted, but more commonly only a portion of the branches will show symptoms. Blighted tissues drop off the plant. As the season progresses, a second flush of leaves is produced. By mid-summer, affected plants look normal except that they produce little fruit. Plants may exhibit shock symptoms for 1 to 3 years and may be symptom-free thereafter, producing a normal fruit yield. Even though symptom-free, the plant still has the virus and serves as a source of inoculum for pollen transmission to other plants. In 2010, which had a very cool and wet spring, several cultivars that had recovered from shock symptoms expressed a leaf reddening (including 'Berkeley,' 'Bluetta,' 'Bluegold,' 'Liberty,' and several others).

Prior to planting a new field it is important to include a survey of the plant-parasitic nematode *Xiphinema americanum* in the site evaluation to determine population levels, as these nematodes transmit a number of viruses (including tomato ringspot virus [ToRSV], tobacco ringspot virus [TRSV], and peach rosette mosaic virus [PRMV]) that infect blueberry. PRMV has not been detected in the Pacific Northwest, and TRSV has not been detected in the past 20 years in Pacific Northwest blueberries. These viruses can reduce plant growth and fruit yield. If sampling indicates that *X. americanum* is present in the soil, or if there is a history of either of these viruses in the previous crop that was grown in the field, the site should be treated with a pre-plant soil fumigant to control these nematodes prior to

planting. Virus symptoms on the plants (e.g., low vigor, small leaves) show up in late March through June in the early stages of flower and leaf development. Leaf samples from suspected plants can be tested to determine if these viruses are present in the plant. It should be noted that these viruses are unevenly distributed in the bush, and it is necessary to test multiple leaves per bush when testing.

Tomato ringspot virus (ToRSV) can be difficult to detect due to uneven distribution in the plant. Plants infected with ToRSV or tobacco ringspot virus (TRSV) exhibit poor vigor and shoot dieback. Circular chlorotic lesions may appear on the leaves. Stems may have necrotic spots. Fruit quality and yield are severely reduced. Plant death may occur, especially in young plantings. As noted above, ToRSV is vectored by the dagger nematode (*X. americanum*). Soil tests will indicate if nematodes are present. Controlling nematode populations helps reduce likelihood of tomato ringspot virus. Weeds are a secondary host for nematodes. Good weed control can also help reduce nematode populations. The cultivar 'Bluecrop' appears to be resistant to ToRSV.

Blueberry shoestring virus (BSSV) is aphid-transmitted and primarily occurs in Michigan. The virus causes strapped (i.e., elongated, narrow) leaves but usually only on one or a few canes per plant. The blossoms tend to have reddish stripes on the petal tube (i.e., candy-striping). This virus either does not occur in the Pacific Northwest or is currently very limited. In addition, the aphid vector has not been reported in this region. In Michigan this virus causes severe economic loss; therefore, growers should be wary about getting plants from uncertified sources.

During the past few years, a fruit drop symptom has been observed in several blueberry fields in Oregon, Washington, and British Columbia, Canada. The plants flower normally, though the young leaves and flowers have a transient red coloration that is absent in healthy plants. The fruit develops to 3 to 5 millimeters in diameter and then aborts, so that affected plants bear virtually no mature fruit. The incidence within fields increases year to year, suggesting that a pathogen is involved. The virus isolated from symptomatic bushes is widespread wherever blueberries are grown and is not believed to be associated with fruit drop disease. This virus, now called blueberry latent virus, has been detected in northern highbush, southern highbush, and rabbiteye blueberries and is considered a cryptic virus. Further work on identification of the causal agent is being done.

#### **Potential Virus Threats Not Yet Present in the Pacific Northwest:**

There are a number of well-documented virus diseases of blueberry that are not known to occur or are very limited in the Pacific Northwest. These include: tobacco ringspot virus (one report in the 1980s; not detected since then), peach rosette

mosaic virus (never reported in the Pacific Northwest), blueberry shoestring virus (reported in a field in the 1980s; field was taken out, and virus not observed since then in the Pacific Northwest), blueberry leaf mottle virus (never reported in the Pacific Northwest), and blueberry red ringspot virus (only observed in 'Bluetta,' all known fields with this virus in the Pacific Northwest have been removed). During the past few years, several new diseases of blueberry have been reported in other parts of North America. Blueberry necrotic ring blotch virus in the southeastern United States can lead to complete defoliation of bushes and has been reported in southern highbush and rabbiteye blueberries. There is a virus consistently associated with this disease. (Fifty of 50 symptomatic plants were infected with the virus, and it was not detected in symptomless plants.) It should be noted that symptoms develop in late summer, and it would be very difficult or impossible to identify infected plants based on symptoms early in the growing season. There is a good test available for blueberry necrotic ring blotch virus (the virus that has been associated with this disease). A second disease that appears to be caused by a virus is blueberry bronze leaf curl, reported in Michigan. At this time, it is suspected of being a virus, but a causal virus has not been identified. Work in this area is under way.

It is important that any plant material being introduced into the Pacific Northwest from other areas be tested for the above viruses to minimize the risk of introducing these viruses into the region. There is an effort organized by USDA's Animal and Plant Health Inspection Service (APHIS) and the National Clean Plant Network to develop a national blueberry certification program. This process will likely take several years to develop and implement. Once it is established, it is hoped that all of the above viruses will be covered in certification programs. However, until then it would be advisable for blueberry plants from other parts of the country and the world to be tested prior to being planted in fields in the Pacific Northwest.

**Note: Viruses are controlled through vector management, described below.**

***Chemical control:***

- There are no chemicals to control viruses, but for vector management see sections in this document for nematode or aphid control.

***Cultural control:***

- Virus-free planting material is essential for good establishment and productivity throughout the life of the planting. Plant or re-plant with virus-tested, disease-tolerant cultivars such as 'Bluecrop' (which is resistant to tomato ringspot virus).
- After treating for aphids, remove plants that show symptoms of blueberry scorch virus (BIScV) and/or that test positive for the virus.

***Biological control:***

- None known.

**Critical Needs for Virus Management:**

**Research:**

- Develop diagnostic tools for identifying current and emerging viruses.
- Identify management practices to mitigate negative effects when shock occurs in a blueberry planting.

**Regulatory:**

- Develop a national certification program for viruses.

**Education:**

- Educate growers on importance of not bringing in untested planting material from other regions and/or nursery and garden retail centers (to prevent spread of viruses from other regions).



## IV. Weeds

### Weeds during ESTABLISHMENT

In a long-lived plant like blueberries, control of weeds, especially perennial weeds, is critical prior to planting. In fields that will be planted to blueberries, perennial weeds (such as clover, Canada thistle, dandelion, quackgrass, and field bindweed) are often treated with a systemic herbicide such as glyphosate in the fall or spring prior to tillage and planting. Control of annual weeds (such as pigweed, groundsel, and mustards) prior to planting is accomplished by tilling the field several times, allowing annual weeds to germinate between tillage operations. A newly planted field is often treated with a pre-emergence herbicide after planting. Sawdust mulch or fabric weed cloth applied to the plant row are weed control options for organic growers. Several herbicides are registered for use in nonbearing blueberries. These provide additional options for weed control in newly planted fields if a crop won't be harvested for more than 365 days after application.

Management of row middles varies widely in Oregon and Washington blueberry fields. Middles are sometimes planted to a permanent sod and mowed periodically. Other growers choose to keep row middles vegetation-free, and they accomplish this by cultivating periodically throughout the growing season or disking and then treating with a pre-emergence herbicide.

#### *Chemical control:*

- 2,4-D (Saber): Post-emergence and non-selective for broadleaf weeds. Available through a 24(c) in both Oregon and Washington. 30-day PHI.
- Acetic acid, 20% (vinegar, 200 grain): New registration; approved for organic production. Non-selective for broadleaf and grass weeds. 0-day PHI.
- Bentazon (Basagran): Nonbearing only. Post-emergence and non-selective for broadleaf weeds and nutsedge. 365-day PHI.
- Clethodim (Select): Post-emergence for grasses. Good control of annual bluegrass and other non-fescue grasses. 14-day PHI.
- Fluazifop (Fusilade): Nonbearing only. Post-emergence for grasses; might be used to control quackgrass. 365-day PHI.
- Glufosinate (Rely): Post-emergence and non-selective for broadleaf and grass weeds. Excellent control, widely used. 14-day PHI.
- Glyphosate (Roundup, others): Post-emergence and non-selective; widely used during site preparation. Need to wait at least 10 days after application before disking. 14-day PHI.

