Pest Management Strategic Plan

for

Oregon and Washington Blueberries

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Executive Summary

EPA is now engaged in the process of registering and re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA). EPA's regulatory focus on the organophosphate (OP), carbamate, and suspected B2 carcinogen pesticides has created uncertainty as to the future availability of these products to growers. At some point, EPA may propose to modify or cancel some or all uses of these chemicals on blueberries. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling certain registrations.

The blueberry industry is at risk of losing a number of essential chemicals critical for pest management. At the same time, a number of newer, unproven, low-risk chemistries are becoming available. The blueberry industry faces efficacy and economic uncertainties surrounding these shifts in control strategies. In addition, widespread reductions in funding have reduced or weakened the ability of land-grant university personnel to conduct field research and extension programs.

The Endangered Species Act (ESA) mandates that Federal agencies such as EPA consult with the National Oceanic and Atmospheric Administration (NOAA-Fisheries) if EPA takes an action that may affect threatened or endangered species. Recently, lawsuits have been filed against EPA stating that they failed to complete the consultation process. The result of one of these lawsuits is that mandatory no-spray buffer zones have been temporarily imposed for certain pesticides in threatened and endangered salmonid species habitat in Washington, Oregon, and California. Because of the number of consultations that must take place to satisfy the mandates of the ESA and because of the complexity of the process, it is expected that mandatory buffer zones from this lawsuit will remain in effect for several years. These buffer zones, whether planted to crops or abandoned to weeds, have the potential to act as pest reservoirs that will repeatedly infest neighboring crops. The total effect of ESA implementation is yet to be determined; however, it will clearly require new pest management strategies in the blueberry industry.

A cross-section of blueberry growers, researchers, Extension service personnel, industry representatives, and crop advisors from Oregon and Washington met for a full day in March 2004 to develop a Pest Management Strategic Plan that identifies the critical research, regulatory, and educational needs for their industry. This document is the result of that meeting.

Summary of the Most Critical Pest Management Needs in Oregon and Washington Blueberries

The following priority areas must be addressed to maintain the long-term viability of the blueberry industry in Oregon and Washington.

RESEARCH

- Identify and develop economically feasible organic pest management alternatives.
- Address bird control.
- Develop prediction models for fruit and cane diseases.
- Determine economic thresholds for nematodes and insect pests.
- Maintain full funding for Extension and research programs at land-grant universities. Recent budgetary cutbacks and personnel layoffs threaten the viability of IPM research.

REGULATORY

- Expedite the full registration of fenbuconazole (Indar) and propiconazole (Orbit) for mummy berry disease control and iodomethane (Midas) for soil fumigation.
- Encourage EPA to allow multiple Section 18 (emergency exemption) registrations for the same pest/crop complex for resistance management.
- Develop a certification program for blueberry diseases and viruses for the entire United States.
- Expedite registration of any insecticide that has the potential to be a replacement for diazinon.
- Continue to allow multiple applications of diazinon.

EDUCATION

- Maintain full funding for Extension and research programs at land-grant universities, as well as personnel and 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.
- Develop materials, such as pocket guides and CDs, to educate growers about scouting and other IPM tactics in blueberry production.
- Continue to educate growers about the importance of proper timing and application techniques (e.g., adequate coverage) when making a pesticide application.
- Continue to educate growers, via printed material, CDs, or video, about the principles of resistance management and techniques to avoid resistance.

Production Facts

Together, in 2003, the Pacific Northwest states of Oregon and Washington produced about 20% of the total cultivated blueberry crop in the United States.

Oregon ranks third in U.S. blueberry production. In 2003, Oregon produced 23.9 million pounds of berries on 3,300 acres with a value of $20.8 million. Most (88%) of the blueberry production in Oregon occurs in the Willamette Valley, located on the west side of the Cascade Mountains, in Marion, Washington, Clackamas, Yamhill, Benton, Multnomah, Linn, Lane, Columbia, and Polk counties. Some production also takes place in counties along the Pacific Coast, in the southwestern part of the state (Douglas County), and in the northcentral part of the state along the Columbia River (Hood River and Wasco counties).

Washington ranks sixth nationally in blueberry production. In 2003, Washington growers harvested 13.2 million pounds of blueberries from 2,200 acres, with a value of $12.1 million. Like Oregon, most of the blueberry production in Washington occurs west of the Cascade Mountains. The northern counties of Whatcom and Skagit account for 43% of Washington's acreage. There is also significant blueberry production in Lewis, Clark, and Thurston counties, and small acreage along the coast and in other counties in both western and central 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.); there are also some 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 the most common type of irrigation but many new fields are drip irrigated. 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.

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; Bluecrop, Rubel, Earliblue, Brigitta, Bluejay, Jersey, Reka, and Elliot are other common cultivars.

Well-maintained blueberry plants can remain productive for 50+ years; good site selection and proper soil preparation is imperative. Blueberries can be planted in either the fall or the spring. 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 two-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, loose growing medium for the plants. Sawdust mulch in the plant row is commonly applied after planting to help keep the roots cool and moist and to aid in weed suppression. Depending on the cultivar, plants may be stripped of flowers or fruit for the first year or two in the ground to allow the plants 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 six to eight years to reach full production. Some cultivars can grow up to 10 or more feet high. Pruning during dormancy (winter months) is done to maintain plant vigor.

Many blueberry cultivars are self-fertile but, for some cultivars, cross-pollination 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%. Bees are required for pollination and fruit set. Although native bees may provide adequate pollination in small plantings, most commercial growers place honeybee hives in the field to ensure good pollination and optimum fruit set.

The majority of the blueberries produced in Oregon and Washington is destined for processing (frozen, jams, purees), with the remainder being sold for the fresh market. However, fresh market production is increasing. 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. This operation requires little labor, consisting of the driver and two workers who sort the berries (discarding underripe or damaged fruit) as berries come across the belt. Sorted berries fall into crates and are then brought to the processing plant. Fresh market berries are mostly hand-picked (and require large crews) but the trend is towards machine-picked berries that are suitable for the fresh market. Blueberries grow in clusters or bunches, with the fruit within each cluster ripening at different rates over a period of three to five weeks. As such, the same plant is harvested three or four times during the harvest period. Fruit damage and yield loss due to bird feeding is a major problem at harvest time for most growers.

Integrated Pest Management (IPM) Strategies in Blueberry Production

Practically all blueberry growers use some IPM practices (which include cultural, biological, and chemical techniques) 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.

Commonly used IPM practices for disease control include use of resistant cultivars, field scouting, sanitation, plant spacing, proper pruning, and weed control. For insect control, field scouting, sanitation, and preservation of habitat for beneficial arthropods are widely used IPM practices. Scouting, cultivation, and mulches are used in IPM programs for weed control. When using agricultural chemicals, blueberry growers and commercial applicators regularly calibrate pesticide application equipment to ensure proper and accurate delivery.

Foundation for the Pest Management Strategic Plan

The remainder of this document is a discussion of the common pests that can cause significant damage and economic losses during the various growth stages of blueberries, and the field and worker activities that occur during these stages. This document also summarizes current and potential management practices for these pests. Any differences between Oregon and Washington are discussed, where appropriate. Finally, it lists what the blueberry industry of Oregon and Washington believes are the research, regulatory, and educational needs for dealing with pests that occur in blueberry production.

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 one to three years prior to planting to determine fertility levels and pH of the soil; 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 in prior to planting. Perennial weeds are oftentimes treated with a non-selective, systemic herbicide such as glyphosate prior to soil tillage. The use of a pre-plant soil fumigant 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 can get established and 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 the 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 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 two-year-old plants are planted by hand into flat or raised beds. Two to four inches of sawdust mulch are commonly applied after planting to the soil surface in the plant row to help keep the roots cool and moist and to aid in weed suppression. The field is irrigated immediately after planting.

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 "non-bearing." 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 non-bearing years.

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

Planting cover crop
Removing cover crop (herbicide or tillage)
Applying pre-plant herbicide
Sampling soil for nutrients, pH, nematodes, soil insects

Tiling (for drainage)
Tilling soil
Adding organic matter for incorporation
Creating raised beds
Scouting for weeds and insects
Fertilizing (pre- or post-planting)
Fumigating soil
Planting
Applying pre-emergence herbicide
Mulching organic matter into the plant row
Irrigation
Establishing permanent cover crop or permanent grass sod
Installing irrigation system
Solarizing soil

Insects

Garden Symphylan (*Scutigerella 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 (plants lose vigor and, in severe cases, can die). The symptoms of low vigor and weak growth usually show up sometime between April and June. There are no good controls for symphylans once a blueberry planting is established, so treatment for symphylans is best done prior to planting. Symphylans are usually controlled when the soil is fumigated for other soilborne pests.

Chemical control:
Dazomet (Basamid): Too expensive. Not very effective; fumigant is effective only as deep as it can be rototilled.

Dichloropropene (Telone II): OK but not as effective as methyl bromide.

Methyl bromide: Most effective fumigant available but it is becoming cost prohibitive and is to be phased out by 2005.

Sodium methyldithiocarbamate (Metam Sodium): Application techniques limit its effectiveness. Adequate dispersal is often a problem; if poorly dispersed, failure results.

Cultural control:
Tillage helps but is not a standalone method.

Growers avoid rotating to crops such as corn that are known hosts for symphylans.

Biological control:
Biostimulants are available but efficacy is unknown.

Root Weevils
Black vine weevil (*Otiorhynchus sulcatus*)
Strawberry root weevil *(O. ovatus*)
Rough strawberry root weevil (*O. rugosostriatus*)

Root weevil larvae overwinter two to eight inches deep in the soil and can be found in fields prior to planting. They are 1/4- to 1/2-inch long, are white with tan heads, and have no legs. They feed on small roots and can quickly reduce the vigor of young plants.

Chemical control:
Dazomet (Basamid): Too expensive. Not very effective; fumigant is effective only as deep as it can be rototilled.

Dichloropropene (Telone II): OK but not as effective as methyl bromide.

Methyl bromide: Most effective fumigant but it is becoming cost prohibitive and it is to be phased out by 2005.

Sodium methyldithiocarbamate (Metam Sodium): Application techniques limit its effectiveness. Adequate dispersal is often a problem; if poorly dispersed, failure results.

Cultural control:
Tillage helps reduce weevil populations by crushing the soft-bodied larvae, but is not a standalone method.

Adjacent area management can aid in reducing in-field populations; adult weevils don't fly.

Biological control:
Parasitic nematodes are available but expensive. Efficacy depends on soil temperature and moisture; it is difficult to obtain consistent results.

Wireworms (*Limonius* spp.) and **Craneflies** (*Tipula paludosa*) can also be found in the soil prior to planting blueberries. Chemical controls for these insect pests are the same as those for symphylans (above).

Critical Needs for Management of Insects in Blueberries: Establishment

Research

- Identify methyl bromide alternatives.
- Develop detection or sampling methods to determine threshold levels of symphylans, wireworms, craneflies, and root weevil larvae prior to planting.
- Evaluate ethoprop (Mocap), and other pre-plant soil-incorporated insecticides with the likelihood of registration, for effectiveness of symphylans, wireworms, craneflies, and root weevil larvae control.
- Identify and evaluate alternatives to synthetic chemistries, such as biological stimulants or soil amendments (e.g., Sunburst, Teenio).
- Continue research on biofumigants (e.g., mustard plants).

- Determine efficacy of soil-applied granular insecticides, incorporated prior to planting, to control root weevil larvae.

