General Production Information

- Washington produces about 40% of the USA’s sweet cherries (55% of those grown for fresh consumption) annually.

- Washington ranks first in the nation for sweet cherry production.

- As of 2001, there were 29,000 acres of sweet cherries in the state: 20,000 in full production and 9,000 non-bearing acres. Three hundred acres of Washington's sweet cherries are organically grown.

- For 1996 through 2000, annual production averaged about 78 thousand tons, with an average 60 thousand tons sold as fresh and the remainder processed as frozen or canned cherries. In 2001, 70,000 tons were sold on the fresh market while 30,000 tons were processed. It is predicted that sweet cherry production will reach 140,000 tons per year before 2008.

- Average sweet cherry production in Washington is five tons per acre with well-managed orchards producing between seven and ten tons per acre. Production of ten to fourteen tons is possible in newer orchards.

- The annual farmgate value of Washington sweet cherries is estimated to be between $130 and $180 million. The total value for packed boxes and processed product sales is $215 million. The value to the grower for an acre of cherries ranges from $4,000 to $14,000 with processing cherries worth 30% to 40% of the value of fresh market cherries.

- Annual production costs per acre for sweet cherries range between $6,800 and $8,300.

- One quarter of Washington's sweet cherry crop is exported annually.

Production Regions

The Crop Profile/PMSP database, including this document, is supported by USDA NIFA.
The major sweet cherry production regions are east of the Cascade Mountains in the central area of the state. The three primary sweet cherry production regions are the Yakima Valley, with 12,000 acres; the North Central (Wenatchee) district, with 9,500 acres; and the Columbia Basin, with about 4,500 acres of cherries. Twenty-eight percent of Washington sweet cherries are grown in Yakima County with another 18% grown in Chelan, 15% in Benton, 12% in Grant, 10% in Douglas, and 9% in both Franklin and Okanogan counties.

**General Information**

**Botany**

Cherry trees grow naturally to over 50 feet in height; they must be pruned severely to maintain a commercial height of 12-14 feet, the limit of practical harvest. Cherry trees are vegetatively propagated by budding onto rootstocks. In Washington, the highly vigorous Mazzard variety is typically used for rootstock. Mahaleb, another seedling rootstock that results in high tree vigor, is less popular, but may be used on sandy, overly well drained, and calcareous (chalky) sites.

The sweet cherry tree must experience sufficient winter chilling in order to properly break dormancy and bloom over a relatively few days in the summer. Most common sweet cherry varieties grown in Washington must experience a period of 800 to 1600 hours when temperatures are between about 55 and 35°F during the late fall and winter in order to bloom the following spring.

Flowers are borne on short spurs that develop on wood produced the previous season. Trees bloom the spring of the third season. Blossoms open in the spring about a week after those of peach trees and three to seven days before those of apple trees. The fruit ripens, depending on the local microclimate and cultivar, from 60 to 80 days after full bloom.

**Varieties**

As cherries are highly perishable and must be moved to market within a week to ten days after harvest, it is imperative that the state's crop mature over a long period of time. This is accomplished, as much as possible, by the planting of early, main season, and late-season varieties in the diverse growing regions from low to high elevations in the state. Orchards in the lower Columbia Basin and lower Yakima Valley (650-850 ft. above sea level) bloom as much as three or four weeks before those at highest elevations (3000 ft.) in North Central Washington. Warmer, long-season areas are best suited to early and mid-season varieties such as Chelan and Bing, while the more moderate and cooler regions are more likely to grow mid-season and late varieties, such as Bing, Van, Lambert, Lapins, and Sweetheart.
Post Harvest

About sixteen packing companies store, sort, box, and ship Washington sweet cherries during a season that starts about the second week of June and continues through the first week of August. Production peaks near July 4th. Packing houses in Washington are either privately or cooperatively owned and range in capacity from as few as 200,000 twenty-pound boxes to about one million boxes per season.