- Isoxaben (Gallery): Nonbearing only. Pre-emergence for broadleaf weeds. 365-day PHI.
- Paraquat (Gramoxone): Non-selective, contact, post-emergence. Avoid new shoots. Widely used.
- Sethoxydim (Poast): Post-emergence grass herbicide. 30-day PHI.
- Some pre-plant soil fumigants that are used for nematode, insect, and disease control will also control weeds that develop from seed.

***Cultural control:***

- Cultivation prior to planting can help reduce amount of annual weeds. Cultivation of row middles controls annual weeds but must be done regularly.
- Drip irrigation. (Provides water to the blueberry plants only and reduces weed growth in non-irrigated areas.)
- Use of a permeable nylon weed mat installed at planting or in mature plantings.
- Mulching.

***Biological control:***

- None known.

**Weeds during BUD BREAK through BLOOM**

Numerous annual and perennial weeds appear during the bud break-through-bloom crop stage and must be prevented from getting established. Weeds like groundsel, chickweed, pigweed, and grasses may be present at bud break. As the soil warms up, hard-to-control perennial weeds like Canada thistle and quackgrass begin to appear.

Growers rely on a combination of chemical and cultural practices to manage weeds. Weeds within the plant row are usually managed with either pre- or post-emergence herbicide applications. To create a vegetation-free zone in the plant row prior to the application of a pre-emergence herbicide in early spring (at bud break), actively growing weeds are removed by hand hoeing or are treated with a contact herbicide such as paraquat (Gramoxone) or glufosinate (Rely). Weeds that appear after a pre-emergent herbicide is applied in the early spring are often treated with a post-emergent herbicide like glufosinate (Rely), paraquat (Gramoxone), and glyphosate (Roundup), or clopyralid (Stinger) for spot spraying. If grasses are problematic, a postemergence grass herbicide, such as clethodim (Select) or sethoxydim (Poast)

might be used. If a field is young and in a nonbearing stage (i.e., a crop won't be harvested for at least 365 days), additional herbicides are available for use.

Weeds between the rows are managed primarily by frequent, shallow cultivation during the growing season. If a permanent grass strip is established between the plant rows, which is more common, broadleaf weeds within the grass strip can be controlled with an application of 2,4-D (Saber). Grass strips or other types of vegetation between the plant rows require periodic mowing. Growers practicing integrated weed management take note of shifts in predominant weed species, which indicate development of resistance and the need to select alternative weed management strategies or materials.

***Chemical control:***

- 2,4-D (Saber): Post-emergence and non-selective for broadleaf weeds. Available through a 24(c) in both Oregon and Washington. 30-day PHI.
- Acetic acid, 20% (vinegar, 200 grain): New registration; approved for organic production. 0-day PHI.
- Bentazon (Basagran): Nonbearing only. Post-emergence and non-selective for broadleaf weeds and nutsedge. 365-day PHI.
- Carfentrazone-ethyl (Aim): Post-emergence for broadleaf weeds. 0-day PHI.
- Clethodim (Select): Post-emergence for grasses. Good control of annual bluegrass and other non-fescue grasses. 14-day PHI.
- Clopyralid (Stinger): Post-emergence and non-selective for broadleaf weeds; especially good on Canada thistle, dandelion, and clover. Available through a 24(c) in both Oregon and Washington. 30-day PHI.
- Diuron (Karmex): Pre-emergence for broadleaf and grass weeds. Cannot use on plants within 1 year of planting. Spring or fall use.
- Fluazifop (Fusilade): Nonbearing only. Post-emergence for grasses. 365-day PHI.
- Flumioxazin (Chateau): Pre-emergence for broadleaf weeds and some grasses. Avoid new shoots. 7-day PHI.
- Glufosinate (Rely): Post-emergence and non-selective for broadleaf and grass weeds. Excellent control for broadleaf weeds and widely used. 14-day PHI.
- Glyphosate (Roundup, others): Post-emergence and non-selective; used for spot spraying. 14-day PHI.
- Halosulfuron (Sanda): Pre- and post-emergence for broadleaf weeds, post-emergence for nutsedge. New registration; little grower experience at this time. Timing is critical for good efficacy; consult label. 14-day PHI.
- Hexazinone (Velpar): Post-emergence for broadleaf and grass weeds. May be used on plants that have been in the ground for at least 3 years. Growers

- report good to excellent control, but caution is advised as hexazinone has long soil residual. 90-day PHI.
- Isoxaben (Gallery): Nonbearing only. Pre-emergence for broadleaf weeds. 365-day PHI.
  - Mesotrione (Callisto): Pre- and post-emergence for broadleaf weeds and some grasses. Use is allowed prior to bloom.
  - Napropamide (Devrinol): Pre-emergence for broadleaves and grasses. Spring or fall use.
  - Norflurazon (Solicam): Pre-emergence for broadleaf and grass weeds. 60-day PHI.
  - Oryzalin (Surflan): Pre-emergence for broadleaf and grass weeds. Spring or fall use.
  - Paraquat (Gramoxone): Non-selective, contact, post-emergence. Avoid new blueberry shoots.
  - Pronamide (Kerb): Pre-emergence for broadleaf and grass weeds. Fall or winter use.
  - S-metolachlor (Dual Magnum): Pre-emergence for broadleaf weeds and nutsedge. New registration; little grower experience at this time. Available through a 24(c) in both Oregon and Washington. 28-day PHI.
  - Sethoxydim (Poast): Post-emergence grass herbicide. 30-day PHI.
  - Simazine (Princep): Pre-emergence for broadleaf and grass weeds. Spring or fall use. There are some concerns regarding toxicity to aquatic organisms.
  - Terbacil (Sinbar): Pre-emergence for broadleaf and grass weeds. Spring or fall use.

***Cultural control:***

- Hand hoeing in the plant row is effective but expensive.
- Flaming is practiced with some efficacy against small annual broadleaf weeds.
- Use of a permeable nylon weed mat installed at planting or on mature plants is a common trend.
- Mulching in the plant row can help suppress weeds.
- Establishment of a living mulch (e.g., grass) between blueberry rows can also help control weeds.

***Biological control:***

- Naturally occurring Cinnabar moth larvae feed on groundsel and tansy ragwort, but neither conservation nor augmentative biocontrol has been developed for commercial use.

**Weeds during POST-BLOOM through HARVEST**

Weed management in bearing fields is limited during this time period. Weeds between the plant rows are mowed or the ground is cultivated. Permanent grass sod between the blueberry rows is mowed as needed. Broadleaf weeds in the grass strip can be controlled with an application of 2,4-D (Saber) if it is at least 30 days prior to harvest. Grass weeds that have emerged within the blueberry plant row can be treated with a post-emergence grass herbicide, such as clethodim (Select) or sethoxydim (Poast), or glyphosate (Roundup) or glufosinate (Rely). Grass and broadleaf weeds in the plant row can also be removed by hand hoeing.

***Chemical control:***

- Acetic acid, 20% (vinegar, 200 grain): New registration; approved for organic production. 0-day PHI.
- Bentazon (Basagran): Nonbearing only. Post-emergence and non-selective for broadleaf weeds and nutsedge. 365-day PHI.
- Carfentrazone-ethyl (Aim): Post-emergence for broadleaf weeds. 0-day PHI.
- Clethodim (Select): Post-emergence for grasses. Good control of annual bluegrass. 14-day PHI.
- Clopyralid (Stinger): Post-emergence and non-selective for broadleaf weeds; especially good on Canada thistle, dandelion, and clover. Available through a 24(c) in both Oregon and Washington. 30-day PHI.
- Fluazifop (Fusilade): Nonbearing only. Post-emergence for grasses. 365-day PHI.
- Glufosinate (Rely): Post-emergence and non-selective for broadleaf and grass weeds. 14-day PHI.
- Glyphosate (Roundup, others): Systemic, non-selective, and post-emergence. Directed spray application, avoid contact with the blueberry plant. 14-day PHI.
- Halosulfuron (Sandea): Pre- and post-emergence for broadleaf weeds, post-emergence for nutsedge. New registration; little grower experience at this time. 14-day PHI.
- Paraquat (Gramoxone): Post-emergence. Avoid contact with blueberry plant. Avoid new shoots.
- Sethoxydim (Poast): Post-emergence grass herbicide. 30-day PHI.

***Cultural control:***

- Hand hoeing in the plant row is effective but expensive.

***Biological control:***

- None known.