Regulatory

- If ethoprop (Mocap) proves to be effective in controlling soilborne insects in blueberries, develop residue data and expedite registration.
- Expedite registration of iodomethane (Midas).
- Clarify status of "non-bearing" plants.
- Register bifenthrin (Brigade, Capture) for weevil control in non-bearing plantings.

Education

- Educate growers on scouting techniques for soilborne insects.

Diseases

Phytophthora Root Rot (*Phytophthora* spp.)
Root rot can negatively affect the vigor of the blueberry plant, especially young plants. This fungal disease is commonly found in areas where the soils are heavy or where drainage is poor. Experience shows that soil fumigation delays the onset of disease but does not cure it.

Chemical control:
Pre-plant soil fumigants:
Dazomet (Basamid): Too expensive. Not very effective; fumigant is effective only as deep as it can be rototilled.

Dichloropropene + chloropicrin (Telone C35): Effective in delaying the onset of the disease.

Methyl bromide + chloropicrin: Effective but expensive; often cost prohibitive. MB is to be phased out by 2005.

Sodium methyldithiocarbamate (Metam Sodium, Vapam): Dispersal a problem; if poorly dispersed, failure results.

At or after planting:
Mefenoxam (Ridomil Gold): Resistance has been documented.

Cultural control:
Growers 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 tilth). They also avoid overwatering and they plant disease-free, certified 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 two years.

Biological control:
Biostimulants are available but efficacy is unknown.

Viruses
Prior to planting a new field, it is important to include a survey of *Xiphinema* nematodes in the site evaluation to determine population levels, as these nematodes transmit a number of viruses (including tomato ringspot virus and tobacco ringspot virus) that infect blueberry. These viruses can reduce plant growth and fruit yield. If sampling indicates that *Xiphinema* nematodes are 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, then the site should be treated with a pre-plant soil fumigant to control these nematodes prior to planting. Virus symptoms on the plants (low vigor, small leaves) show up in late March through April, in the early stages of flower and leaf development.

Chemical control:
(For control of the *Xiphinema* nematode, which vectors the viruses.)

Dazomet (Basamid): Expensive. Not very effective; fumigant is effective only as deep as it can be rototilled.

Dichloropropene (Telone II): Not as effective as methyl bromide.

Methyl bromide: Most effective fumigant available but it is becoming cost prohibitive and is to be phased out by 2005.

Sodium methyldithiocarbamate (Metam Sodium, Vapam): Dispersal a problem; if poorly dispersed, failure results.

Cultural control:
It is important to consider the plant source. Virus-free planting material is essential for good establishment and for good productivity throughout the life of the planting.

Biological control:
None known.

Critical Needs for Management of Diseases in Blueberries: Establishment

Research

- Identify and evaluate alternatives to synthetic chemistries, such as biological stimulants or soil amendments (e.g., Sunburst, Teenio).
- Determine the relationship between Pythium and Phytophthora as a cause for root rot.
- Identify a replacement for mefenoxam (Ridomil), taking resistance management into consideration.
- Develop a program to test cultivars for resistance to Phytophthora.

Regulatory

- Develop a blueberry plant certification program.

- Streamline quarantine regulations and testing of blueberry nursery stock for diseases. Interagency cooperation is needed.
- Develop a test for sudden oak death disease in planting stock.

Education

- Educate growers on field scouting for diseases and viruses.
- Educate growers on things to consider when selecting a site for establishing blueberries.

Weeds

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. Several herbicides are registered for use in non-bearing blueberries, which provide additional options for weed control in newly planted fields if a crop won't be harvested for more than 365 days after application.

Treatment 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 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-emergent broadleaf herbicide. Available through a 24c in both Oregon and Washington.

Bentazon (Basagran): Non-bearing only. Post-emergent.

Clethodim (Select): Non-bearing only. Post-emergent grass herbicide. Good control of annual bluegrass and other non-fescue grasses.

Fluazifop (Fusilade): Non-bearing only. Post-emergent grass herbicide.

Glyphosate (Roundup, others): Systemic herbicide used during site preparation. Need to wait at least 10 days after application before disking.

Napropamide (Devrinol): Pre-emergent, used after planting.

Norflurazon (Solicam): Pre-emergent, used after planting.

Oryzalin (Surflan): Pre-emergent, used after planting.

Paraquat (Gramoxone): Post-emergent.

Sethoxydim (Poast): Post-emergent grass herbicide.

Simazine (Princep): Pre-emergent, used after planting.

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 waters the plants only and reduces weed growth in non-irrigated areas.

Biological control:
None known.

Critical Needs for Management of Weeds in Blueberries: Establishment

Research
- Seek products with different modes of action and for control of resistant weeds.
- Research organic methods for weed control (e.g., flaming, organic herbicides).

Regulatory
- Expedite registration of clopyralid (Stinger), oxyfluorfen (Goal), and S-Metolachlor (Dual Magnum).

Education
- Teach weed identification and scouting techniques to growers.

Nematodes
Several genera of plant-parasitic nematodes have been found in blueberry planting in Oregon and Washington: the dagger nematode (*Xiphinema* spp.), the stubby root nematode (*Paratrichodorus* spp.), the ring nematode (*Mesocriconema* spp.), the spiral nematode (*Helicotylenchus* spp.), the pin nematode (*Paratylenchus* spp.), and the root-lesion nematode (*Pratylenchus* spp.). The root-lesion and dagger nematodes are the most common.

The dagger nematode is an ectoparasite, which feeds along the root surface, but causes little or no direct damage. However, it is capable of transmitting tomato ringspot virus, which, even at low nematode densities, can negatively affect blueberry growth and productivity. Stubby root nematode, an ectoparasite, has been shown to reduce the root growth of blueberry cuttings in propagation beds. Ring, spiral, and pin nematodes are also ectoparasites but they have not been associated with blueberry plants of low vigor. Root-lesion nematodes enter roots and cause direct damage to root tissue.

Chemical control:
Note: Pre-plant soil fumigants, preferably in the fall, can be used for control of all the abovementioned nematodes. Growing a shallow-rooted grass crop for one to two years will bring nematodes to upper soil levels where fumigation can more easily control them.

Dazomet (Basamid): Expensive. Effective only if nematodes are within the tillage zone.

Dichloropropene (Telone II): Very good control, but not as good as methyl bromide.

Methyl bromide: The most effective fumigant available but it is becoming cost prohibitive and is to be phased out by 2005.

Sodium methyldithiocarbamate (Metam Sodium, Vapam): Dispersal a problem; if poorly dispersed, failure results.

***Cultural control*:**
Crop rotation: Plant blueberries in soil that has been fallow for at least two years.

Organic matter: Maintaining high levels of organic matter (sawdust or other mulch) in the soil will 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* (rapeseed, mustard) crops, which are not hosts for tomato ringspot virus and are poor hosts for dagger nematode, for one year. (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 nematode species affecting blueberries is unknown.

Critical Needs for Management of Nematodes in Blueberries: Establishment

Research
- Develop thresholds for all nematodes.
- Determine efficacy of ethoprop (Mocap), oxamyl (Vydate), and *Myrothecium verrucaria* (DiTera) for nematode control in blueberries.
- Determine efficacy of biologically based nematicides and bio-stimulants.

Regulatory
- Register ethoprop (Mocap), oxamyl (Vydate), and/or *Myrothecium verrucaria* (DiTera) if they prove effective.

Education
- Educate new growers on field sampling of nematodes.
- Once developed, educate growers about thresholds.

Budbreak through Bloom

In early spring, usually sometime in March, buds on plants that have been dormant will begin to open. Plants in the non-bearing phase will also begin to open at this time but are oftentimes 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 partially 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 will be in full bloom while leaves are still beginning to expand. Flowers open about two to three weeks after bud break and full bloom occurs about two weeks after that. Petal drop (when flowers fall to the ground at the end of the bloom period) begins about five to six weeks after budbreak.

Field activities that may occur during Budbreak 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
Strip blossoms from young plants (non-bearing phase)
Bring in bee hives for pollinzation
Frost control (e.g., sprinkler irrigation; products such as FrostGard)
Establish sod between rows
Manage row middles (mowing, herbicide application, disking)
Scout for vertebrate pests (add fencing if necessary)
Establish trellis system

Insects

Aphids

The green peach aphid (*Myzus persicae*) and *Fimbriaphis fimbriata* (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 probably reduce yield and fruit quality. Aphids have also been identified as the vector of blueberry scorch virus, which can cause plant death.

Chemical control:

Azadirachtin (Neem, Neemix, Azatin): Not much efficacy information available.

Beauveria bassiana (Mycotrol): Live fungal spores; efficacy poor or unknown.

Diazinon: While effective against aphids, cannot be used when blooms are present because of bee toxicity. EPA proposes to allow only one application of diazinon per season; its use will likely be restricted to pre-bloom, due to potential for pollinator kill.

Imidacloprid (Provado, Admire): Provides good aphid control.

Malathion: Effective but toxic to bees.

Methomyl (Lannate): Not very effective. Toxic to bees and, also, is a bee repellent.

Oils: Applied at early bud break. Apparently, not effective at the rate given on the label.

Soaps (M-Pede): Effective when coverage is good (must contact the aphid directly).

Cultural control:
None known.

Biological control:
Creation of habitat for beneficial insects or release of predatory arthropods such as ladybird beetles could prove beneficial.

Blueberry Gall Midge (*Dasineura oxycoccana*)
This is a newly emerging pest; its range and the extent of its damage is not well known. The adult blueberry gall midge is a very small fly, about one to three millimeters long, and reddish in color. The female midge lays eggs in either floral or vegetative buds just after bud swell, when bud scales are beginning to separate. Eggs hatch into larvae within a few days and begin feeding within the blueberry bud. Within a week's time, the bud is dead, having a dry, shriveled appearance, often crumbling when touched. Larvae are white to orange in color, very small, located within the bud, and difficult to see with the naked eye. Blueberry gall midge can reduce yields by destroying buds before they develop. There may be a few generations per year in a blueberry field.

Chemical control:
Note: Blueberry gall midge is not listed on any pesticide label.

Diazinon: Cannot be used when blooms are present because of bee toxicity. EPA proposes to allow only one application of diazinon per season; its use will likely be restricted to pre-bloom, due to potential for pollinator kill.

Malathion: Efficacy unknown; research needed.

Spinosad: Efficacy unknown; research needed.

Cultural control:
None known.

Biological control:
None known.

Leafrollers
The orange tortrix leafroller (*Argyrotaenia fransicana*) and the obliquebanded leafroller (*Choristoneura rosaceana*) are the most common leafrollers found in blueberry fields.

The adult orange tortrix moth is orange, about 1/2- to 3/4-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 3/4-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, if the winter is warm, they remain active and will feed on cane buds.

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Expensive and ineffective.

Bacillus thuringiensis (Bt): This product is preferred and most effective at this stage, when larvae are young and small. Bt has the advantage that it can be used when blooms are present because it is safe to bees.

Carbaryl (Sevin): Fairly effective.

Diazinon: Cannot be used when blooms are present because of bee toxicity. EPA proposes to allow only one application of diazinon per season; its use will likely be restricted to pre-bloom, due to potential for pollinator kill.

Methomyl (Lannate): Excellent efficacy but toxic to bees; cannot use when blooms are present.

Phosmet (Imidan 70W): 24c registration. Toxic to bees; cannot use when blooms are present.

Spinosad (Success, Entrust): Entrust is the organic formulation of spinosad.

Tebufenozide (Confirm 2 F): Effective on very young larvae.

Cultural control:
Pheromone traps are used to monitor male moth flight, which helps determine if and when an insecticide application should be made.