Sweet cherries are not stored. They are picked, packed, and consumed or processed as soon as possible. Cherries are hydrocooled upon receipt at the packinghouse to remove field heat. Bins are stacked three high and placed on a chain belt that moves through the hydrocooler. A 20°F reduction in temperature can occur when a hydrocooling unit of 20 feet is used. Either chlorine or chlorine dioxide is used to reduce the spore load in the cooling water. Fungicides are not applied at this time. If sweet cherries were stored, they would be subject to post harvest diseases and losses would approach 100%.

Production Costs

Production costs for sweet cherries range between $6,800 and $8,300 per acre. This breaks down as follows: picking labor - $2,600 per acre (it takes about 30 people a day to pick an acre of cherries.); yearly pruning - $350 per acre; packing and marketing - $3,500 to $4,900 per acre; and pest management - $440 per acre. Labor costs account for 44% of total production costs.

Organic Production

Organic sweet cherries constitute about 300 of the more than 29,000 cherry acres in Washington State. Low disease pressure from brown rot (Monilinia sp.) in the drier production regions allows Washington growers to produce cherries under organic methods relatively successfully. There have been recent concerns about cherry fruit fly because rotenone, the only effective organically approved spray product, has been removed from the market leaving growers with very limited, and relatively weak, organically accepted spray materials for cherry fruit fly control. As this pest has quarantines imposed against it in important domestic and foreign markets, there is great concern that it will force some producers out of organic production. Black cherry aphid has also been difficult to control with organic methods and materials and has forced several growers out of organic cherry production. In organic production, weed control can be managed by mechanical means or by flaming. Soil fertility management, while expensive, is generally accomplished through application of composted animal by-products, manures, or legumes.

The major impediment to growers who might wish to convert to organic production is the three-year mandatory conventional-to-organic transition period. During this transition, fruit must be sold under a conventional label, though the cost of production is often significantly increased by following organic production methods. While organic production is reported to be significantly more expensive and labor intensive than conventional production methods, prices received for organic sweet cherries are sometimes no better than those in the general cherry market.
Cultural Practices

Orchard Systems

Most Washington State cherry orchards utilize the Bing variety on Mazzard rootstock planted about 110 trees to the acre. Each tree is about 18 feet wide and 14 feet high, which makes pruning, spraying, and picking difficult and labor intensive. Large mature trees are highly productive; they are removed only when they become so damaged by winter cold and wood rots that the orchard is no longer profitable.

Orchards are replaced about every 30-35 years at a cost of $10,000 per renovated orchard acre. When changing orchards to new, more profitable trees, concerns about Specific Replanting Disease must be addressed. Replant disease is especially serious in older production regions where family farms predominate. Most orchards now being planted to cherries have supported apples for many years (see below). Replanting problems occur, but are less common and severe when cherries are planted after apples. The effects of Specific Replanting Disease are severe when cherries are planted on land that had recently produced any stone fruit crop. (See additional information on Specific Replanting Disorder in the disease section of this profile.)

The rate of apple orchard removal and subsequent replanting with sweet cherries has greatly increased in the 1990s, especially in 1998 through 2001. New cherry orchards are being added at a rate of 1,000 to 2,000 acres per year and this growth is expected to continue for the next few years. Some of these new orchards are planted more intensively, a few on dwarfing rootstock, a practice that remains experimental. These higher-density orchards are freestanding, as there are few advantages gained by using wire trellising. Production starts as early as the third season after planting, significant production may be attained in the fourth year, and full production is attained in the fifth to eighth year. (Pesticide labels referring to non-bearing trees now usually relate only to the first or second season after planting.)

Pollination

Cherries are dependent upon pollination by honeybees for fruit set. About one tree of every nine is a pollen source variety.