**Weeds during POST-HARVEST through DORMANCY**

Most fields are treated with a pre-emergence herbicide in the fall after final harvest is completed to maintain a weed-free area in the plant row during dormancy. Prior to application of a pre-emergence herbicide the soil surface should be free of actively growing weeds. Emerged weeds are removed either by hand hoeing or with the use of a post-emergence herbicide. Row middles continue to be mowed after harvest as needed, or cultivated. Broadleaf weeds in the grass sod between the blueberry rows can be controlled with the application of 2,4-D (Saber). Post-harvest weed management activities generally occur in the fall (usually in October, prior to the onset of the fall/winter rainy season) and are discontinued once the plants go into dormancy. Weed management activities commence the following spring at the end of dormancy or the beginning of bud break. If a field is young and in a “nonbearing” stage (i.e., a crop won’t be harvested for at least 365 days), additional herbicides are available for use at this time.

***Chemical control:***

- 2,4-D (Saber): Post-emergence and non-selective for broadleaves. Available through a 24(c) in both Oregon and Washington.
- Acetic acid, 20% (vinegar, 200 grain): New registration; approved for organic production.
- Bentazon (Basagran): Nonbearing only. Post-emergence and non-selective for broadleaf weeds and nutsedge.
- Carfentrazone-ethyl (Aim): Post-emergence for broadleaf weeds.
- Clethodim (Select): Post-emergence for grasses. Good control of annual bluegrass and other non-fescue grasses.
- Clopyralid (Stinger): Post-emergence and non-selective for broadleaf weeds; especially good on Canada thistle, dandelion, and clover. Available through a 24(c) in both Oregon and Washington.
- Dichlobenil (Casoron): Pre-emergence for broadleaf and grass weeds. Good control, especially on perennial weeds, and commonly used. Not recommended on new plantings; must wait 1 year before use.
- Diuron (Karmex): Pre-emergence for broadleaf and grass weeds. Cannot use on plants within 1 year of planting.
- Fluazifop (Fusilade): Nonbearing only. Post-emergence for grasses.
- Flumioxazin (Chateau): Pre-emergence for broadleaf weeds and some grasses.
- Glufosinate (Rely): Post-emergence and non-selective for broadleaf and grass weeds.
- Glyphosate (Roundup, others): Post-emergence and non-selective; often used for spot spraying.

- Halosulfuron (Sandea): Pre- and post-emergence for broadleaf weeds, post-emergence for nutsedge. New registration; little grower experience at this time.
- Hexazinone (Velpar): Post-emergence for broadleaf and grass weeds. May be used on plants that have been in the ground for at least 3 years. Caution is advised, as hexazinone has long soil residual.
- Isoxaben (Gallery): Nonbearing only. Pre-emergence for broadleaf weeds.
- Mesotrione (Callisto): Pre- and post-emergence for broadleaf weeds and some grasses.
- Napropamide (Devrinol): Pre-emergence for broadleaf and grass weeds.
- Norflurazon (Solicam): Pre-emergence for broadleaf and grass weeds.
- Oryzalin (Surflan): Pre-emergence for broadleaf and grass weeds.
- Paraquat (Gramoxone): Non-selective, contact, post-emergence.
- Pronamide (Kerb): Pre-emergence for broadleaf and grass weeds.
- S-metolachlor (Dual Magnum): Pre-emergence for broadleaf weeds and nutsedge. New registration; little grower experience at this time. Available through a 24(c) in both Oregon and Washington.
- Sethoxydim (Poast): Post-emergence grass herbicide.
- Simazine (Princep): Pre-emergence for broadleaf and grass weeds. There are concerns regarding toxicity to aquatic organisms.
- Terbacil (Sinbar): Pre-emergence for broadleaf and grass weeds.

***Cultural control:***

- Growers employ a variety of cultural practices during this crop stage, including hand hoeing and mulching within the plant row, and flaming.
- Use of a permeable nylon weed mat installed at planting or on mature plants is a common trend.
- Use of sawdust at the base of the plant (in conjunction with addition of the weed mat) to smother weeds at the junction between the weed mat and the plant.

***Biological control:***

- None known.

**Critical Needs for Weed Management:**

**Research:**

- Identify and evaluate organic methods for weed control.
- Identify and evaluate management options for hard-to-control weeds such as horsetail, nutsedge, smartweed, bindweed, morningglory, etc.

**Regulatory:**

- None at this time.

**Education:**

- Educate growers on impacts of weed mat use, such as impacts on other pests (e.g., voles), irrigation needs, and other potential problems.
- Educate growers on how to avoid damage to plants and economic loss by misuse of herbicides.
- Educate growers about geographic restrictions of flumioxazin (Chateau).



## V. Nematodes

Plant-parasitic nematodes are commonly encountered in blueberry plantings, with nematodes being detected in 73 percent of surveyed blueberry plantings. The two most commonly encountered plant-parasitic nematodes in Oregon and Washington are stubby-root nematode (*Paratrichodorus renifer*) and root-lesion nematode (*Pratylenchus* spp.). The dagger nematode (*Xiphinema americanum*) is also commonly found in blueberry plantings but appears to be geographically limited to southwestern Washington and western Oregon. Other plant-parasitic nematodes found in blueberry plantings in Oregon and Washington include: ring nematode (*Mesocriconema* spp.), spiral nematode (*Helicotylenchus* spp.), and pin nematode (*Paratylenchus* spp.).

The stubby-root nematode is a migratory ectoparasite found only in the soil. (It does not enter the blueberry root.) This nematode has been shown to reduce the root growth of blueberry cuttings in propagation beds and to reduce canopy size and yield in microplot experiments. Several blueberry cultivars, including 'Duke,' 'Misty,' 'Bluecrop,' 'Brunswick,' and 'O'Neal' were good hosts for stubby-root nematode. The rabbiteye blueberry cultivar 'Powderblue' was a poor host for stubby-root nematode.

Root-lesion nematodes are migratory endoparasites, migrating between the soil and roots. When this nematode enters the roots it causes direct damage to root tissue. Although root-lesion nematodes are commonly encountered in blueberry fields, in greenhouse studies blueberry plants were not hosts for *Pratylenchus penetrans*. Another root-lesion nematodes species, *P. crenatus*, is also found in blueberry plantings; however, the host status of blueberry for this nematode is currently unknown.

The dagger nematode, a migratory ectoparasite, feeds along the root surface but causes little or no direct damage. However, it is capable of transmitting tomato ringspot virus, which can negatively affect blueberry growth and productivity, severely reducing fruit quality and yield. Circular chlorotic lesions may appear on the leaves, and stems may have necrotic spots. Plant death may occur, especially in young plantings. Ring, spiral, and pin nematodes are also migratory ectoparasites, but they have not been associated with blueberry plants of low vigor.

### ***Chemical control:***

Pre-plant soil fumigants can be used, preferably in the fall, for control of all the above-mentioned nematodes. Growing a shallow-rooted grass crop for 1 to 2 years

will bring nematodes to upper soil levels where fumigation can more easily control them.

In 2009, all of the soil fumigants except 1,3-dichloropropene underwent reregistration by the USEPA. Future use will require fumigant management plans as well as buffer zones around treated areas. Consult the label prior to application.

- 1,3-dichloropropene (Telone II): Very good control. Often combined with chloropicrin (Telone C-17 or C-35).
- Dazomet (Basamid): Expensive. Effective only if nematodes are within the tillage zone. Efficacy of dazomet is temperature-dependent, with best results occurring prior to cool winter rains.
- Dimethyl disulfide (Paladin): Unknown efficacy in the Pacific Northwest.
- Sodium methyldithiocarbamate (Metam Sodium, Metam Potassium) and methyl isothiocyanate: Adequate dispersal in soil is required for good results.

***Cultural control:***

- Crop rotation: Plant blueberries in soil that has been fallow for at least 2 years.
- Organic matter: Maintaining high levels of organic matter (sawdust or other mulch) in the soil will help suppress plant-parasitic nematode population densities.
- Site selection: Plant in soil that has been tested and found free of dagger nematodes.
- Cover crops: Grow grass or *Brassica* (e.g., rapeseed, mustard) crops for 1 year. These crops are not hosts for tomato ringspot virus and are poor hosts for the dagger nematode. To be successful, these crops need to be maintained free of broadleaf weeds that are hosts for the virus. Cover crops such as marigolds, forage pearl millet (Canadian Forage Pearl Millet Hybrid 101), or Saia oats can help reduce populations of the root-lesion nematode.

***Biological control:***

- Biologically-based nematicides and biostimulants are available, but their efficacy against nematodes in blueberry production systems is unknown. Registered products include: azadirachtin (i.e., Molt-X, Azasol, Agroneem), quillaja saponins (Nema-Q), and harpin protein (Employ).