Biological control:
Naturally occurring predators and parasitoids exist but they alone do not keep leafroller populations under control.

Winter Moth/Bruce Spanworm (*Operophtera brumata, O. bruceata*)
Adults are mottled brown moths about one inch long. Female moths are wingless. Adults are active during the winter months; females deposit eggs in the cracks and crevices of the

blueberry canes during the winter months. Larvae hatch in early spring, where they feed on newly opening flower and leaf buds. Larvae can balloon into fields from neighboring trees and shrubs. 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. 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. Feeding damage to fruit buds can significantly reduce yields.

Chemical control:
Bacillus thuringiensis (Bt): Poor to fair effectiveness.

Diazinon: Cannot be used when blooms are present because of bee toxicity. EPA proposes to allow only one application of diazinon per season; its use will likely be restricted to pre-bloom, due to potential for pollinator kill.

Esfenvalerate (Asana XL): More research needed.

Methomyl (Lannate): Toxic to bees; do not use when blooms are present. Fairly effective.

Spinosad (Success, Entrust): This is a newer product and there is little grower experience with it. Toxic to bees until spray has dried. Entrust is the organic formulation.

Tebufenozide (Confirm 2 F): More research needed.

Cultural control:
Growers trim trees around field borders, as trees are also a preferred habitat of the winter moth and spanworm. They also scout in early spring for evidence of larvae and/or larval feeding. A pheromone for the male moth has been identified and shown to be an effective monitoring tool, but is not readily available.

Biological control:
Naturally occurring predators and parasitoids exist but, alone, do not keep populations under control.

Critical Needs for Management of Insects in Blueberries: Budbreak through Bloom

Research

- Study the biology, ecology, and management of the blueberry gall midge.
- Continue researching the biology, ecology, and management of winter moth/spanworm. Determine economic threshold.
- Determine the best timing of diazinon if only one application is allowed (currently allowed five applications).
- Identify alternatives for diazinon.
- Identify alternatives for aphid control, e.g., acetamiprid (Assail), pymetrozine (Fulfill).
- Develop phenology models for aphids, midge, leafrollers, and winter moth.

Regulatory

- Expedite diazinon alternatives when identified.

Education

- Educate growers about virus transmission (aphids management).
- Provide information to growers to enable them to indentify damage caused by gall midge.

Diseases

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. Infection causes shoot tips to become blighted and flowers turn brown or black. Under warm and rainy conditions, orange-colored spore masses may appear on the fruit.

Chemical control:
Azoxystrobin (Abound): Effective.

Boscalid + pyraclostrobin (Pristine): New registration, little grower experience.

Captan: Effective.

Captan + fenhexamid (Captevate): New registration and little grower experience but should be nearly as effective as captan.

Chlorothalonil (Bravo, Echo): Long PHI (42 days) limits its use to early bloom only. Performance in the PNW is variable; mostly ineffective. Cannot use during bloom and is not effective prebloom.

Cyprodinil+ fludioxonil (Switch): Effective.

Fosetyl-al (Aliette): Ineffective in the PNW during prebloom or bloom.

Pyraclostrobin (Cabrio): New registration, little grower experience.

Ziram: Effective but last application allowed is three weeks after full bloom, which minimizes its usefulness.

Cultural control:
Avoid overhead irrigation.

Biological control:
None known.

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; attacks one-year old wood. Cankers can kill

buds and, if a canker girdles the stem, the stem portion above the canker dies. Leaves turn orange and wilt after buds have leafed out.

Chemical control:
Fixed coppers (many brands): Some strains of the bacterium may be resistant to coppers.

Cultural control:
Growers scout for the disease and prune out diseased wood as soon as it is noticed.

Biological control:
None known.

Botrytis Blossom Blight (*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. Blossoms are sometimes covered with a dense mass of grey powdery spores. Pale brown lesions may form on young leaves. Infected succulent twigs turn brown or black, later bleaching to tan or grey.

Chemical control:
Note: Application of chemical controls begins at 5% bloom.

Bacillus subtilis (Serenade): Little grower experience. Botrytis is not on label but there may be some potential for control.

Benomyl (Benlate): Benlate is still labeled and available for use until existing stock is depleted. Effective if there is no resistance.

Boscalid + pyraclostrobin (Pristine): Very effective.

Captan: Effective.

Captan + fenhexamid (Captevate): New registration and little grower experience but should be effective.

Cyprodinil + fludioxonil (Switch): Very effective.

Fenhexamid (Elevate): Very effective.

Harpin protein (Messenger): Not effective.

Iprodione (Rovral): Excellent control if there is no resistance. However, Rovral label and iprodione tolerance may soon be cancelled for blueberries.

Ziram: Efficacy has been poor to moderate.

Cultural control:
Growers prune during dormancy to open the canopy for good air circulation. They also practice good weed control and use drip irrigation instead of overhead sprinklers, if possible.

Biological control:
None known.

Botrytis Fruit Rot (*Botrytis cinerea*)
Infection from this fungal organism occurs during bloom but remains latent until the fruit is ripe. Control tactics are implemented during the bloom and fruit development period. Fruit and fruit clusters are covered with dense powdery grey spores at harvest or post harvest.

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

Benomyl (Benlate): Benlate is still labeled and available for use until existing stock is depleted. Effective if there is no resistance.

Boscalid + pyraclostrobin (Pristine): Very effective.

Captan: Effective.

Captan + fenhexamid (Captevate): New registration and little grower experience but should be effective.

Cyprodinil + fludioxonil (Switch): Very effective.

Fenhexamid (Elevate): Very effective.

Harpin protein (Messenger): Not effective.

Iprodione (Rovral): Excellent control if there is no resistance. However, Rovral label and iprodione tolerance may soon be cancelled for blueberries.

Ziram: Efficacy has been poor to moderate.

Cultural control:
Growers prune during dormancy to allow good air circulation.

If overhead sprinklers are used, growers try to irrigate when water on plants has time to evaporate quickly. They use drip instead of overhead sprinklers, if possible.

Biological control:
None known.

<u>Godronia Canker</u> (*Godronia cassandrae,* asexual: *Fusicoccum putrefaciens*)
This disease is also known as Fusicoccum canker. It is the most serious canker 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 anytime between late spring and early fall.

Chemical control:
No fungicides are currently registered for this disease but Captan appears to have some activity against the fungus.

Cultural control:
Pruning can remove infected wood but is not a standalone solution.

Biological control:
None known.

<u>Mummy Berry</u> (*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% yield loss if infection is widespread. It can also affect the following year's crop.

Chemical control:
Note: Many products are labeled but fenbuconazole (Indar) is necessary for economic control; Indar is currently allowed under Section 18 registration (emergency exemption). Some pre-emergent herbicides (e.g., simazine) are known to destroy the apothecia.

Azoxystrobin (Abound): Efficacy unknown; more research needed.

Bacillus subtilis (Serenade): Poor control.

Boscalid + pyraclostrobin (Pristine): Efficacy in PNW unknown.

Captan: Efficacy is poor to fair.

Captan + fenhexamid (Captevate): Efficacy is poor to fair.

Chlorothalonil (Bravo, Echo): Provides suppression only. Fruit russeting will occur.

Cyprodinil + fludioxonil (Switch): Efficacy is poor.

Fenbuconazole (Indar): Excellent efficacy. Use allowed under Section 18 registration.

Lime sulfur: Applied to soil to destroy apothecia (spore cups) as they are developing. Organic approved. Efficacy is fair.

Pyraclostrobin (Cabrio): Provides suppression only.

Triforine (Funginex): Excellent efficacy. Blueberries were dropped from label in 1996, but old product can be used if available.

Ziram: Efficacy is poor.

Cultural control:
Growers destroy developing apothecia (spore cups) by disrupting the soil under the plants and in alleyways by raking, mulching, or cultivating. Some apply the powdered formulation of urea fertilizer to burn the apothecia, while others flame the ground underneath the blueberry plants for the same purpose.

Sanitation measures include destruction of cull piles near fields, controlling weeds, and letting birds feed on the mummified fruit after harvest.

Biological control:
None known.

Phomopsis Twig Blight (*Phomopsis vaccinii*)
This fungus overwinters on infected plant debris; infection occurs through flower buds and wounds from budbreak to bloom, causing twig, flower, or shoot dieback. Twig blight is not common in Oregon and Washington and growers usually don't treat for it.

Chemical control:
Azoxystrobin (Abound), boscalid + pyraclostrobin (Pristine), captan, and pyraclostrobin (Cabrio) are possible treatments should this disease begin to present a problem in Oregon and Washington.

Cultural control:
Avoid wounding or injuring plants.

Biological control:
None known.

Phytophthora Root Rot (*Phytophthora cinnamomi*)
This fungus resides in the soil and is transported in water and 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:
Fosetyl-al (Aliette): Foliar applications. Effective.

Phosphorous acid (Fosphite, Phostrol): Foliar applications. Effective.

Mefenoxam (Ridomil Gold): Applied to the soil at or after planting. It can also be applied to the soil in established blueberries. Effective, but resistance has been documented.

Cultural control:
Irrigation management: Avoid overwatering.

Biological control:
Biostimulants are available but efficacy is unknown.

Viruses
Blueberry scorch virus (BlScV)
Blueberry shock virus (BlShV)
Tomato ringspot virus (ToRSV)
Tobacco ringspot virus (TRSV)
Blueberry shoestring virus (BSSV)

Symptoms of these viruses are noticed during the early stages of flower and leaf growth. Leaf samples from suspected plants can be tested to determine if these viruses are present in the plant. ToRSV can be difficult to detect due to uneven distribution in the plant.

In plants infected with BlScV, 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 BlScV, plants do not recover; yields decline over time and blight symptoms appear year after year. BlScV is vectored by aphids. There are two types of strains of BlScV: the East Coast type (EC) or the Northwest type (NW). Both strains infect all cultivars of blueberry that have been tested. The EC strains cause symptoms in most cultivars with the exception of Jersey, while the NW strain does not cause symptoms in many cultivars or may cause a slight leaf yellowing but no necrosis of the blooms.

In plants infected with BlShV, flowers and young vegetative leaf shoots suddenly die when flowers are just about to open (shock reaction). The entire bush may be blighted but, more commonly, only a portion of the branches will show symptoms. Blighted tissues drop; as the season progresses a second flush of leaves is produced. By mid-summer, affected plants look normal except they produce little fruit. Plants may exhibit shock symptoms for one to three years and may be symptom-free thereafter, producing a normal fruit yield. Even though symptom-free, the plant still has the virus and can transmit it to other plants. Current laboratory tests indicate that all cultivars that have been grafted with BlShV recover from the symptoms and do not develop symptoms a second time.

Plants infected with ToRSV or 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.

ToRSV is vectored by the dagger nematode (*Xiphinema americanum*); soil tests will indicate if the nematodes are present. The cultivar Bluecrop appears to be resistant to ToRSV.

BSSV is aphid-transmitted and primarily occurs in Michigan. The virus causes strapped (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 (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.

Chemical control:
There are no chemical controls for BlScV, BlShV, or ToRSV. However, since BlScV is aphid-vectored, good aphid control strategies will help reduce the spread of this virus. ToRSV and TRSV are vectored by the dagger nematode. If the nematode is present in the soil, the infected plant can be removed and the soil treated with dazomet (Basamid), a granular soil fumigant. After a waiting period, a new plant can be planted in its place.

Cultural control:
Remove plants that show symptoms of *Blueberry scorch virus* (BlScV) and/or test positive for the virus.