Production is predominately the Bing variety as these are considered the highest quality cherry and are in greatest demand in the market. As Bing is not self-fertile, other varieties such as Van and Black Republican were originally planted extensively as pollen sources. These varieties, however, are rarely sold at a profit to the grower. Presently, higher-value varieties, such as the early Chelan and the late season Rainier, Lapins, and Sweetheart have taken over as pollen sources and may soon constitute about 25-30 percent of production.
One to two hives per acre provide sufficient bees for good pollination. Hives must be placed at a time when an adequate number of cherry flowers are open to attract the bees; otherwise, the bees will forage for pollen elsewhere. Only one good day of pollination is necessary, but due to weather conditions affecting flower opening and bee activity, hives are generally left in the orchard for four to five days. One hundred percent of cherry producers contract with bee owners to provide hives. Bees are usually trucked from California to Oregon, then to Washington, then, finally, to Montana, following the cycle of blooming crops. Hives are rented at the rate of $20-$30/hive for one use, regardless of the number of contiguous days of that use. All growers are aware of their responsibility for bee health and of the dangers of bee poisonings and how to prevent them. Replacement costs of hives are $100, but the ill will generated from damage to the beekeepers’ livelihood or the neighbors’ pollination rate is far more expensive.

**Fruit Set and Thinning**

Fruit will not set unless it is fertilized by a compatible gamete after pollination, which in most cultivars, must come from another compatible cultivar. The percentage of flowers that are fertilized and remain to develop fully into fruit varies. A balance between best yields and quality usually occurs with about three to four fruit per fruiting spur. The availability of compatible pollen during the 2-4 day pollination window and the activity of pollinating insects affect fruit set. Other factors that may reduce fertilization and fruit set are frost; excessive heat, rain, or dry winds during bloom; and cold weather following pollination. Optimum conditions during bloom may result in excessive fruit set, which compromises fruit quality.

It is necessary for growers to regulate fruit set. This is generally accomplished through careful, relatively heavy pruning of the dormant tree. No Washington growers chemically thin their cherries, though research has recently produced some encouraging results with this technique.

**Irrigation**

The average orchard requires 42 inches of water per season, most of which must be applied mid-summer. Irrigation, at times, complicates pest management by triggering disease infection in specific blocks, or removing (washing off) protectant materials too soon after application.

**Crop Time Line**

The adjacent chart describes the typical timing and schedule for activities in a Washington State sweet cherry orchard.
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Insect Pests

WESTERN CHERRY FRUIT FLY

*Rhagoletis indifferens* (Curran)

Western cherry fruit fly is native to North America and has been found in the Pacific Northwest states since the 1940s. Even though it does very little actual damage to commercial fruit and is rarely found in commercial orchards, it is the most important pest of sweet cherries in Washington because of quarantine restrictions. Quarantine agreements with California and export market countries carry a zero tolerance for cherry fruit fly larvae in packed fruit. Washington State Department of Agriculture (WSDA) inspectors are stationed at each cherry packing facility during the harvest season to check fruit for infestation as it comes to the packinghouse, prior to acceptance, and again after packing. Fruit is rarely found to be infested. However, single larvae are found during inspections of fruit produced in Washington State’s sweet cherries from five to twenty times per season. When a larva is found, the entire load of infested fruit is rejected, and all other fruit from that grower is intensively inspected for signs of cherry fruit fly. While native cherry species have been reported as hosts, it is uncommon to find this pest on any tree other than sweet or tart cherry.

Control

Scouting/Predictive Models

The zero quarantine tolerance for cherry fruit fly has forced growers into intensive control programs to achieve perfect control. Commercial growers begin spraying when first fly emergence is detected by advisors on infested sentinel trees or when temperature-driven phenology models (Jones, et al., 1991) indicate emergence has commenced in the region. The phenology model has predicted first trap catch of adults on heavily infested trees very accurately during eight seasons of use in Washington State. Once growers commence spraying for cherry fruit fly control, they continue to spray every week to ten days,
depending upon the product used, until harvest is completed. Typically one or two sprays are applied post-harvest to disrupt the attack on unharvested fruit.