### **Critical Needs for Nematode Management:**

#### **Research:**

- Identify and develop nematode control options for bearing blueberries.
- Conduct an assessment of nematode presence and economic loss and plant growth for stubby-root and root-lesion nematodes.
- Develop a fumigant or alternative to fumigation for use pre-plant.
- Develop economic thresholds indicating when to use fumigation against nematodes, diseases, and other pests.

#### **Regulatory:**

- None at this time.

#### **Education:**

- Educate growers on proper scouting methods and when to sample for nematodes.
- Develop a simple field guide for nematode scouting techniques.
- Educate growers on new fumigant label restrictions (including new restrictions on buffer zones).

## VI. Vertebrate Pests (Birds, Deer, Voles) and Slugs

Several different types of vertebrate pests such as birds, deer, and voles have the potential to reduce blueberry plant vigor and fruit yields, and in the case of deer and voles, can cause plant death. Deer and voles can be problematic through most of the year, while birds cause the most damage (i.e., yield loss) just prior to and during harvest. Slugs can be found year-round in irrigated blueberry fields but are most likely to require control prior to and during harvest, when they can be a contaminant in the harvested fruit.

### **Birds**

Damage to blueberries by birds is a serious and perennial problem, often resulting in 25 to 50 percent yield losses. Birds are most problematic just prior to and during harvest as the fruit is turning blue and the sugar content in the fruit is increasing. Damage is most often caused by robins and starlings, but other birds are also known to cause damage. Large birds such as robins eat the berries, causing direct crop loss as well as further yield losses when they knock fruit off the bush as they forage. Smaller birds such as starlings puncture the fruit, which can cause rot problems. Punctured fruit is difficult to detect during harvesting and sorting operations. Bird droppings on fruit are also a contaminant at harvest.

Exclusion (e.g., netting the entire field) is an effective method for controlling bird damage. However, the materials (posts, wire, netting, etc.) and installation costs for bird netting are prohibitively high for some growers. In addition, netting large acreage is not only costly but often impractical.

Some growers use falconry for bird abatement, with satisfactory results. Although it is expensive, this method is reported by growers to be cost effective when compared to the economic loss incurred from reduced yields caused by pest birds. Providing perches for native raptors and nesting boxes for kestrels around the perimeter of the blueberry field is common but provides only partial control of nuisance birds. Abatement must begin before migratory birds arrive and target roosts.

Chemical repellents with methyl anthranilate or polysaccharide compounds as the active ingredient are registered for use in blueberries, but results have been variable and these repellents are not widely used.

Auditory frightening devices such as cannons, sirens, and bangers (hand-held pyrotechnics) are commonly used in Oregon and Washington blueberry fields but offer only short-term control, as most birds become habituated to the sound. As of May 2011, bangers require a U.S. Bureau of Alcohol, Tobacco, Firearms and

Explosives permit to use on farm. However, for the most part, growers consider hand-held pyrotechnics to be ineffective.

Broadcasts of recorded distress or alarm calls have been used with some success, but as with the noise devices, the birds soon become habituated to the sound. In addition, the distress or alarm calls are often species-specific, and their success is dependent on the grower's being able to accurately identify the species causing the damage.

Visual frightening devices such as eye-spot balloons, scarecrows, hawk kites, and animated owls require high labor inputs and are vulnerable to wind damage or vandalism. Although these devices are more common in urban areas where auditory frightening devices might not be appropriate, their effectiveness in reducing bird damage has been erratic and unreliable. The glittering surface and movement of reflective tape strung across blueberry plants has the potential to scare off birds from landing and feeding in the blueberry field, but it has not proven successful in repelling birds or reducing bird damage.

Decoy traps installed prior to crop ripening can reduce bird populations and damage, but they are not very effective for flocks of birds that migrate seasonally and arrive in very large numbers. Many bird species are protected by federal law. Protected birds caught in traps must be released unharmed. In cooperation with dairymen and blueberry growers in the area, Whatcom and Skagit counties in northwestern Washington have a USDA trapping/poisoning program for starlings that has been somewhat successful. Another option for bird control is monitoring fields and shooting birds as they fly into the blueberries. Nuisance birds that are not protected species can be shot with a shotgun; however, there is a risk that pellets remaining in the fruit or in the bushes can be a contaminant in the harvested fruit.

Bird control is a very serious issue for blueberry growers, with no solution in sight. Removing pestiferous birds from protected species lists would aid greatly in growers' ability to control the damage that birds cause to the crop.

### Deer

Deer feed on foliage, twigs, buds, and fruit, which can delay maturity, reduce yield, have a negative impact on growth, and in severe cases cause death of the young blueberry plant. Deer can be pests year-round, during all stages of blueberry plant growth. An integrated approach to control is generally most effective in reducing damage from deer.

Physical barriers such as fences offer the best control and should be installed around a new blueberry field prior to or immediately after planting if deer are known to be a problem in the area. Although effective, fencing is expensive and usually cost-prohibitive for most growers.

Various brands of chemical repellents are available that interrupt deer feeding by having an unpleasant taste or disagreeable odor, but their effectiveness is generally inconsistent.

Deer populations may be controlled by growers who apply for a crop damage permit, which allows landowners to destroy deer that are causing damage. This method is most effective for solitary deer or infrequent visitations.

### Voles

Voles feed on plant roots and foliage near the ground. Their gnawing and chewing can girdle roots, crowns, canes, and the trunk of the plant. Subterranean feeding activity also creates air pockets along the root zone. The presence of voles is indicated by chewing marks on canes and roots, surface runways in sawdust or grass row middles, and tunnel entrance holes about 1 inch in diameter. Vole populations can be monitored by use of bait stations. These are protected shelters (e.g., a roof shingle) covering a runway or tunnel entrance and baited with apple wedges. (Chewing on the apple wedges indicates vole activity.)

Voles most frequently damage blueberry plants during the fall, winter, and early spring, when other food sources are limited. Their populations are cyclic, with peaks occurring about every 2 to 5 years. Severe vole damage can reduce plant vigor, lower fruit yields, and increase plant mortality. Moles and pocket gophers can also be found in blueberry fields and can also cause damage to the blueberry plant. However, there are no chemicals registered in blueberries for mole or gopher control.

Zinc phosphide bait pellets are registered for use in blueberries. Broadcast application is allowed from after harvest until just before bud break in the spring (with a 70-day PHI). Also, some growers have had success using snap-traps in the spring (metal trigger only; plastic has not been successful), with two blueberry buds as bait.

Habitat reduction can also help reduce vole damage. Mowing and managing vegetation along field borders and keeping sod or groundcover between the berry rows mowed aids in this effort. Plant guards for young plants can prevent above-ground vole feeding, and trapping can reduce vole populations. However, neither of

these management methods is practical or cost effective for large plantings. Although weed mats are common and provide good weed control, some growers are able to get vole populations under control only after the weed mat is removed from the field.

More research is needed to determine the effectiveness of owl boxes and raptor perches in or near blueberry fields for vole control.

### **Slugs**

*Limax* spp., *Arion* spp., *Deroceras* spp.

Slugs can climb up the blueberry plant and feed on foliage and berries. Their feeding and the slime trails they leave behind can reduce fruit quality. They can also be a contaminant in the harvested fruit. When branches heavy with fruit bend down and make contact with the ground or vegetation between the plant rows, slugs can readily climb onto the plants and into the fruit clusters. They are most likely to be a problem in cool, wet summers.

Slug baits are registered for use in blueberries. The most widely used are baits with metaldehyde as the active ingredient, but growers note that caution is required to reduce exposure to workers at harvest. Baits containing iron phosphate as the active ingredient are also available, but efficacy has been variable. However, they have the added benefit of being approved for organic production. Baits can be applied broadcast or in a band, but they must not come in contact with the fruit. Baiting prior to harvest is common if slugs are known to be present. Baiting after harvest in the fall helps reduce next year's population by controlling the adult, egg-laying slugs.

Trellising the blueberry plants keeps branches that are heavy with fruit off the ground, which can reduce the number of slugs gaining access to the plant. Vegetation management (mowing or complete elimination) in the plant row and between the berry rows can reduce slug habitat. Because slugs migrate into and under crates taken to the field before harvest, keeping crates and pallets away from damp soil and grass helps reduce the chance of contaminated fruit. Geese have been used for slug control with some success in small organic blueberry fields.

### **Critical Needs for Vertebrate Pest and Slug Management:**

#### **Research:**

- Identify and evaluate alternative methods for bird control (while keeping in mind the challenges of the urban/rural interface). Methiocarb (Mesurol) was

once registered for use in blueberries and highly effective. A product with methiocarb's level of efficacy is very much needed.