Plant (or replant with) virus-tested, disease-tolerant cultivars; several cultivars, such as Bluecrop, Duke, and Jersey are known to be tolerant to Northwest strains of blueberry scorch virus.

Biological control:
None known.

Critical Needs for Management of Diseases in Blueberries: Budbreak through Bloom

Research
- Determine effectiveness of coppers for bacterial blight and resistance.
- Develop effective mummy berry control options.
- Develop organic control options for mummy berry and other diseases.
- Develop cultivar resistance to mummy berry and viruses.
- Develop modeling for disease control.
- Develop integrated program for mummy berry control.
- Identify new fungicides that have activity against Godronia canker.
- Determine reaction of newer cultivars to Godronia canker disease (greenhouse and field trials).

Regulatory
- Expedite registration of fenbuconazole (Indar) and propiconazole (Orbit) for mummy berry control.
- Develop and implement virus certification program.

Education

- Educate growers about the importance of aphid control to limit scorch virus.
- Educate growers about the different viruses and control options.
- Educate growers on fungicide resistance.

Weeds

Numerous annual and perennial weeds appear during the budbreak-through-bloom crop stage and must be prevented from getting established. Weeds like groundsel, chickweed, pigweed, and grasses may be present at budbreak. 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-emergent 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 budbreak), currently growing weeds are removed by hand hoeing or are treated with a contact herbicide such as paraquat (Gramoxone) or pelargonic acid (Scythe). Weeds that appear after a pre-emergent herbicide is applied in the early spring are often treated with a post-emergent herbicide like glyphosate (Roundup) or, if grasses are problematic, sethyoxdim (Poast). If a field is young and in a non-bearing stage (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, 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 indicates development of resistance and the need to select alternative weed management strategies or materials.

Chemical control:

2,4-D (Saber): Controls broadleaf weeds that have already emerged. Avoid contact with the blueberry plant. Damage to the blueberry plant can occur if label precautions are not followed.

Bentazon (Basagran): Non-bearing only. Post-emergent.

Clethodim (Select): Non-bearing only. Post-emergent grass herbicide. Good control of annual bluegrass.

Dichlobenil (Casoron): Must be incorporated if used after budbreak. It is more commonly used during dormancy.

Diuron (Karmex): Pre-emergent. Cannot use on plants within one year of planting.

Fluazifop (Fusilade): Non-bearing only. Post-emergent grass herbicide.

Glufosinate (Rely): Post-emergent. New registration and little grower experience.

Glyphosate (Roundup, others): Systemic, non-selective, post-emergent. Use as a directed spray application, avoiding contact with blueberry plant.

Isoxaben (Gallery): Non-bearing only.

Napropamide (Devrinol): Pre-emergent.

Norflurazon (Solicam): Pre-emergent; 60-day PHI limits use.

Oryzalin (Surflan): Pre-emergent.

Paraquat (Gramoxone): Post-emergent. Avoid contact with blueberry plant.

Pelargonic acid (Scythe): A non-selective, post-emergent, contact herbicide. Efficacy is best under warm conditions.

Sethoxydim (Poast): Post-emergent grass herbicide.

Simazine (Princep): Pre-emergent.

Terbacil (Sinbar): Pre-emergent.

Cultural control:
Cultivation between the blueberry rows is common.

Hand hoeing in the plant row has some efficacy against annual broadleaves, but is expensive.

Flaming likewise is fairly efficacious, but only against annual broadleaves.

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.

Critical Needs for Management of Weeds in Blueberries: Budbreak through Bloom

Research
- Develop data for efficacy of glufosinate (Rely).
- Identify products that are effective in controlling horsetail, Canada thistle, and yellow nutsedge.
- Identify effective biological controls.

Regulatory
- Expedite registration of clopyralid (Stinger).
- Shorten PHI for sethoxydim (Poast).
- Register fluazifop (Fusilade) and clethodim (Select) for use in bearing blueberries.
- Clarify regulatory status for acetic acid (vinegar), including organic status.

Education

- Continue educating growers on weed identification, weed biology, and the best time to control certain weeds.
- Educate growers about resistance management and herbicide modes of action.
- Educate growers about the vulnerable stages of hard-to-control weeds such as Canada thistle, yellow nutsedge, field bindweed, and horsetail.

Nematodes

Nematode control is not practiced during this crop stage.

Post-Bloom through Harvest

After blossoms have dropped, small green fruits begin to develop. Depending on the cultivar, the period of post-bloom to harvest lasts about five to six 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 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 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 three to five weeks. Only the ripe fruit is harvested, which necessitates harvesting the same plant three or four times during the harvest period.

Most blueberries grown in Oregon and Washington are machine-harvested and destined for processing; the remainder is 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, 55 to 75% of the harvested crop is processed. As fruit load becomes heavy prior to harvest, use of farm equipment in the fields is limited to avoid damaging or knocking fruit 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:

Scout for insects, diseases, and weeds
Fertilization (foliar feeding)
Post-emergent herbicide application
Hand weed in plant row
Fungicide application
Insecticide application
Irrigation
Mow or cultivate row middles
Hand harvest
Machine harvest
Remove bee hives from the field
Vertebrate control
Tissue testing (also after harvest)

Fruit thinning (for young plantings)
Apply fruit-maturing agents

Insects

Aphids
Aphids can vector the devastating blueberry scorch virus (which causes plant death), thus, control is important.

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Efficacy unknown.

Beauveria bassiana (Mycotrol): Poor efficacy.

Diazinon: Good to excellent efficacy, but EPA proposes to allow only one application of diazinon per season.

Imidacloprid (Provado, Admire): Provides good aphid control.

Malathion: Provides good aphid control.

Methomyl (Lannate): Poor to fair efficacy.

Oils: Fair to good efficacy.

Soaps (M-Pede): Effective when coverage is good.

Cultural control:
None known.

Biological control:
Some growers create habitat for beneficial insects and/or release predatory arthropods, such as ladybird beetles.

Box Elder Bug *(Leptocoris trivittatus)*
Box elder 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. There are no specific chemical controls for box elder bug.

Cherry Fruitworm (*Grapholita packardi* Z.)
The adult is a small, dark gray moth with brown bands on the wings; it lays its eggs on small, developing green fruit, beginning at about the time of blossom drop. The eggs hatch in about a week and the young larvae, white with black heads, bore into and feed in the developing fruit. As larvae feed and mature, they become pink with brown heads. This pest is not widespread in PNW blueberry fields but, where it is a problem, up to 25% of the berries may be destroyed or rendered unmarketable.

Chemical control:
Bacillus thuringiensis (Bt): Effective, especially when larvae are young and small.

Carbaryl (Sevin): Efficacy unknown.

Diazinon: Efficacy unknown; EPA proposes to allow only one application of diazinon per season.

Esfenvalerate (Asana XL): Efficacy unknown.

Malathion: Efficacy unknown.

Methomyl (Lannate): Efficacy unknown.

Phosmet (Imidan): Good efficacy.

Pyriproxyfen (Esteem): This is a new registration and growers don't yet have experience with it.

Spinosad (Success, Entrust): Good efficacy.

Tebufenozide (Confirm): Efficacy unknown.

Cultural control:
If possible, eliminate host species (cherries).

Biological control:
None known; parasitoid wasps may merit study.

Leafrollers
Orange tortrix leafroller (*Argyrotaenia fransicana*)
Obliquebanded leafroller (*Choristoneura rosaceana*)

At this stage of crop growth, the leafroller larvae feed directly on developing fruit and also can be a contaminant in harvested fruit.

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Expensive and ineffective.

Bacillus thuringiensis (Bt): Effective if larvae are small. Short PHI and safety to beneficials makes Bt a popular choice.

Carbaryl (Sevin, others): Fair efficacy.

Diazinon: Very effective, but EPA proposes to allow only one application of diazinon per season.

Malathion: Fair to good efficacy.

Methomyl (Lannate): Excellent efficacy.

Phosmet (Imidan 70W): 24c registration, fair to good efficacy.

Spinosad (Success, Entrust): Good efficacy.

Tebufenozide (Confirm 2 F): Effective on young larvae. The 14-day PHI limits its use prior to harvest.

Cultural control:
None known.

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

Lecanium Scale (crawler stage) (*Lecanium* spp.)
Immature scale insects leave their protective shells on the blueberry stems prior to harvest and crawl to leaves where they begin to feed. Feeding can stunt and distort shoot growth, cause witches-broom, and reduce fruit yield and quality. These insects are spread by wind, birds, harvest machinery, and human activity.

Chemical control:
Malathion: Efficacy unknown.

Pyriproxyfen (Esteem): New registration; little grower experience.

Oils: Fair to good efficacy, but use limited if close to harvest.

Soaps (M-Pede): Use limited if close to harvest. Efficacy unknown.

Cultural control:
None known.

Biological control:
None known.

Root Weevil (adults)
Black vine weevil (*Otiorhynchus sulcatus*)
Strawberry root weevil *(O. ovatus*)
Rough strawberry root weevil (*O. rugosostriatus*)
Obscure root weevil (*Sciopithes obscurus*)

Adult root weevils can cause serious economic losses as a contaminant in harvested fruit. Adults are snout-nosed beetles and, depending on species, about 1/2- to 3/4-inch long, black to brown in color. The adults emerge from the soil and appear in fields, generally after bloom. If undetected and left uncontrolled, the adults will lay eggs and enable populations to build that will be problematic the following year (the larvae feed on roots during the fall, winter and early spring and can reduce plant vigor or cause plant death in young plantings).

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Not effective.

Beauveria bassiana (Mycotrol): Efficacy poor.

Cryolite Bait: 24c registration. While this product offered fair to good efficacy, it was expensive and has been discontinued by the manufacturer.

Esfenvalerate (Asana XL): Fair efficacy.

Malathion: Efficacy unknown.

Cultural control:
For best control results, growers scout for adults to determine population and best time for treatment applications.

Biological control:
Parasitic nematodes can be applied to the soil for control of the larvae at this time but such treatment is usually done after harvest. Efficacy has been erratic or poor.

Critical Needs for Management of Insects in Blueberries: Post-bloom through Harvest

Research
- Develop attract-and-kill tool for box elder bug.
- Develop thresholds for cherry fruitworm, leafrollers, and root weevil adults and larvae.
- Study biology, ecology, and management of the cherry fruitworm and determine this pest's economic impact.

Regulatory
- Expedite registration of bifenthrin (Brigade, Capture).

Education
- Provide growers information about cherry fruitworm.
- Educate growers in insect pest identification.

Diseases

Alternaria Fruit Rot (*Alternaria* spp.)
This fungal organism infects blueberry plants beginning at the end of bloom and 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.

Chemical control:
Azoxystrobin (Abound): Good efficacy.

Captan: Good efficacy.

Pyraclostrobin (Cabrio): Good efficacy.

Boscalid + pyraclostrobin (Pristine): Good efficacy.

Cultural control:
Avoid wounding or bruising fruit during harvest.

Harvest frequently to avoid overripe fruit.

Cool berries rapidly after harvest.

Avoid overhead irrigation if possible.

Biological control:
None known.

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 (post-bloom to harvest). Infection remains latent until the fruit is nearly mature. Infection causes shoot tips to become blighted and flowers turn brown or black. Under warm and rainy conditions, orange-colored spore masses may appear on the fruit.

Chemical control:
Azoxystrobin (Abound): Very effective.

Boscalid + pyraclostrobin (Pristine): New registration with little grower experience, but results look very promising.

Captan: Good efficacy.