Control materials fall into two categories: knockdown and residual. Knockdown products kill the adults only if the substance contacts them during or very soon after application. Included in this group are pyrethrums, malathion ultra low volume applications (Malathion ULV), and spinosad (Success 2L). Knockdown products are usually applied by air or ground sprayer about every week to prevent egg laying. Residual products kill both by contact and by residual action, probably through ingestion as the adult cleans itself or feeds on the treated tree surface. Products in this group include carbaryl, diazinon, azinphos-methyl, dimethoate and phosmet. Dimethoate is the only product that can control the larvae developing inside unharvested fruit, thereby affecting the following year’s hatch. It is most effective when applied to the unharvested fruit within a week after harvest. Products that kill flies both by contact and residue are generally applied by air-blast sprayer every 10-14 days. Careful planning is necessary as harvest nears, because pre-harvest intervals, export restrictions, and control leading up to and during extended harvest must be taken into consideration. Most control failures occur in the last 10 days prior to harvest and during harvest. There is no evidence of resistance to any insecticide in the Pacific Northwest cherry fruit fly population.

Cultural Management

Growers use proper spacing and pruning of trees to improve insecticide spray application efficiency and coverage.

While traps can be effective control and/or monitoring devices for some pests in some crops, the traps currently available for commercial cherry orchards are not effective for these purposes. The traps are, however, successful when used to monitor first emergence of adults on infested trees.

Pest populations can be suppressed or eliminated by careful attention to harvest. Few cherry fruit flies will complete their life cycle if all fruit is picked and removed from the orchard each season early in the traditional harvest period. The author determined that from 10,000 to 20,000 fruit/acre remain in the average well-picked orchard after harvest. These fruit are sufficient to maintain endemic populations of this pest in the orchard, unless control is continued post-harvest. If all of the fruit is removed from an isolated tree or orchard, the subject becomes free of the pest until reintroduction. If fruit is abandoned in the orchard (as might be the case with rain cracking) and post-harvest pest management is neglected, cherry fruit fly populations often greatly increase and control is more difficult the next several seasons.

Chemical Control

**Dimethoate** (Digon 400, Dimate 4EC) - Dimethoate is applied to trees post-harvest in about 50% of Washington cherry orchards. This application is critical for cherry fruit fly control and is considered to be the most important spray of the year. The spray is important because dimethoate is the only product available that will kill the cherry fruit fly larvae inside the fruit. This application kills larvae in any
unpicked fruit in the orchard and it returns the in-orchard cherry fruit fly populations to zero. Cherry growers can then enter the next growing season with very low populations of cherry fruit fly. The post-harvest dimethoate application is made at a rate of 1.0 to 1.5 lb. a.i./acre. All applications are made with ground equipment.

**Azinphos-methyl** (Guthion Solupak 50W) - This product is applied by air-blast sprayer, usually once or twice per season. The number of applications necessary depends on the time to harvest, the number of possible cherry fruit fly sources near the orchard, and the destination market. Rates applied range from 0.5 to 0.75 lbs. a.i./acre per application. Residues of this product can control the pest for 10 to 14 days. Most cherry orchards are sprayed with this product at the "first cover" timing, soon after adults are detected, usually about four to five weeks prior to harvest. Azinphos-methyl remains the most effective residual control product, but residue concerns in specific important markets have reduced the number of orchards treated, and the number of applications per season. The PHI for azinphos-methyl is 15 days.

**Phosmet** (Imidan 70W) - Phosmet was first registered for use during the 2001 growing season. It controls cherry fruit fly as well as azinphos-methyl does, but it gained very little acceptance, as it was soon found to induce leaf drop, especially in certain varieties. This excessive leaf drop may be more likely if mineral oils are applied to the same trees for powdery mildew control. Phosmet is registered at 1.75 lbs. a.i./acre. The PHI of this material is 7 days.

**Carbaryl** (Sevin XLR Plus, Carbaryl 4L) - This product is applied at 2 pounds a.i./acre, one to two times per season. Usually the flowable formulation is used, as visible carrier residues from other formulations are often difficult to remove from the fruit during packing. This product is commonly used, is very effective, and is generally considered lower in toxicity than alternatives. The PHI for carbaryl is 3 days.