- Develop economic thresholds for vole damage.
- Investigate the interaction between vole activity/damage and the use of weed mats for weed control.
- Evaluate efficacy of existing control methods for voles (e.g., zinc phosphide baiting).
- Identify impacts of gophers on blueberry plants and identify gopher control methods.

**Regulatory:**

- None at this time.

**Education:**

- Educate growers on types of permits allowed for controlling vertebrate pests.
- Educate growers on identification and damage symptoms of various rodent pests such as voles, moles and gopher and current management techniques such as trapping and poisoning.
- Inform the blueberry industry that an Extension wildlife specialist has recently been hired in the Department of Fisheries and Wildlife at Oregon State University and can be of assistance to the industry with rodent management.



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## Activity Tables for Oregon and Washington Blueberries

Note: Each "X" represents one week of the month.

### Cultural Activities

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Bring in bees for pollination			XX	XXXX	XX							
Drain tile installation									XXXX	XXXX		
Establish cover crop			XXXX	XXXX						XXXX	XXXX	
Establish row middles			XXXX	XXXX						XXXX	XXXX	
Fertilization (granular)			XXXX	XXXX	XXXX	XXXX			XXXX	XXXX		
Fertilization (foliar or drip)			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Frost protection (irrigation or wind machines)				XXXX	XXXX							
Hand hoeing			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Harvest						XX	XXXX	XXXX	XXXX	XXXX		
Install irrigation			XXXX	XXXX	XXXX				XXXX	XXXX		
Irrigation					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Leaf sampling (nutritional)					XXXX	XXXX	XXXX	XXXX	XXXX			
Mowing/cultivating row middles			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Organic mulch added to plant row	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX	XXXX
Planting			XXXX	XXXX					XXXX	XXXX		
Pruning	XXXX	XXXX	X									XXXX
Removal of annual cover crop				XXXX								
Removal of bees from field					XX	XXXX						
Replanting (if necessary)									XXXX	XXXX		
Soil testing (for nutrients and pH)	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Subsoil row middles									XXXX	XXXX	XX	

### Pest Management Activities

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Bird control						XXXX	XXXX	XXXX	XXXX	XXXX		
Flaming for weeds	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
Fungicide/bactericide application			XX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX	XX	
Herbicide application	XXXX	XXXX	XXXX	XXXX	XXXX	XX			XXXX	XXXX	XXXX	XXXX
Insecticide application	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XX		
Rodent control	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Sample for nematodes			XXXX	XXXX					XXXX			
Scout for diseases	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			XXXX
Scout for insects		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Scout for vole, mole, and gopher damage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Scout for weeds	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Slug control					XXXX	XXXX				XXXX		
Soil fumigation (pre-plant)								XXXX	XXXX	XXXX		

## Seasonal Pest Occurrence for Oregon and Washington Blueberries

### Notes:

- ~ Each "X" represents one week of the month.
- ~ X = times when pest management strategies are applied to control these pests, not all times when pest is present.
- ~ Workers are removed from fields during and after pesticide applications in accordance with applicable pesticide labels regarding restricted-entry intervals (REIs).

<b>Insects</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Aphids				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X		
Blueberry gall midge			XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XX			
Garden symphylan		X	XXXX	XXXX	XXXX	XX						
Leafrollers				XX	XXXX	XXXX	XXXX	XX				
Root weevil, adults			XX	XXXX		XXXX	XXXX	XXXX				
Root weevil, larvae		XX	XXXX	XX					XX	XXXX	XX	
Scale, crawlers			XXXX	XXXX								
Scale, dormant	XXXX	XXXX										XXXX
Spotted wing drosophila					XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Winter moth (eggs)	XXXX	XXXX	X									XXXX
Winter moth (larvae)			XXXX	XXXX	XXX							
<b>Diseases</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Alternaria fruit rot				X	XXXX	XXXX						
Anthracnose ripe rot			X	XXXX	XXXX	XX						
Bacterial canker/blight									X	XXXX	XX	
Botrytis blossom blight/fruit rot			XXXX	XXXX	XXXX	XX						
Fusicoccum/Godronia canker			XXXX	XXXX								
Mummy berry (primary)			XXXX	XXXX								
Mummy berry (secondary)				XXXX	XXXX							
Phomopsis twig blight			XXXX	XXXX	XX							
Phytophthora root rot		XX	XXXX	XX					X	XXXX	XXXX	
Viruses:												
*Fruit drop					XXXX	XXXX	XXX					
*Scorch			XX	XXXX	XXXX	XXXX	XXXX	XXXX				
*Shock			XX	XXXX	XXXX	XXXX						
*Tomato ring spot			XX	XXXX	XXXX	XX						
<i>* This is when symptoms can be seen on the plant. See the narrative portion of this document for control methods and timing.</i>												
<b>Weeds</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
<b>Annual Grasses:</b>												
Annual bluegrass	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Barnyardgrass						XXXX	XXXX	XXXX				
Crabgrass						XXXX	XXXX	XXXX				
Ryegrass			XX	XXXX	XXXX	XXXX						
Fescues	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Wild oats				XXXX	XXXX	XXXX						
<b>Perennial Grasses:</b>												
Quackgrass	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
<b>Annual Broadleaves:</b>												
Chickweed (common)	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX
Dog fennel			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
Groundsel	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Henbit			XX	XXXX	XXXX	XXXX	XXXX	XXXX				

SEASONAL PEST OCCURRENCE TABLE

<b>Annual Broadleaves (cont.):</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Knotweed (prostrate)				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Lambsquarters				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Mallow (common)					XXXX	XXXX	XXXX					
Mustards	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Nightshade (hairy or black)						XXXX	XXXX	XXXX				
Pigweed (redroot)				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Pineapple weed			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
Prickly lettuce				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Shepherd's-purse	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Smartweed				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Sowthistle				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Speedwell	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
<b>Perennial Broadleaves:</b>												
Bindweed (field)				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Blackberry	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Buckhorn plantain				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Canada thistle				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Clovers	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Curly dock				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Dandelion				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Red sorrel				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Willow weed	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
<b>Other weeds:</b>												
Horsetail	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Nutsedge (yellow)					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
<b>Nematodes*</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Dagger				XXXX	XX					XXXX	XX	
Pin				XXXX	XX					XXXX	XX	
Ring				XXXX	XX					XXXX	XX	
Root-lesion				XXXX	XX					XXXX	XX	
Spiral				XXXX	XX					XXXX	XX	
Stubby-root				XXXX	XX					XXXX	XX	
<i>* Nematodes appear year-round, but treatment for control usually occurs pre-plant in the spring or fall.</i>												
<b>Vertebrates and Slugs</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Birds					XX	XXXX	XXXX	XXXX	XXXX	XXXX		
Deer	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Slugs					XX	XXXX	XXXX	XXXX	XXXX	XXXX	XX	
Voles, moles, and gophers	XXXX	XXXX	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX

**Efficacy Ratings for INSECT Management Tools in Blueberries**

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

Note: Pesticides or practices with two ratings (e.g., F-G) are dependent on pest pressure (e.g., fair if high pest pressure; good if low pest pressure), or it may be due to regional differences.