Captan + fenhexamid (Captevate): New registration and little grower experience but should be nearly as effective as captan.

Chlorothalonil (Bravo, Echo): Long PHI (42 days) limits its use to early bloom only. Performance in the PNW is variable; mostly ineffective. Cannot use during bloom and is not effective pre-bloom.

Cyprodinil+ fludioxonil (Switch): Effective.

Fosetyl-al (Aliette): Ineffective in the PNW during pre-bloom or bloom.

Pyraclostrobin (Cabrio): New registration with little grower experience, but results look very promising.

Ziram: Effective but last application allowed is three weeks after full bloom, which minimizes its usefulness.

Cultural control:
Growers avoid overhead irrigation and sanitize picking totes. Fruit is picked frequently and field heat is removed quickly.

Biological control:
None known.

<u>**Botrytis Fruit Rot**</u> (*Botrytis cinerea*)
Infection from this fungal organism occurs during bloom but remains latent until the fruit is ripe. Control tactics are implemented during the bloom and fruit development period. Fruit and fruit clusters are covered with dense powdery grey spores at harvest.

Chemical control:
Benomyl (Benlate): Benlate is still labeled and available for use until existing stock is depleted. Effective if there is no resistance.

Boscalid + pyraclostrobin (Pristine): Very effective.

Captan: Effective.

Captan + fenhexamid (Captevate): New registration and little grower experience but should be very effective.

Cyprodinil + fludioxonil (Switch): Very effective.

Fenhexamid (Elevate): Very effective.

Harpin protein (Messenger): Not effective.

Iprodione (Rovral): Excellent control if there is no resistance. However, Rovral label, and iprodione tolerance, may soon be cancelled for blueberries.

Ziram: Efficacy has been poor to moderate.

Cultural control:
Prune during dormancy to allow good air circulation. In addition, if overhead sprinklers are used, growers make every effort to irrigate when water has time to evaporate quickly from the plants. They use drip irrigation instead of overhead sprinklers, if possible.

Biological control:
None known.

Godronia Canker (*Godronia cassandrae,* asexual: *Fusicoccum putrefaciens*)
This disease is the most serious canker disease of blueberry, affecting only new wood. The fungus overwinters in cankers on infected bushes. New infections appear as small reddish-brown areas around buds and wounds. As cankers enlarge, the center turns gray and the margin remains 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 anytime between later spring and early fall.

Chemical control:
No fungicides are registered for this disease but Captan may have some activity.

Cultural control:
None known.

Biological control:
None known.

Viruses
Blueberry fruit drop disease
A new disease symptom has recently appeared in Pacific Northwest blueberries. 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 3-5 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 associated virus can be detected by laboratory tests but, based on sequence information, it is more like a fungal virus than a plant virus. The possibility of a systemic virus-infected fungal pathogen cannot be ruled out at this time.

Critical Needs for Management of Diseases in Blueberries: Post-bloom through Harvest

Research
- Identify other minor fruit rots.
- Develop forecasting model for anthracnose.
- Identify alternative (especially organic) disease control options.
- Develop efficacy and residue data for fenamidone (Reason) for Alternaria fruit rot control.
- Identify new fungicides that have activity against Godronia.

Regulatory
- Need shorter PHIs for some products.
- Consider machine-picked vs. hand-picked fruit when setting REIs.

Education
- None identified at this time.

Weeds

Weed management in bearing fields is limited during this time period. Weeds between the plant rows are either mowed or the ground is cultivated. Permanent grass sod between the blueberry rows are 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 sethoxydim (Poast). Grass and broadleaf weeds in the plant row can be removed by hand hoeing.

Chemical control:
Bentazon (Basagran): Non-bearing only. Post-emergent.

Clethodim (Select): Non-bearing only. Post-emergent grass herbicide. Good control of annual bluegrass.

Fluazifop (Fusilade): Non-bearing only. Post-emergent grass herbicide.

Glyphosate (Roundup, others): Systemic, non-selective, post-emergent. Directed spray application, avoid contact with blueberry plant.

Paraquat (Gramoxone): Post-emergent. Avoid contact with blueberry plant.

Sethoxydim (Poast): Post-emergent grass herbicide.

Cultural control:
Growers may cultivate between the plant rows and/or hand hoe weeds within the row.

Biological control:
None known.

Critical Needs for Management of Weeds in Blueberries: Post-bloom through Harvest

Research
- Develop efficacy data for glufosinate (Rely).
- Identify products that are effective in controlling horsetail, Canada thistle, and yellow nutsedge.
- Identify effective biological controls.

Regulatory
- Expedite registration of clopyralid (Stinger).
- Shorten PHI for sethoxydim (Poast).
- Register fluazifop (Fusilade) and clethodim (Select) for use in bearing blueberries.
- Clarify regulatory status for acetic acid (vinegar), including organic status.

Education
- Continue educating growers on weed identification, weed biology, and the best time to control certain weeds.

- Educate growers about resistance management and herbicide modes of action.
- Educate growers about the vulnerable stages of hard-to-control weeds such as Canada thistle, yellow nutsedge, field bindweed, and horsetail.

Nematodes
Nematode control is not practiced at this time.

Post-Harvest through Dormancy
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 five or six feet is maintained. Prunings are removed from the field and either burned or composted. Irrigation continues post-harvest but is discontinued as the days get shorter and cooler, and moist weather begins (usually sometime in October).

Field activities that may occur during Post-harvest through Dormancy:
Scouting for insects, diseases, and weeds
Applying herbicide (pre- or post-emergence)
Hand weeding in plant row
Applying fungicide (copper sprays)
Insecticide application
Irrigation
Mowing or cultivating row middles
Pruning
Soil fumigation prior to planting a new field
Soil & tissue testing
Vertebrate control

Insects
Aphids
Aphids can still be present in blueberry fields after summer harvest and into the early fall. Aphids vector the devastating blueberry scorch virus (which causes plant death) and, thus, control is important.

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Efficacy unknown.

Beauveria bassiana (Mycotrol): Efficacy unknown.

Diazinon: Efficacy good to excellent, but EPA proposes to allow only one application of diazinon per season.

Imidacloprid (Provado, Admire): Provides good aphid control.

Malathion: Good to excellent efficacy.

Methomyl (Lannate): Poor to fair efficacy.

Oils: Fair to good efficacy.

Soaps (M-Pede): Effective when coverage is good.

Root Weevil (larvae)
Black vine weevil (*Otiorhynchus sulcatus*)
Strawberry root weevil *(O. ovatus*)
Rough strawberry root weevil (*O. rugosostriatus*)
Obscure root weevil (*Sciopithes obscurus*)

Adult root weevils may still be present and laying eggs after harvest, especially if the blueberries are an early-season cultivar. Adult weevils are present primarily in June, July and August. Chemical controls are targeted at the adult weevils, as there are no chemical controls for the root weevil larvae.

Adults are snout-nosed beetles and, depending on species, about 1/2- to 3/4-inch long, black to brown in color; they are nocturnal and feed on leaves. After emergence from the soil, they feed for about four 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. In mild winters, the larvae can continue to actively feed through the dormant period. Larval feeding can reduce plant vigor or cause death in young plantings.

Chemical control for root weevil adults:
Azadirachtin (Neem, Neemix, Azatin): Not effective.

Beauveria bassiana (Mycotrol): Efficacy poor.

Cryolite Bait: 24c registration. While this product offered fair to good efficacy, it was expensive and has been discontinued by the manufacturer

Esfenvalerate (Asana XL): Fair efficacy.

Malathion: Efficacy unknown.

Cultural control:
Growers scout for adults to determine population and best time for treatment applications.

Biological control:
Parasitic nematodes can impact larvae if applied to the soil in the fall, but this technique is expensive and results are inconsistent. Efficacy is dependent on soil temperature and moisture.

Lecanium Scale (*Lecanium* spp.)
During dormancy, small, yellowish-brown, helmet-shaped scales can be found on blueberry stems and branches. These shells cover and protect scale eggs that will hatch into

"crawlers" the following spring and summer. Feeding by the immature crawlers causes stunted and distorted growth, witches' broom, and reduced fruit yield and quality.

Chemical control:
Azadirachtin (Neem, Neemix, Azatin): Efficacy unknown.

Diazinon: Tank mixed with oil. Effective.

Dormant oil: Oil suffocates the scale insects.

Pyriproxyfen (Esteem): New registration with little grower experience. Can tank mix with oil.

Malathion: Tank mixed with oil. Effective.

Cultural control:
Burn winter prunings.

Biological control:
None known.

Winter Moth (*Operophtera brumata*)
Adults are mottled brown moths about one inch long that emerge from the soil in the early fall from pupal cases. They fly and lay eggs during the winter months. Control strategies are targeted at the young larvae at budbreak but the eggs, also, can be controlled during the dormant period. Feeding damage to fruit buds by larvae causes a reduction in fruit yield.

Chemical control:
Dormant oil or dormant oil + diazinon: Oil sprays during dormancy suffocate the eggs and reduce the number of eggs that will hatch into larvae. The addition of diazinon increases egg mortality. EPA proposes to allow only one application of diazinon per season.

Cultural control:
None known.

Biological control:
None known.

Critical Needs for Management of Insects in Blueberries: Post-harvest through Dormancy

Research

- Continue research of soil-applied thiamethoxam (Platinum) and imidacloprid (Admire) for root weevil larvae control.
- Determine the correlation between winter moth pheromone trap counts and damage/yield loss. Determine economic threshold for winter moth larvae.
- Determine economic threshold for scale insects.

Regulatory

- Expedite registration of thiamethoxam (Actara, Platinum) for root weevil control.

Education

- Educate growers about scouting for scale insects, pruning to remove branches with scale, and the importance of burning the prunings.

Diseases

Subsoiling during dormancy increases drainage and can help reduce the effects of Phytophthora root rot, which effects plants during the active growing season.

Bacterial Canker (*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. One-year-old wood, or older, is attacked. Cankers can kill buds and, if a canker girdles the stem, the stem portion above the canker dies. Leaves turn orange and wilt after buds have leafed out.

Chemical control:
Make two applications with copper products in the fall, preferably the first week of October, and again four weeks later. Bacterial canker is also treated with copper in the spring.

Fixed coppers (many brands): Effective.

Cultural control:
Prune out diseased wood as soon as it is noticed.

Avoid over-fertilization and late-season fertilization.

Biological control:
None known.

Godronia Canker (*Godronia cassandrae,* asexual: *Fusicoccum putrefaciens*)
Symptoms and progression of this disease described in previous sections.

Chemical control:
No fungicides are currently registered for this disease but Captan may have some activity against the fungus.

Cultural control:
Prune and destroy (burn) branches with cankers. Train pruning crews to recognize cankers so they can be removed during pruning. 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 Management of Diseases in Blueberries: Post-harvest through Dormancy

Research

- Identify other minor fruit rots.
- Identify alternative (especially organic) disease control options.
- Identify new fungicides that have activity against Godronia.

Regulatory

- Ensure that growers are able to get burning permits when needed, to burn prunings infected with Godronia canker.

Education

- Develop a bulletin about Godronia canker, including the disease cycle and photographs showing the disease symptoms.

Weeds

Most fields are treated with a pre-emergence herbicide in the fall, after 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 "non-bearing" 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-emergent broadleaf herbicide. Avoid contact with the blueberry plant. Apply in the fall.

Bentazon (Basagran): Non-bearing only. Post-emergent.

Clethodim (Select): Non-bearing only. Post-emergent grass herbicide.

Dichlobenil (Casoron): Pre-emergent.