**Spinosad** (Success 2L) - This product is rapidly gaining popularity, but has had only three years (2000-2002) of use in cherry orchards. It is recommended at 0.0625-0.0938 lbs. a.i./acre. It appears to be quite effective, is expected to be "softer" on beneficial arthropods, and is relatively easy to use around foliage-contacting orchard laborers. Spinosad is narrow in its spectrum of activity, but may help reduce Western tentiform leafminers and various leafrollers. It will not help control scales, aphids, and Campylomma as common alternative products will. As it is considered a contact control product, good spray coverage is necessary. Spinosad must be sprayed at seven-day intervals to control emerging adults prior to their egg-laying maturity. It has a 7-day PHI.

**Malathion** (Malathion ULV) - Malathion is applied as an Ultra Low Volume aerial application at 1.22 lbs. a.i./acre and is considered a critical use for the following reasons: The ULV application is effective in controlling cherry fruit fly if carefully applied; it may be applied within one day of harvest. Harvest in orchards with a mixture of various cherry varieties may last from 7 to 14 days. If uncontrolled, newly emerged cherry fruit fly may commence egg deposition during harvest. The 1-day PHI of Malathion ULV allows application during harvest, while picking crews are out of the orchard for a day.
**Horticultural mineral oil** - Recent research has shown that a 1% emulsion of highly refined, narrow-range boiling point horticultural mineral oil may be effective as a cherry fruit fly suppressant. However, this product cannot be used by commercial cherry growers, as applying oil after the pit hardening stage will dull the finish of the ripe fruit, rendering it unfit for sale.

**Biological Control**

Few biocontrol agents for cherry fruit fly presently exist in Washington and none are effective in reducing the pest to zero levels. Populations develop to infest 100% of the fruit on unsprayed trees. Research continues to find parasitic and predatory nematodes that may be applied to attack the cherry fruit fly larvae or pupae as they drop from the tree and move into the soil under the tree. Efforts also continue to identify other effective predators and parasites.

**Leaf Rollers**

**Pandemis Leafroller, Pandemis pyrusana (Kearfott)**

**Obliquebanded Leafroller, Choristoneura rosaceana (Harris)**

Both the pandemis leafroller and the obliquebanded leafroller have increased their range and have become important secondary pests in sweet cherry orchards. It is likely that both were controlled during routine sprays for cherry fruit fly until they became resistant to many common insecticides.

Control of this pest is most certain if effective materials are applied during good weather in the pre-bloom period. Unfortunately, the weather conditions are not often optimal, and leafrollers remain on the trees into the summer. Control is also made difficult because growers and advisors find it very difficult to monitor this insect, and thus control thresholds are not established. Male leafrollers fly relatively long distances from native tree hosts, so trap catches do not illustrate the number of females that may exist in the orchard.

Control procedures are usually carried out based on the history of problems in the block, rather than on observed damage. Research continues to develop usable management methods and materials. Until these tools are better developed, this pest will remain a significant presence in cherry orchards.

**Chemical Control**

**Chlorpyrifos** (Lorsban 4EC) - Chlorpyrifos is commonly used for control of this pest on other tree fruits, but is not used on cherries after the dormant stage, as it may cause serious damage to the newly emerged foliage. Applications aimed at scales may have some limited effect on leafrollers, but the leafrollers usually remain inactive on the tree until a few days prior to bloom, when the tree is too far into its development for the safe application of this product. The recommended rate is 1 pint (0.5 lb. a.i.) per 100 gallons of water carrier, or up to 2.0 lbs. a.i./acre.
**Spinosad** - (Success 2L). Use of this product is rapidly increasing in Washington cherry orchards. It appears quite effective as a control for both leafroller and cherry fruit fly if applied at the correct rate and timing. Spinosad is expected to be "softer" on beneficial arthropods and relatively easy to use around foliage-contacting orchard laborers. It is narrow in its spectrum of activity, and will not control scales, aphids, and Campylomma as some alternative products will. It is recommended for leafroller control at 0.0938-0.125 lbs. a.i./acre, with the 0.125 lbs. a.i. rate expected to be more effective.