MANAGEMENT TOOLS	Aphids	Blueberry gall midge	Garden symphylan	Leafrollers	Root weevils	Scale	Spotted wing drosophila	Winter moth	COMMENTS
<b>Registered Chemistries</b>									
Acetamiprid (Assail)	E	G	NU	NU	F	NU	F	NU	
Azadirachtin (Aza-Direct, Neemix)	?	?	?	P	P	?	P	?	
<i>Bacillus thuringiensis</i> (Bt; several brands)	NU	NU	NU	F-G	NU	NU	NU	P-F	
<i>Beauveria bassiana</i> (Mycotrol)	P	?	NU	?	P	NU	NU	?	
Bifenthrin (Brigade)	G	?	NU	G	G-E	G-E	E	G	
Carbaryl (Sevin)	NU	?	NU	F	NU	NU	E	NU	
Cryolite Bait	NU	NU	NU	NU	P	NU	NU	NU	Not readily available for purchase.
Dazomet (Basamid)	NU	NU	P-F	NU	P	NU	NU	NU	PPI soil fumigant
Diazinon	G-E	G	NU	G-E	NU	F-G	E	G-E	
Dichloropropene (Telone II)	NU	NU	F-G	NU	F-G	NU	NU	NU	PPI soil fumigant
Esfenvalerate (Asana XL)	G	?	NU	F-G	F	F-G	E	G	
Fenpropathrin (Danitol)	NU	?	NU	NU	F	NU	E	NU	
Hydrogen Dioxide (Oxdate)	?	?	NU	?	?	?	?	?	
Imidacloprid (Admire Pro, Provado 1.6F)	G-E	NU	NU	NU	NU	NU	P-F	NU	
Indoxacarb (Avaunt)	NU	NU	NU	G-E	G-E	NU	NU	G-E	
Malathion	G-E	F	NU	F-G	F-G	?	E	NU	
Methomyl (Lannate)	P-F	?	NU	E	?	NU	E	E	
Methoxyfenozide (Intrepid)	NU	NU	NU	G-E	NU	NU	NU	G-E	
Novaluron (Rimon)	NU	NU	NU	G	NU	NU	P	G	
Oils (Superior, JMS, 6E, others)	F-G	NU	NU	NU	NU	F-G	P	F-G	
Phosmet (Imidan)	F-G	?	NU	F-G	NU	NU	E	F	
Pyrethrin (Pyganic)	P	?	NU	NU	NU	NU	F	NU	
Pyriproxyfen (Esteem)	NU	NU	NU	NU	NU	F-G	NU	NU	
Soaps (Safer, M-Pede, others)	F	NU	NU	NU	NU	NU	P	NU	Thorough coverage is critical.
Sodium methylthiocarbamate (Metam Sodium, Metam Potassium)	NU	NU	P	NU	P	NU	NU	NU	PPI soil fumigant
Spinetoram (Delegate)	NU	G-E	NU	G	NU	NU	E	?	
Spinosad (Success, Entrust)	NU	G	NU	G	NU	NU	E	E	
Thiamethoxam (Actara, Platinum)	G	NU	NU	NU	G-F	NU	P-F	NU	
Zeta-cypermethrin (Mustang)	NU	NU	NU	E	G	E	E	G	

EFFICACY RATINGS TABLES: INSECT MANAGEMENT

MANAGEMENT TOOLS	Aphids	Blueberry gall midge	Garden symphylian	Leafrollers	Root weevils	Scale	Spotted wing drosophila	Winter moth	COMMENTS
<b>Unregistered/New Chemistries</b>									
BYI-02960	G-E	?	NU	?	?	?	NU	?	
Chlorantraniliprole (Altacor)	E	F	NU	G-E	NU	NU	P	G-E	
Cyantraniliprole	NU	G	NU	G-E	NU	NU	NU	G-E	
Spirotetramat (Movento)	G-E	G-E	NU	?	?	G-E	NU	?	
Tolfenpyrad	NU	G	NU	?	?	NU	?	?	
<b>Biological</b>									
Lady bird beetles	?	NU	NU	NU	NU	NU	NU	NU	
Entomopathogenic nematodes	NU	NU	NU	NU	P-F	NU	NU	NU	
Parasitic wasps	NU	?	NU	?	NU	NU	NU	?	
Predacious bugs (minute pirate bug, etc.)	?	?	?	?	?	?	?	?	
<b>Cultural/Non-Chemical</b>									
Adjacent area management	NU	NU	NU	NU	*	NU	*	*	
Burn winter prunings	*	*	NU	NU	NU	*	NU	*	
Crop rotation	NU	NU	*	NU	NU	NU	NU	NU	
Eliminate or reduce host species	NU	NU	*	NU	NU	NU	*	NU	
Enhancing habitat for beneficials	*	NU	NU	*	NU	NU	*	*	Potential benefits exist for most foliar pests.
Harvest in a timely manner	NU	NU	NU	NU	NU	NU	*	NU	
Sanitation in field (clean up infested fruit)	NU	NU	NU	*	NU	NU	*	NU	
Scouting and monitoring	*	*	*	*	*	*	*	*	
Tillage	NU	NU	*	NU	*	NU	*	NU	
Traps—pheromone or other types	NU	NU	NU	*	NU	NU	*	NU	

### Efficacy Ratings for DISEASE Management Tools in Blueberries

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

Note: Fungicides or practices with two ratings (e.g., F-G) are dependent on disease pressure (e.g., fair if high disease pressure; good if low disease pressure), or it may be due to regional differences.

MANAGEMENT TOOLS	Alternaria fruit rot	Anthraxnose ripe rot	Bacterial canker/blight	Botrytis blossom blight and fruit rot	Fusicoccum/Godronia canker	Mummy berry (primary infection)	Mummy berry (secondary infection)	Phomopsis twig blight	Phytophthora root rot	COMMENTS
<b>Registered Chemistries</b>										
Azoxystrobin (Abound)	G	E	NU	P	NU	NU	NU	?	NU	
<i>Bacillus subtilis</i> (Serenade)	NU	NU	?	?	NU	P	P	NU	NU	
Boscalid + Pyraclostrobin (Pristine)	G	G-E	NU	G-E	?	?	?	?	NU	
Captan	G	G	NU	G	?	P	F	?	NU	
Captan + Fenhexamid (Captevate)	F-G	F-G	NU	E	NU	P	F	NU	NU	
Chlorothalonil (Bravo, Echo)	?	P-F	NU	P	NU	P	P	NU	NU	
Cyprodinil + Fludioxonil (Switch)	F	P-G	NU	E	NU	P	P	NU	NU	
Fenbuconazole (Indar)	NU	NU	NU	NU	NU	E	E	NU	NU	
Fenhexamid (Elevate)	NU	NU	NU	E	NU	F	F	NU	NU	
Fixed Copper (Bordeaux, Champ, Kocide, others)	NU	NU	G	NU	NU	NU	NU	NU	NU	Rating assumes no resistance.
Fluazinam (Omega)	G	G	NU	?	NU	NU	NU	?	NU	
Fosetyl-al (Aliette)	NU	P-G	NU	NU	NU	NU	NU	NU	G	
Hydrogen Dioxide (Oxidate)	?	?	?	?	?	?	?	?	?	
Iprodione	G	NU	NU	G	NU	NU	NU	NU	NU	Rating assumes no resistance.
Lime sulfur	NU	NU	NU	NU	NU	F	NU	NU	NU	Rating based on soil application.
Mefenoxam (Ridomil Gold)	NU	NU	NU	NU	NU	NU	NU	NU	G	Rating assumes no resistance.
Phosphorous acid (various formulations)	?	?	NU	NU	NU	NU	NU	NU	G	
Propiconazole (Orbit)	NU	NU	NU	NU	NU	E	E	NU	NU	
Pyraclostrobin (Cabrio)	G	G-E	NU	P	NU	NU	NU	?	NU	
<i>Reynoutria sachalinensis</i> (Regalia)	?	?	?	?	?	?	?	?	?	
<i>Streptomyces lydicus</i> (Actinovate AG)	?	?	?	?	?	?	?	?	?	
Ziram	F	G	NU	P-F	NU	P	P	NU	NU	
<b>Unregistered or New Chemistries</b>										
None										
<b>Biological</b>										
Biostimulants	?	?	?	?	?	?	?	?	?	
<b>Cultural/Non-Chemical</b>										
Adjacent area management	NU	NU	NU	NU	NU	*	*	NU	*	For mummy berry, eliminate cull piles.
Avoid bruising fruit during harvest	NU	NU	NU	NU	NU	NU	NU	NU	NU	
Avoid wounding or injuring plants	*	*	*	NU	*	NU	NU	*	NU	

EFFICACY RATINGS TABLES: DISEASE MANAGEMENT

MANAGEMENT TOOLS	Alternaria fruit rot	Anthraxnose ripe rot	Bacterial canker/blight	Botrytis blossom blight and fruit rot	Fusicoccum/Godronia canker	Mummy berry (primary infection)	Mummy berry (secondary infection)	Phomopsis twig blight	Phytophthora root rot	COMMENTS
<b>Cultural/Non-Chemical (cont.)</b>										
Cool berries rapidly after harvest	*	*	NU	NU	NU	NU	NU	NU	NU	
Cultivation, raking, mulching	NU	NU	NU	NU	NU	*	NU	NU	NU	
Flaming	NU	NU	NU	NU	NU	*	NU	NU	NU	
Frequent harvests (avoid overripe fruit)	*	*	NU	NU	NU	NU	NU	NU	NU	
Irrigation management	*	*	NU	NU	NU	NU	NU	NU	*	
Maintain/enhance drainage	NU	NU	NU	NU	NU	NU	NU	NU	*	
Nitrogen management	NU	NU	*	NU	NU	NU	NU	NU	NU	Avoid late-season fertilization.
Pruning	NU	NU	*	NU	*	NU	NU	NU	NU	
Raised beds	NU	NU	NU	NU	NU	NU	NU	NU	*	
Resistant/tolerant cultivars	NU	NU	*	NU	NU	*	*	NU	NU	
Sanitation	*	*	*	*	*	*	*	*	*	Sanitize picking totes between uses.
Sawdust mulch	NU	NU	NU	NU	NU	*	NU	NU	NU	
Scouting and monitoring	*	*	*	*	*	*	*	*	*	
Soil solarization	NU	NU	NU	NU	NU	NU	NU	NU	*	
Subsoiling during dormancy	NU	NU	NU	NU	NU	NU	NU	NU	*	
Weed control	NU	NU	*	*	NU	*	*	NU	NU	



**Efficacy Ratings for WEED Management Tools in Blueberries – Annual Broadleaf Weeds**

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

- Notes: ~ 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.  
 ~ Mode of Action Class based on Weed Science Society of America classification system.