Diuron (Karmex): Pre-emergent. Cannot use on plants within one year of planting.

Fluazifop (Fusilade): Non-bearing only. Post-emergent grass herbicide.

Glufosinate (Rely): Post emergent. New registration and little grower experience.

Glyphosate (Roundup, others): Systemic, non-selective, post-emergent. Directed spray application, avoid contact with blueberry plant.

Hexazinone (Velpar): May be used on plants that have been in the ground for at least three years. Caution is advised as hexazinone has long soil residual.

Napropamide (Devrinol): Pre-emergent.

Norflurazon (Solicam): Pre-emergent.

Oryzalin (Surflan): Pre-emergent.

Paraquat (Gramoxone): Post-emergent. Avoid contact with blueberry plant.

Pronamide (Kerb): Pre-emergent.

Sethoxydim (Poast): Post-emergent grass herbicide.

Simazine (Princep): Pre-emergent.

Terbacil (Sinbar): Pre-emergent.

Cultural control:
Growers employ a variety of cultural practices during this crop stage including cultivation between the blueberry rows, hand hoeing within the plant row, flaming of weeds, and mulching within the plant row.

Biological control:
None known.

Critical Needs for Management of Weeds in Blueberries: Post-harvest through Dormancy

Research
- Develop efficacy data for glufosinate (Rely).
- Identify herbicides that are safer than 2,4-D to control broadleaf weeds in the grass sod between the blueberry rows .
- Identify products that are effective in controlling horsetail, Canada thistle, yellow nut sedge, and fireweed.
- Identify effective biological controls .

Regulatory
- Expedite registration of clopyralid (Stinger).
- Register fluazifop (Fusilade) and clethodim (Select) in bearing blueberries.
- Clarify regulatory status for acetic acid (vinegar), including organic status.

Education
- Continue to educate growers on weed identification, weed biology, and the best time to control certain weeds.
- Educate growers about resistance management and mode of action of herbicides.

- Educate growers about the vulnerable stages of hard-to-control weeds, such as Canada thistle, yellow nutsedge, field bindweed, and horsetail.
- Educate growers about weed mapping with GPS units.

Nematodes

Dagger Nematode (*Xiphinema americanum*)
The dagger nematode is a migratory ectoparasite found only in the soil (it does not enter the blueberry root). ToRSV is vectored by the dagger nematode; soil tests will indicate if the nematodes are present (populations are highest during the winter months). Plants infected with ToRSV exhibit poor vigor and shoot dieback. Circular chlorotic lesions may appear on the leaves and stems may have necrotic spots. Fruit quality and yield are severely reduced. Plant death may occur, especially in young plantings.

Chemical control:
If nematodes are present in the soil, the infected plant can be removed and the soil treated with dazomet (Basamid), a granular soil fumigant. Efficacy of dazomet is temperature dependent with best results occurring prior to cool winter rains. After a waiting period, a new plant can be planted in its place.

Cultural control:
None known.

Biological control:
None known.

Critical Needs for Management of Nematodes in Blueberries: Post-harvest through Dormancy

Research
- Develop thresholds for the dagger nematode.
- Determine efficacy of biologically based nematicides and bio-stimulants.

Regulatory
- None at this time.

Education
- Educate new growers on field sampling of nematodes.
- Educate growers on use of sodium methyldithiocarbamate (Metam Sodium, Vapam) for spot fumigation.

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 (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% 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.

Exclusion (netting the entire field) is by far the most 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 oftentimes impractical.

Chemical repellents, with methyl anthranilate or polysaccharide compounds as the active ingredients, are registered for use in blueberries but they have not provided satisfactory results. Methiocarb (Mesurol) was used with great success in the past but has not been available to blueberry growers since the late 1980s. Most blueberry growers would welcome the availability of this chemical or a product of similar efficacy.

Auditory frightening devices, such as cannons, sirens, and bangers, are commonly used in Oregon and Washington blueberry fields but offer only short-term control, as most birds become habituated to the sound. 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 being able to 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 the blueberry bushes has the potential to scare off birds from landing and feeding in the blueberry bushes but 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 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. Whatcom and Skagit counties in northern Washington have, in cooperation with dairymen in the area, a USDA trapping/poisoning program for starlings that has been somewhat successful. Unfortunately, their Canadian neighbors don't have such a program and flocks of starlings often cross the border into Washington blueberry fields. Another option for bird control is monitoring fields and shooting birds as they fly into the blueberries. If not a protected species, nuisance birds 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.

Providing perches for raptors around the blueberry field is common but provides only partial control of nuisance birds. Some growers have hired falconers for bird control but this practice is prohibitively expensive.

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 they 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 for use 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, also known as field mice, 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. 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 one inch in diameter. Vole populations can be monitored by use of bait stations, which 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 two to five years. Severe vole damage can reduce plant vigor, lower fruit yields, and increase plant mortality.

Zinc phosphide bait pellets are registered for use in blueberries; broadcast application is allowed from after harvest until just before budbreak in the spring. 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 nor cost effective for large plantings.

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, and the most effective, are baits with methaldehyde as the active ingredient. Baits containing iron phosphate as the active ingredient are also available and have the added benefit of being approved for organic production. Limited experience in the Pacific Northwest with this relatively new active ingredient for slug control in blueberries is insufficient, at this time, to make a comprehensive efficacy comparison to metaldehyde. Baits can be applied broadcast or in a band, but 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 egg-laying adult slugs.

Trellising the blueberry plants keeps branches 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 with some success in small, organic blueberry fields.

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Activity Table for Oregon and Washington Blueberries

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 matter 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								
Remove bees from field					XX	XXXX						
Replanting (if necessary)									XXXX	XXXX		
Soil testing (for nutrients)	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	XXXX		
Check leafroller trap count			XX	XXXX	XXXX	XXXX						
Flaming for weeds	XXXX	XXXX	XXXX	XXXX								
Fungicide application	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Herbicide application	XXXX	XXXX	XXXX	XXXX	XXXX	XX			XXXX	XXXX	XXXX	XXXX
Insecticide application	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
Rodent control	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Scout for diseases	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Scout for insects	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Scout for mouse/vole 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
Samples for nematode			XXXX	XXXX					XXXX			
Slug control					XXXX	XXXX						
Soil fumigation (pre-plant)								XXXX	XXXX	XXXX		

Seasonal Pest Occurrence* for Oregon and Washington Blueberries

(*Time when the pest causes problems or is targeted for control)

Insects	J	F	M	A	M	J	J	A	S	O	N	D
Aphids				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	X		
Blueberry gall midge					XXXX	XXXX	XXXX	XXXX	XX			
Cherry fruitworm						XX	XXXX	XXXX				
Garden symphylan		X	XXXX	XX								
Leafrollers				XX	XXXX	XXXX	XXXX	XX				
Lecanium scale, crawlers			XXXX	XXXX								
Lecanium scale, dormant	XXXX	XXXX										XXXX
Root weevil, adults						XXXX	XXXX	XXXX				
Root weevil, larvae		XX	XXXX	XX					XX	XXXX	XX	
Winter moth (eggs)	XXXX	XXXX	X									XXXX
Winter moth (larvae)			XXXX	XXX								
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Alternaria fruit rot				X	XXXX	XXXX						
Anthracnose ripe rot			X	XXXX	XXXX	XX						
Bacterial canker/blight			XXXX	XXXX					X	XXXX	XX	
Botrytis blossom blight			XXXX	XXXX	XXXX	XX						
Botrytis fruit rot			XXXX	XXXX	XXXX	XX						
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							
*Tobacco ring spot			XX	XXXX	XXXX							
*Tomato ring spot			XX	XXXX	XXXX							
* This is when symptoms can be seen on the plant. See the narrative portion of this document for control methods and timing.												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual Grasses:												
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						
Perennial Grasses:												
Quackgrass	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Perennial ryegrass	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Annual Broadleaves:												
Common mallow					XXXX	XXXX	XXXX					
Common chickweed	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX
Dog fennel			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
Goosefoot				XXXX	XXXX	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				

	J	F	M	A	M	J	J	A	S	O	N	D
Knotweed, prostrate				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Lambsquarters				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Miners lettuce				XXXX	XXXX	XXXX	XXXX					
Mustards	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Nightshade, hairy/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		
Purslane					XXXX	XXXX	XXXX	XXXX				
Sheperdspurse	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Smartweed / Ladysthumb				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
Perennial Broadleaves:												
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	
Field bindweed				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
Red sorrel				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Willow	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Other weeds:												
Field horsetail	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Yellow nutsedge					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
***Nematodes**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Dagger		XX	XXXX	XX						XXXX	XX	
Pin		XX	XXXX	XX						XXXX	XX	
Ring		XX	XXXX	XX						XXXX	XX	
Root-lesion		XX	XXXX	XX						XXXX	XX	
Spiral		XX	XXXX	XX						XXXX	XX	
Stubby root		XX	XXXX	XX						XXXX	XX	
* Nematodes appear year-round but treatment for control usually occurs pre-plant in the spring or fall.												
Invertebrates and Slugs	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Birds						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	XXXX	XXXX	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX

Efficacy Ratings for INSECT Management Tools Against Blueberry Pests

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; ***** = used but not a standalone management tool; **blank space** = not used for this pest.

MANAGEMENT TOOLS	Aphids	Blueberry gall midge	Cherry fruitworm	Garden symphylan	Leafrollers	Lecanium scale	Root weevils	Winter moth	COMMENTS
Registered Chemistries									
Azadirachtin (Azatin, Neemix, etc.)	?	?	?	?	P	?	P	?	
Bacillus thuringiensis (Bt)			F		F-G			P-F	
Beauveria bassiana (Mycotrol)	P	?			?		P	?	
Carbaryl (Sevin, Carbaryl)		?	?		F				
Cryolite Bait							F-G		24c registration; marketing discontinued
Dazomet (Basmid)				P-F			P		PPI soil fumigant
Diazinon	G-E	G	?		G-E	F-G		G-E	
Dichloropropene (Telone II)				F-G			F-G		PPI soil fumigant
Esfenvalerate (Asana XL)	G	?	?		F-G		F	?	
Imidacloprid (Admire, Provado)	G-E								
Malathion	G-E		?		F-G	?			
Methomyl (Lannate)	P-F		?		E		?	F	
Methyl bromide				E			E		To be phased out by 2005; PPI soil fumigant
Oils (Superior, JMS, 6E)	F-G					F-G		F-G	Ratings for scale and weevils based on the addition of OP insecticide
Phosmet (Imidan)	F-G	?	?		F-G			F	24c registration
Pyrethrin (Pyganic)	?	?							
Pyriproxyfen (Esteem)						?			
Rotenone (Pyrellin)									
Soaps (Safer, M-Pede)	G					?			Thorough coverage is critical
Sodium methyldithiocarbamate (Metam Sodium,Vapam)				P-F			P		PPI soil fumigant
Spinosad (Success, Entrust)		?	G		G			?	
Tebufenozide (Confirm)			?		G			?	
Unregistered / New Chemistry									
Acetamiprid (Assail)	F-G						F		
Bifenthrin (Brigade, Capture)	G	?	G		G		G-E		
Fenpropathrin (Danitol)							F		
Indoxacarb (Avaunt)			G		G-E			G-E	
Novaluron (Diamond)		?			?			?	
Thiamethoxam (Actara, Platinum)	G						G		
Biological									
Lady bird beetles									
Parasitic nematodes							P		
Parasitoid wasps			?		?				
Cultural / Non-Chemical									
Adjacent area management			*					*	
Crop rotation				*					
Enhancing habitat for beneficials									Potential benefits exist for most foliar pests
Pheromone traps					*				
Tillage				*			*		

Efficacy Ratings for DISEASE Management Tools Against Blueberry Pests

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; **blank space** = not used for this pest; * = used but not a standalone management tool. (Note: Percent control does not represent a specific level of control based on research data but is based on field experience and usage response over time by growers and other blueberry industry representatives.)