Weed Family →			Amaranthaceae (Pigweed family)	Asteraceae (Sunflower family)	Brassicaceae (Brassica family)	Caryophyllaceae (Pink family)	Chenopodiaceae (Goosefoot family)	Lamiaceae (Mint family)	Malvaceae (Malvaceae family)	Polygonaceae (Buckwheat family)	Scrophulariaceae (Figwort family)	Solanaceae (Nightshade family)	
MANAGEMENT TOOLS	Mode of Action Class	Type	Pigweed (redroot)	Dog fennel Groundsel Pineapple-weed Prickly lettuce Sowthistle	Mustards Shepherd's-purse	Chickweed (common)	Lambs-quarters (common)	Henbit	Mallow (common)	Knotweed (prostrate) Smartweed	Speedwell	Nightshade (black) (hairy)	COMMENTS
			Registered Chemistries										
2,4-D amine (Saber)	4	Post	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	24(c) registration.
Bentazon (Basagran)	6	Post	F	F	G	G	F	G	P	G	G	F	Nonbearing only. Weak on shepherd's-purse.
Carfentrazone-ethyl (Aim)	14	Post	G	G	G	G	G	G	F	F	G	G	
Clopyralid (Stinger)	4	Post	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	24(c) registration.
Dichlobenil (Casoron)	20	Pre	G	F-G	G	G	G	G	F	G	G	G	Not recommended for use in new plantings.
Diuron (Diurex, Karmex)	7	Pre	G	G	G	F	G	G	P	F	G	G	No use within 1 year of planting.
Flumioxazin (Chateau)	14	Pre	G	G	F	G	G	G	P	F	G	F	
Glyphosate (Roundup)	9	Post	G	G	G	G	G	G	F	G	G	G	
Glufosinate (Rely)	9	Post	G	G	G	G	G	G	F	G	G	G	
Halosulfuron (Sanda)	2	Pre & Post	F	G	G	G	F	G	F	F	F	P	
Hexazinone (Velpar)	5	Pre & Post	F-G	G	G	G	G	G	F	F-G	F	G	
Isoxaben (Gallery)	20	Pre	G	F-G	G	G	G	G	G	G	G	G	Nonbearing only. Weak on pineapple weed.
Mesotrione (Callisto)	27	Pre & Post	G	G	G	G	G	G	F	F	G	G	

EFFICACY RATINGS TABLES: WEED MANAGEMENT

Weed Family →			Amaranthaceae (Pigweed family)	Asteraceae (Sunflower family)	Brassicaceae (Brassica family)	Caryophyllaceae (Pink family)	Chenopodiaceae (Goosefoot family)	Lamiaceae (Mint family)	Malvaceae (Malvaceae family)	Polygonaceae (Buckwheat family)	Scrophulariaceae (Figwort family)	Solanaceae (Nightshade family)	
MANAGEMENT TOOLS	Mode of Action Class	Type	Pigweed (redroot)	Dog fennel Groundsel Pineapple-weed Prickly lettuce Sowthistle	Mustards Shepherd's-purse	Chickweed (common)	Lambs-quarters (common)	Henbit	Mallow (common)	Knotweed (prostrate) Smartweed	Speedwell	Nightshade (black) (hairy)	COMMENTS
	<b>Registered Chemistries (cont.)</b>												
Napropamide (Devrinol)	15	Pre	G	G	G	P	G	P	G	P-F	G	P	Weak on pineapple weed and shepherd's-purse.
Norflurazon (Solicam)	12	Pre	F	F	G	G	G	G	F	F-G	F	G	
Oryzalin (Surflan)	3	Pre	G	P	P	P	G	F	P	F-G	G	P	
Paraquat (Gramoxone)	22	Post	G	G	G	F	F	G	F	F	G	G	Controls seedlings only of dog fennel & pineapple weed.
Pronamide (Kerb)	3	Pre	P	P	G	F	F	F	P	F	P	F	
S-metolachlor (Dual Magnum)	15	Pre	G	G	G	P	G	P	G	P-F	G	P	24(c) registration.
Simazine (Princep)	5	Pre	G	G	G	G	G	G	F	F-G	F	G	
Terbacil (Sinbar)	5	Pre	F	G	G	G	G	F	G	G	F	G	
<b>Unregistered or New Chemistries</b>													
Quinclorac (Quinstar)	26	Post	?	?	?	?	?	?	?	?	?	?	
Sulfentrazone (Spartan)	14	Pre	G	F	G	G	E	F	F	P	?	E	
<b>Biological</b>													
None	--	--	---	---	---	---	---	---	---	---	---	---	
<b>Cultural/ Non-Chemical</b>													
Disking	na	na	G	G	G	G	G	G	G	G	G	G	
Flaming	na	na	F	F	F	F	F	F	F	F	F	F	
Irrigation management	na	na	*	*	*	*	*	*	*	*	*	*	
Hand hoeing/weed eater	na	na	F	F	F	F	F	F	F	F	F	F	
Mowing	na	na	G	P-F	F	P	G	P	P	G	F	F	
Mulching	na	na	F	F	F	F	F	F	F	F	F	F	
Tillage	na	na	F	F	F	F	F	F	F	F	F	F	

**Efficacy Ratings for WEED Management Tools in Blueberries – Perennial Broadleaf Weeds**

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

- Notes: ~ 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.  
 ~ Mode of Action Class based on Weed Science Society of America classification system.

Weed Family →			Asteraceae (Sunflower family)	Convolvulaceae (Morningglory family)	Fabaceae (Legume family)	Onagraceae (Fireweed family)	Plantaginaceae (Buckhorn family)	Polygonaceae (Buckwheat family)	Rubiaceae (Rubus family)	
MANAGEMENT TOOLS	Mode of Action Class	Type	Canada thistle Dandelion	Bindweed (field)	Clovers	Willow weed	Buckhorn plantain	Curly dock Red sorrel	Blackberry	COMMENTS
			Registered Chemistries							
2,4-D amine (Saber)	4	Post	F-G	F-G	P	F	F	F	P	24(c) registration.
Bentazon (Basagran)	6	Post	NU	NU	NU	NU	NU	NU	NU	Nonbearing only.
Carfentrazone-ethyl (Aim)	14	Post	F	F	P	F	F	P	P	
Clopyralid (Stinger)	4	Post	E	P	E	P	P	P	P	24(c) registration.
Dichlobenil (Casoron)	20	Pre	G	P-F	G	G	G	G	G	Not recommended for use in new plantings.
Diuron (Diurex, Karmex)	7	Pre	NU	NU	NU	NU	NU	NU	NU	
Flumioxazin (Chateau)	14	Pre	NU	NU	NU	NU	NU	NU	NU	
Glyphosate (Roundup)	9	Post	G	F-G	G	G	G	G	F	
Glufosinate (Rely)	9	Post	F	F	F	F	F	F	p	
Halosulfuron (Sanda)	2	Pre & Post	NU	NU	NU	NU	NU	NU	NU	
Hexazinone (Velpar)	5	Pre & Post	F-G	P	P	F	G	F	G	
Isoxaben (Gallery)	20	Pre	NU	NU	NU	NU	NU	NU	NU	Nonbearing only.