MANAGEMENT TOOLS	Alternaria fruit rot	Anthracnose ripe rot	Bacterial canker/blight	Botrytis blossom blight	Botrytis fruit rot	Godronia canker	Mummy berry (primary infection)	Mummy berry (secondary infection)	Phomopsis twig blight	Phytophthora root rot	Scorch virus	Shock virus	Tomato ring spot virus	COMMENTS
Registered Chemistries														
Azoxystrobin (Abound)	G	E		F	F	?	?	?	?					
Benomyl (Benlate)				G	G									Limited to stocks on hand
Boscalid + Pyraclostrobin (Pristine)	G	G-E		G-E	G-E	?	?	?	?					
Captan	G	G		G	G	?	P	F	?					
Captan + Fenhexamid (Captevate)	F-G	F-G		E	E		P	F						
Chlorothalonil (Bravo, Echo)		P-F					P	P						
Cyprodinil + Fludioxonil (Switch)	F	P-G		E	E		P	P						
Dazomet (Basmid)										P			F-G	PPI soil fumigant
Dichloropropene + Chloropicrin (Telone C-35)										G			G	PPI soil fumigant
Fenhexamid (Elevate)				E	E		F	F						
Fixed Copper (Bordeaux,Champ,Kocide)			G											Rating assumes no resistance
Fosetyl-al (Aliette)		P-G								G				
Harpin Protein (Messenger)	?	?		P	P				?					
Iprodione (Rovral)	G			G-E	G-E									Rating assumes no resistance
Lime sulfur							F							Rating based on application to the soil
Mefenoxam (Ridomil Gold)										G				Rating assumes no resistance
Methyl bromide + chloropicrin										G-E			G-E	To be phased out by 2005; PPI soil fumigant
Phosphorous acid (Fosphite, Phostrol)		G								G				
Pyraclostrobin (Cabrio)	G	G-E		F	F	?	?	?	?					
Sodium methyldithiocarbamate (Metam Sodium, Vapam)										P			P-F	PPI soil fumigant
Ziram	F	G		P-F	P-F		P	P						
Unregistered / New Chemistries														
Bacillus subtilis (Serenade)			?				?	F						
Famoxadone + Cymoxanil (Famoxate)	?	?		?	?	?	?	?	?					
Fenamidone (Reason)	F	?		?	?	?	?	?	?					
Fenbuconazole (Indar)							E	E						Section 18 for mummy berry
Fluazinam (Omega)	G	G		?	?	?	?	?						
Propiconazole (Orbit)							E	E						

MANAGEMENT TOOLS	Alternaria fruit rot	Anthracnose ripe rot	Bacterial canker/blight	Botrytis blossom blight	Botrytis fruit rot	Godronia canker	Mummy berry (primary infection)	Mummy berry (secondary infection)	Phomopsis twig blight	Phytophthora root rot	Scorch virus	Shock virus	Tomato ring spot virus	COMMENTS
Pyrimethanil (Scala)	?			?	?	?	?	?						
Thiophanate methyl (Topsin-M)				G	G			F						Rating assumes no resistance
Triforine (Funginex)							E	E						Limited to stocks on hand
Biological														
Bird feeding on fruit							*							
Cultural / Non-Chemical														
Adjacent area management			*				*	*		*	*			For mummy berry, eliminate cull piles
Frequent harvests (to avoid overripe fruit)	*	*			*									
Insect control											G			Scorch virus is vectored by aphids
Irrigation management	*	*			*					*				
Maintain/enhance drainage										*				
Nematode control													E	Virus is vectored by the dagger nematode
Nitrogen management			*											Avoid late-season fertilization
Planting stock										*	*	*		Certified stock not available but nursery may be testing for viruses and root rot
Pruning			*		*	*								
Resistant/tolerant cultivars			*								*			Some cultivars are tolerant of scorch virus
Sanitation		*					*							Sanitize picking totes between uses
Sawdust mulch							*							
Soil solarization										*				
Weed control			*	*			*	*					*	Weeds are secondary host for dagger nematode

Efficacy Ratings for WEED 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; **blank space** = not used for this pest; ***** = used but not a standalone management tool. Note**:** Weed size or stage of growth is an important consideration with most post-emergence herbicides. In "Type" column, Pre = soil-active against pre-emerged weeds, Post = foliar-active against emerged weeds.

	Annual Broadleaves																				
MANAGEMENT TOOLS	**Type**	**Common mallow**	**Common chickweed**	**Dog fennel**	**Goosefoot**	**Groundsel**	**Henbit**	**Knotweed, prostrate**	**Lambsquarters, commom**	**Miners lettuce**	**Mustards**	**Nightshade, black or hairy**	**Pigweed, redroot**	**Pineapple weed**	**Prickly lettuce**	**Purslane**	**Shepherdspurse**	**Smartweed / Ladysthumb**	**Sowthistle**	**Speedwell**	**COMMENTS**
Registered Chemistries																					
2,4-D amine (Saber)	Post	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	F-G	24c registration; used with caution
Bentazon (Basagran)	Post								F		G					F	F	G			Non-bearing only
Dichlobenil (Casoron)	Pre	F	G		G	G	G	G	G	G	G	G	G			G	G	G		G	
Diuron (Karmex)	Pre	P	G	G	F	F	G	F	G	G	G	G	G	G	G	G	G	F	F	P	Not for use within one year of planting
Glyphosate (Roundup)	Post	F	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	
Glufosinate (Rely)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	New reg; little experience
Hexazinone (Velpar)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
Isoxaben (Gallery)	Pre	G	G	F		G	G	G	G		G	G	G	G	G	G	G	G	G	G	Non-bearing only
Napropamide (Devrinol)	Pre	G	G		P	G	P	F	G	G	G	P	G	G	G	P	P	P	G		
Norflurazon (Solicam)	Pre	F					G	G	G	F	G	G				G	G	F			
Oryzalin (Surflan)	Pre	P	G	P	P	P	F	G	G	G	G	P	G	P	P		P	F	P		
Paraquat (Gramoxone)	Post	?	G	G	F	G	G	G	F	G	G	G	G	G	G	G	G	G	?	G	Controls seedling stage only of dog fennel and pineapple weed; controls only above-ground prostrate knotweed
Pelargonic acid (Scythe)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	Best in warm conditions
Pronamide (Kerb)	Pre	P	G	P	F	P	F	F	F	F	F	F	P	P	P		F		P	P	
Simazine (Princep)	Pre	F	G			F	G	G	G	G	G	G	G			G	G	F			
Terbacil (Sinbar)	Pre	G	G	G	G		F	G	G	G	G	G	F	G	G	G	G	G	G	F	
Unregistered or New Chemistries																					
Clopyralid (Sitnger)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
Flumioxazin (Valor)	Pre or Post																				
Iodomethane (Midas)	Pre	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	PPI soil fumigant
Oxyfluorfen (Goal)	Pre or Post	P	P	F	G	G	G	F	F	G	F	G	G	F	G	G	P	F			
S-metolachlor (Dual Magnum)	Pre											F-G	G			F					

MANAGEMENT TOOLS	Type	Annual Broadleaves																			COMMENTS
		Common mallow	Common chickweed	Dog fennel	Goosefoot	Groundsel	Henbit	Knotweed, prostrate	Lambsquarters, commom	Miners lettuce	Mustards	Nightshade, black or hairy	Pigweed, redroot	Pineapple weed	Prickly lettuce	Purslane	Shepherdspurse	Smartweed / Ladysthumb	Sowthistle	Speedwell	
Carfentrazone-ethyl (Aim)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
Biological																					
None																					
Cultural (Non-Chemical)																					
Disking		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	
Flaming		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
Irrigation management		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	Drip can reduce growth of weeds in areas irrigated unintentionally by other methods
Hand hoeing/weed eater		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
Mowing		P	P	P	F	P	P	P	G	P	F	F	G	P	F	F	F	F	F	F	
Mulching		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
Tillage		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	

MANAGEMENT TOOLS	Type	Perennial Broadleaves									Grasses							Other		COMMENTS
		Blackberry	Buckhorn plantain	Canada thistle	Clovers	Curly dock	Dandelion	Field bindweed	Red sorrel	Willow	Annual bluegrass	Barnyard grass	Crabgrass	Rye grass	Fescues	Wild oats	Quackgrass (perennial)	Field horsetail	Yellow nutsedge	
Registered Chemistries																				
2,4-D amine (Saber)	Post	P	F	F	P	F	G	F-G	F											24c registration
Bentazon (Basagran)	Post			P-F															P-F	Non-bearing only.
Clethodim (Select, Prism)	Post										G	G	G	G	F	G	F-G			Non-bearing only
Dichlobenil (Casoron)	Pre		G	G			G	P-F	G		G	G	G	G		F	G		G	
Diuron (Karmex, Diuron)	Pre	P	P	P			P	P	G		G	G	F-G	G		P	P		P	Not for use within one year of planting
Fluazifop (Fusilade)	Post										P	G	G	F-G	P	G	F			Non-bearing only
Glyphosate (Roundup)	Post	G	G	G	G	G	G	F-G	G		G	G	G	G	G	G	G		F	
Glufosinate (Rely)	Post	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	New reg; little experience
Hexazinone (Velpar)	Post																			
Isoxaben (Gallery)	Pre		G		F-G	P-F	P-F	P-F												Non-bearing only
Napropamide (Devrinol)	Pre	P		P			F	P			G	F-G		G		G	P		P	
Norflurazon (Solicam)	Pre										G	G	F			G	P		F	

MANAGEMENT TOOLS	Type	Perennial Broadleaves									Grasses							Other		COMMENTS
		Blackberry	Buckhorn plantain	Canada thistle	Clovers	Curly dock	Dandelion	Field bindweed	Red sorrel	Willow	Annual bluegrass	Barnyard grass	Crabgrass	Rye grass	Fescues	Wild oats	Quackgrass (perennial)	Field horsetail	Yellow nutsedge	
Oryzalin (Surflan)	Pre	P		P			P	P			G	G	G	G		P	P		P	
Paraquat (Gramoxone)	Post	G	G	G	G	G	G	G	F		G	G	G	G	S	G	G		F	Controls above-ground plant parts only
Pelargonic acid (Scythe)	Post																			Best in warm conditions
Pronamide (Kerb)	Pre	P	P	P		F	P	P	F		G	P	P	G	G	G	G		P	
Sethoxydim (Poast)	Post										P	G	G	G	P	G	P		P	
Simazine (Princep)	Pre	P	G				G	P			G	F	P-F	G		F	P		P	
Terbacil (Sinbar)	Pre	F	G	P			F	P	G		G	F	G	G		G	F		P	
Unregistered or New Chemistries																				
Clopyralid (Stinger)	Post			E	E	?	E		?											
Flumioxazin (Valor)	Pre or Post																			
Iodomethane (Midas)	Pre	?	?	?	?	?	?	?	?		?	?	?	?	?	?	?	?	?	PPI soil fumigant
Oxyfluorfen (Goal)	Pre or Post	P	F			F	G	F	G										P	
S-metolachlor (Dual Magnum)	Pre												F-G	G			F		G	
Carfentrazone-ethyl (Aim)		?	?	?	?	?	?	?	?	?										
Biological																				
None																				
Cultural / Non-Chemical																				
Disking		F	G	P			F	P	G		G	G	G	G	F	G	P		P	
Flaming		P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	
Irrigation management		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	Drip can reduce growth of weeds in areas irrigated unintentionally by other methods
Hand hoeing/weed eater		P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	
Mowing		F	P	P			P	P	P		F	F	F	F	P	G	F		P	
Mulching		P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	
Tillage											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, more research needed; **blank space** = not used for this pest; ***** = used but not a standalone management tool.