EFFICACY RATINGS TABLES: WEED MANAGEMENT

Weed Family →			Asteraceae (Sunflower family)	Convolvulaceae (Morningglory family)	Fabaceae (Legume family)	Onagraceae (Fireweed family)	Plantaginaceae (Buckhorn family)	Polygonaceae (Buckwheat family)	Rubiaceae (Rubus family)	
MANAGEMENT TOOLS	Mode of Action Class	Type	Canada thistle Dandelion	Bindweed (field)	Clovers	Willow weed	Buckhorn plantain	Curly dock Red sorrel	Blackberry	COMMENTS
			Registered Chemistries (cont.)							
Mesotrione (Callisto)	27	Pre & Post	NU	NU	NU	NU	NU	NU	NU	
Napropamide (Devrinol)	15	Pre	NU	NU	NU	NU	NU	NU	NU	
Norflurazon (Solicam)	12	Pre	NU	NU	NU	NU	NU	NU	NU	
Oryzalin (Surflan)	3	Pre	NU	NU	NU	NU	NU	NU	NU	
Paraquat (Gramoxone)	22	Post	G	G	G	G	G	F		
Pronamide (Kerb)	3	Pre	NU	NU	NU	NU	NU	NU	NU	
S-metolachlor (Dual Magnum)	15	Pre	NU	NU	NU	NU	NU	NU	NU	24(c) registration.
Simazine (Princep)	5	Pre	NU	NU	NU	NU	NU	NU	NU	
Terbacil (Sinbar)	5	Pre	NU	NU	NU	NU	NU	NU	NU	
Unregistered or New Chemistries										
Quinclorac (Quinstar)	26	Post	?	?	?	?	?	?	?	
Sulfentrazone (Spartan)	14	Pre	P	P	P	?	P	P	P	
Biological										
None	--	--	---	---	---	---	---	---	---	
Cultural/ Non-Chemical										
Disking	na	na	P-F	P	F	F	G	G	F	
Flaming	na	na	P	P	P	P	P	P	P	
Irrigation management	na	na	*	*	*	*	*	*	*	
Hand hoeing/weed eater	na	na	P	P	P	F	P	P	P	
Mowing	na	na	P	P	P	P	P	P	F	
Mulching	na	na	P	P	P	P	P	P	P	
Tillage	na	na	NU	NU	NU	NU	NU	NU	NU	

**Efficacy Ratings for WEED Management Tools in Blueberries – Grasses and Other Weeds**

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

- Notes: ~ 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.
- ~ Mode of Action Class based on Weed Science Society of America classification system.

			Winter Annual Grasses				Summer Annual Grasses		Perennial Grasses	Miscellaneous			
MANAGEMENT TOOLS	Mode of Action Class	Type	Bluegrass (annual)	Ryegrass	Fescue	Wild oats	Barnyard-grass	Crabgrass	Quackgrass	Horsetail	Nutsedge (yellow)	COMMENTS	
			<b>Registered Chemistries</b>										
Clethodim (Select)	1	Post	G-E	G	F	G	G	G	F-G	NU	NU		
Dichlobenil (Casoron)	20	Pre	G	G	G	F	G	G	G	G	G	Not recommended for use in new plantings.	
Diuron (Diurex, Karmex)	7	Pre	G	G	G	P	G	F-G	P	P	P	No use within 1 year of planting.	
Flumioxazin (Chateau)	14	Pre	F	F	F	F	G	G	P	P	P		
Fluazifop-butyl (Fusilade)	1	Post	P	F-G	P	G	G	G	F	NU	NU	Nonbearing only.	
Glyphosate (Roundup)	9	Post	G	G	G	G	G	G	G	P	F		
Glufosinate (Rely)	9	Post	F	F	F	F	F	F	P	F	P		
Halosulfuron (Sanda)	2	Pre & Post	NU	NU	NU	NU	NU	NU	NU	F	E		
Hexazinone (Velpar)	5	Pre & Post	G	G	G	F	G	G	G	G	F		
Mesotrione (Callisto)	27	Pre & Post	F	F	F	F	F	F	P	P	P		
Napropamide (Devrinol)	15	Pre	G	G	G	G	F-G		P	P	P		
Norflurazon (Solicam)	12	Pre	G	G	G	G	G	F	P	P	F		
Oryzalin (Surflan)	3	Pre	G	G	G	P	G	G	P	P	P		
Paraquat (Gramoxone)	22	Post	G	G	G	G	G	G	G	P	F		
Pronamide (Kerb)	3	Pre	G	G	G	G	P	P	G	P	P		
S-metolachlor (Dual Magnum)	15	Pre	G	G	G	F	G	G	P	P	G	24(c) registration.	
Sethoxydim (Poast)	1	Post	P	G	P	G	G	G	P	NU	NU		
Simazine (Princep)	5	Pre	G	G	G	F	F	P-F	P	P	P		
Terbacil (Sinbar)	5	Pre	G	G	G	G	F	G	F	P	P		
<b>Unregistered or New Chemistries</b>													
Quinclorac (Quinstar)	26	Post											
Sulfentrazone (Spartan)	14	Pre											

EFFICACY RATINGS TABLES: WEED MANAGEMENT

			Winter Annual Grasses				Summer Annual Grasses		Perennial Grasses	Miscellaneous		
MANAGEMENT TOOLS	Mode of Action Class	Type	Bluegrass (annual)	Ryegrass	Fescue	Wild oats	Barnyard-grass	Crabgrass	Quackgrass	Horsetail	Nutsedge (yellow)	COMMENTS
			Biological									
None	--	--	---	---	---	---	---	---	---	---	---	
Cultural/ Non-Chemical												
Disking	na	na	G	G	F	G	G	G	P	P	P	
Flaming	na	na	P	P	P	P	P	P	P	P	P	
Irrigation management	na	na	*	*	*	*	*	*	*	*	*	
Hand hoeing/weed eater	na	na	P	P	P	P	P	P	P	P	P	
Mowing	na	na	F	F	P	G	F	F	F	F	F	
Mulching	na	na	P	P	P	P	P	P	P	P	P	
Tillage	na	na	F	F	F	F	F	F	F	F	F	

### Efficacy Ratings for NEMATODE Management Tools in Blueberries

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

MANAGEMENT TOOLS	Dagger	Pin	Ring	Root-lesion	Spiral	Stubby-root	COMMENTS
<b>Registered Chemistries*</b>							
Dazomet (Basamid)	F-G	F-G	F-G	F-G	F-G	F-G	
Dichloropropene (Telone II)	E	E	E	E	E	E	PPI soil fumigant
Sodium methylthiocarbamate (Metam Sodium, Vapam)	F-G	F-G	F-G	F-G	F-G	F-G	PPI soil fumigant
<b>Unregistered/Potential Chemistries</b>							
None							
<b>Biological</b>							
Biologically-based nematicides	?	?	?	?	?	?	
<b>Cultural/Non-Chemical</b>							
Cover crops	F	?	?	F	?	?	
Crop rotation	?	?	?	?	?	?	
Fallow 2 or more years	F-G	F-G	F-G	F-G	F-G	F-G	
Increased organic matter	?	?	?	?	?	?	
Site selection	G	G	G	G	G	G	
Solarization	P	P	P	P	P	P	

\* Registered fumigants give good to excellent control of the nematodes. However, in fields where Tomato Ring Spot Virus (ToRSV) was present in the previous crop, fumigation may only give fair control of viruliferous nematodes (i.e., a few viruliferous nematodes may survive fumigation and reinfest the blueberry planting with ToRSV).

**Efficacy Ratings for VERTEBRATE PESTS and SLUG Management Tools in Blueberries**

**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 (chemistry or practice is known to be ineffective); \* = used but not a stand-alone management tool.

<b>MANAGEMENT TOOLS</b>	<b>Birds</b>	<b>Deer</b>	<b>Slugs</b>	<b>Voles</b>	<b>COMMENTS</b>
<b>Registered Chemistries</b>					
Iron Phosphate (Sluggo)	NU	NU	?	NU	
Metaldehyde (Deadline MPs)	NU	NU	G-E	NU	
Methyl anthranilate (Bird Shield, RejeX-it)	P-G	NU	NU	NU	
Polysaccharides (sugar solutions)	P-G	NU	NU	NU	
Zinc Phosphide (Prozap)	NU	NU	NU	G-E	
<b>Unregistered/Potential Chemistries</b>					
None.					
<b>Biological</b>					
Birds (owls, falcons, kestrels)	*	NU	?	?	
Geese	NU	NU	F, *	NU	Most effective in small plantings.
<b>Cultural/Non-Chemical</b>					
Fencing	NU	E	NU	NU	Expensive.
Netting	E	NU	NU	NU	Expensive.
Plant guards (for newly established plantings)	NU	NU	NU	P-F	Impractical in large plantings.
Reflective tape/ribbon	P	NU	NU	NU	
Rodentator (burrow blaster)	NU	NU	NU	F	Expensive.
Scare devices	P-F	F	NU	NU	
Shooting/destroying (as allowed)	P-F	P-F	NU	NU	
Trapping	F	NU	?	P-F	
Trellising	NU	NU	F, *	NU	
Vegetation management (weeds or grass strips)	NU	NU	F, *	F, *	