MANAGEMENT TOOLS	Dagger	Pin	Ring	Root-lesion	Spiral	Stubby-root	COMMENTS
Registered Chemistries*							
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
Methyl bromide	E	E	E	E	E	E	PPI soil fumigant, to be phased out by 2005
Sodium methyldithiocarbamate (Metam Sodium, Vapam)	F-G	F-G	F-G	F-G	F-G	F-G	PPI soil fumigant
Unregistered / Potential Chemistries							
Iodomethane (Midas)	E	E	E	E	E	E	PPI soil fumigant
Myrothecium verrucaria (DiTera)	?	?	?	?	?	?	Biologically based nematicide
Biological							
None							
Cultural / Non-Chemical							
Cover crops	F	?	?	F	?	?	
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 previous crop, fumigation may only give fair control of viruliferous nematodes (i.e., a few viruliferous nematodes may survive fumigation and reinfect the blueberry planting with ToRSV).

Efficacy Ratings for VERTEBRATE and SLUG Management Tools Against Blueberry Pests

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; **blank space** = not used for this pest; ***** = used but not a standalone management tool.

MANAGEMENT TOOLS	Birds	Deer	Slugs	Voles	COMMENTS
Registered Chemistries					
Iron Phosphate (Sluggo)			?		
Metaldehyde (Deadline MPs)			G-E		
Methyl anthranilate (Bird Shield, ReJexiT)	P-G				
Polysaccarides (sugar solutions)	P-G				
Zinc Phosphide (Prozap)				G-E	
Unregistered / Potential Chemistries					
Aluminum phosphide				?	Works well in other crops; no data in blueberries
Biological					
Birds (owls, falcons)	*			?	
Geese			F, *		Most effective in small plantings
Cultural / Non-Chemical					
Fencing		E			Expensive
Netting	E				Expensive
Plant guards (for newly established plantings)				P-F	Impractical in large plantings
Reflective tape/ribbon	P				
Rodentenator (burrow blaster)				F	Expensive
Scare devices	P-F	F			
Shooting/destroying (as allowed)	P-F	P-F			
Trapping	F			P-F	
Trellising			F, *		
Vegetation management (weeds or grass strips)			F, *	F, *	

Toxicity Ratings for BENEFICIALS in Oregon and Washington Blueberries

Key to Beneficials:
BEB = Bigeyed bug (*Geocoris pallens*)
DB = Damsel bug (*Nabis alternatus*)
HB = Honey Bee (*Apis mellifera*)
LW = Lacewings (*Chrysopa* spp.)
LB = Lady beetles (*Hippodamia convergens*)
MPB = Minute pirate bugs (*Orius* spp.)
PM = Predatory mites (*Acari: Phytoseiidae*)
PN = Parasitic nematodes
PW = Parasitic wasps (*Ichneumonidae* and *Braconidae* families)
S = Spiders (*Arachnida: Araneae*)
SF = Syrphid flies
TF = Tachinid flies

Rating Scale: O = Non-toxic; **L** = Slightly toxic; **M** = Moderately toxic; **H** = Highly toxic; **ND** = No Data

	BEB	DB	HB	LW	LB	MPB	PM	PN	PW	S	SF	TF	Comments
Registered chemistries													
Insecticides / Miticides:													
Azadirachtin (Neemix, Azatin, Azatrol)	L	L	L	L	L	L	L	ND	L	L	L	L	
Bacillus thuringiensis (Bt)	O	O	O	O	O	O	O	O	O	O	O	O	
Beauveria bassiana (Mycotrol)	ND	ND	ND	O	ND	ND	ND	ND	O	ND	ND	ND	
Carbaryl (Sevin, others)	M	M	H	M	H	M	H	ND	M	M	M	M	
Cryolite Bait	ND	ND	O	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Diazinon	M	M	H	M	M	M	H	ND	L	M	H	ND	
Esfenvalerate (Asana)	M	H	O	M	H	H	H	ND	H	H	H	H	
Horticultural oils (stylet oil, others)	M	M	ND	L	L	M	M	ND	L	L	ND	ND	
Imidacloprid (Admire)	L	L	L	L	L	L	L	ND	L	L	L	L	
Imidacloprid (Provado)	M	M	M	M	M	M	M	ND	M	M	M	M	
Kaolin (Surround)	ND	ND	O	ND	ND	ND	L	ND	L	ND	ND	ND	
Malathion	M	M	H	M	H	M	H	ND	M	M	H	M	
Methomyl (Lannate)	H	H	H	H	H	H	H	ND	H	H	H	H	
Phosmet (Imidan)	L-M	L-M	M	M	M	M	M	O	M	M	M	M	
Pyrethrin (Pyganic, others)	M	M	O	L	M	M	H	ND	M	H	M	M	
Pyriproxyfen (Esteem)	O-L	O-L	ND	O	M	ND	O	ND	L-M	ND	ND	ND	
Rotenone (Pyrellin)	ND	ND	O	M	M	ND	H	ND	M	ND	ND	ND	
Soaps (M-Pede)													General mode of action may prove toxic to leaf-borne beneficials
Spinosad (Success, Entrust)	M	M	M	M	M	M	M	ND	M	M	M	M	
Tebufenozide (Confirm)	O	O	O	O	O	O	O	ND	O	O	O	O	
Soil Fumigants:													
Dazomet (Basamid)													Not toxic to foliage-borne beneficials
Dichloropropene (Telone II)													Not toxic to foliage-borne beneficials
Dichloropropene+chloropicrin (Telone C17, C35)													Not toxic to foliage-borne beneficials
Chloropicrin													Not toxic to foliage-borne beneficials
Methybromide-chloropicrin													Not toxic to foliage-borne beneficials

	BEB	DB	HB	LW	LB	MPB	PM	PN	PW	S	SF	TF	Comments
Sodium methyldithiocarbamate (Metam Sodium)													Not toxic to foliage-borne beneficials
Fungicides:													
Azoxystrobin (Abound)													ND for all
Boscalid + Pyraclostrobin (Pristine)													ND for all
Captan	ND	ND	ND	L	M	L	L	ND	L	ND	M	L	
Captan + Fenhexamid (Captevate)	ND	ND	ND	L	M	L	L	ND	L	ND	M	L	
Chlorothalonil (Bravo)													ND for all
Cyprodinil + Fludioxonil (Switch)													ND for all
Fenhexamid (Elevate)													ND for all
Fixed Copper (several brands)	ND	ND	ND	ND	ND	ND	L	ND	ND	ND	ND	ND	
Fosetyl-al (Aliette)													ND for all
Harpin Protein (Messenger)													ND for all
Iprodione (Rovral)	ND	ND	ND	ND	ND	ND	L	L	ND	ND	ND	ND	
Lime sulfur (Sulforix, others)													ND for all
Mefenoxam (Ridomil Gold)	ND	ND	ND	ND	ND	ND	L	H	ND	ND	ND	ND	
Phosphorous acid (Fosphite, Phostrol)													ND for all
Pyraclostrobin (Cabrio)													ND for all
Ziram	ND	ND	ND	ND	ND	L	ND	ND	ND	ND	ND	ND	
Herbicides:													
2,4-D Amine (Saber)	ND	ND	ND	O	L	ND	ND	ND	O-M	ND	ND	O	
Bentazon (Basagran)													ND for all
Clethodim (Prism)													ND for all
Dichlobenil (Casoron)													ND for all
Diuron (Karmex, Diuron)	ND	O	ND	ND	M	O	M	L	ND	ND	ND	ND	
Fluazifop (Fusilade)													ND for all
Glufosinate (Rely)	M	M	M	M	M	M	M	M	M	M	M	M	
Glyphosate (Roundup, others)	M	ND	ND	ND	ND	ND	H	ND	L	ND	ND	ND	
Hexazinone (Velpar)	M	M	M	M	M	M	M	M	M	M	M	M	
Isoxaben (Gallery)													ND for all
Napropamide (Devrinol)													ND for all
Norflurazon (Solicam)													ND for all
Oryzalin (Surflan)													ND for all
Paraquat (Gramoxone)	ND	ND	ND	ND	ND	ND	H	ND	ND	ND	ND	ND	
Pelargonic acid (Scythe)													ND for all
Proparnide (Kerb)													ND for all
Sethoxydim (Poast)													ND for all
Simazine (Simazine, Princep)	ND	ND	ND	ND	M	ND	L	ND	M	ND	ND	ND	
Terbacil (Sinbar)	ND	ND	ND	ND	ND	ND	M	ND	ND	ND	ND	ND	
Unregistered or New chemistries													
Insecticides/Miticides:													
Acetamiprid (Assail)	M	M	L-M	ND	M	ND	L-M	ND	M	ND	ND	ND	
Bifenthrin (Brigade, Capture)	M	H	H	M	H	H	H	ND	H	H	H	H	
Fenpropathrin (Danitol)	M	M	L	M	M	M	M	ND	M	H	M	M	
Indoxacarb (Avaunt)	L	L	L	L	L	L	L	ND	L	L	L	L	
Novaluron (Diamond)	ND	ND	ND	ND	ND	ND	O	ND	O	ND	ND	ND	
Thiamethoxam (Actara)	M	M	M	M	M	M	M	ND	M	M	M	M	
Thiamethoxam (Platinum)	L	L	L	L	L	L	L	ND	L	L	L	L	

	BEB	DB	HB	LW	LB	MPB	PM	PN	PW	S	SF	TF	Comments
Fungicides:													
Bacillus subtilis (Serenade)													ND for all
Famoxadone + Cymoxanil (Famoxate)													ND for all
Fenamidone (Reason)													ND for all
Fenbuconazole (Indar)													ND for all
Fluazinam (Omega)													ND for all
Propiconazole (Orbit)													ND for all
Pyrimethanil (Scala)													ND for all
Thiophanate-methyl (Topsin-M)													ND for all
Herbicides:													
Clopyralid (Stinger)													ND for all
Flumioxazin (Valor)													ND for all
Iodomethane (Midas)													ND for all
Oxyfluorfen (Goal)													ND for all
S-metolachlor (Dual Magnum)													ND for all
Biological:													
Parasitic nematodes													ND for all
Parasitoid wasps													ND for all
Predatory flies													ND for all
Cultural / Non-Chemical:													
Adjacent area management	ND	ND	ND	ND	ND	ND	ND	ND	H	H	H	H	May be hazardous if habitat removed
Certified planting stock													Neutral
Cover crops													Beneficial habitat, shelter and alternative prey
Cultivation													Short term disruption to soil dwellers
Enhancing habitat for beneficials													Beneficial habitat, shelter and alternative prey
Flaming													Hazardous to foliage dwellers
Hand hoeing	H	H	H	H	H	H	H	O	H	O	H	H	Hazardous to foliage dwellers
Irrigation management													Neutral
Maintain/enhance drainage													Neutral
Mulch (sawdust or other organic matter)													Neutral
Nitrogen management													Neutral
Resistant/tolerant cultivars													Neutral
Weed control													May remove habitat or alternative prey for some species of beneficials