**Bacillus thuringiensis (Bt)** - This organism is toxic to insects in the Lepidoptera family if ingested in relatively large amounts. Sub-lethal exposure tends to retard the development of the treated individuals, but does not seem to reduce the damage they cause or their ability to reproduce. If applied during relatively warm temperatures, when larvae are feeding actively, control is quite satisfactory. The product has no impact on beneficial arthropods and kills only those Lepidoptera that are in the larval stage and feeding directly on treated foliage. Growers may apply Bt pre-bloom, at petal-fall, and during the larval stage of the first summer generation, which usually occurs mid-June through early July. Warm weather after application increases feeding activity of the larvae, greatly improving control. Unfortunately, warm weather is sporadic during the spring application season, and coverage of foliage is imperfect during the summer, so control of relatively high populations with this product is difficult.

**Cultural Control Practices**

Proper orchard design and pruning greatly improves spray application efficiency, which leads to improved chemical control.

**Biological Controls**

A great number of predators, parasites, and other beneficial organisms play a part in suppressing leafrollers. At times, this complex suppresses the leafrollers in small blocks very well, especially near native vegetation and later in the growing season. Unfortunately, under present management conditions, many biocontrol agents are killed by cherry fruit fly control efforts, so biocontrol is not at all dependable while fruit is present. Post-harvest, biocontrol is the only common practice.

**Concluding Remarks**

This pest causes very limited direct damage to cherry fruit. It is, perhaps, the most successfully controlled tree fruit pest in the Pacific Northwest. However, due to the large populations that survive on neglected trees, cessation of control efforts would lead to rapid infestation of commercial orchards, and complete loss of this major crop. Research continues to find better monitoring tools and less toxic control options.

**SCALES**
San Jose Scale, *Quadraspidiotus perniciosus* (Comstock)
European Fruit Lecanium Scale, *Parthenolecanium corni* (Bouche)

**San Jose scale** is an introduced pest that has been a potentially serious problem in Washington orchards for almost 100 years. It has a wide host range, attacking not only all tree fruits, but also a number of related native hosts. It is most troublesome in older orchards where spray coverage is difficult and in orchards that are near ornamental or native hosts that maintain uncontrolled populations. Low populations of this pest can seriously injure the cherry tree and may result in the culling of high percentages of the fruit. Infested trees have gumming, spur and twig dieback, and dead leaves that cling to the tree during the winter. The presence of scale on fruit is often considered a quarantine violation in international trade.

This scale overwinters on the tree and matures in the early spring. Males emerge from under their scale and mate with the females, which remain under their protective covering. Each female then produces several hundred live young (crawlers) over a six-week period. These crawlers disperse onto the twigs and fruit during June and July. These settle, develop a waxy scale cover, and feed by sucking sap from the tree. The scale mature and produce a second generation of crawlers, often in much higher numbers than the first generation, during August through October. These scale move into protected areas of the tree to overwinter.

**The European fruit lecanium scale** is common on tree fruits in the Pacific Northwest. It is most likely to be seen on stone fruits and numerous ornamental plants, and can be found less frequently on apples and pears. It is a relatively large scale, the dark brown shell often reaching 3 to 5 mm in diameter, several times the size of other tree fruit scales common to the region.

There is a single generation of this scale each year. They overwinter as nymphs, under the shell of the female that bore them the previous summer. They mature into adults during April; the males develop wings, while the wingless females form a protective shell. The males seek out females, mate with them, then die a short time later. The females lay eggs under the shell during May, and slowly waste away, dying by early June. From mid-May through early June, the eggs hatch into crawlers, which move to suitable feeding sites, usually on the undersides of leaves or on tender shoots. Before leaf fall, the nymphs move back onto current season shoots and settle for the winter, forming their large dark brown, hemispheric shells.

**Control**

**Spray Timing**

The San Jose scale is most vulnerable as the overwintering adult is maturing under the protective scale during the pre-bloom period in the spring. The summer crawlers are also likely to be controlled if contacted by insecticides. However, because their numbers may be high and spray coverage is generally poor, control of this stage is often not economical. The European fruit lecanium is also sprayed during
the delayed dormant stage of tree growth, but the insect is most vulnerable as the crawlers emerge from beneath the protective shell during mid-May through early-June. The peak spray timing occurs as most of the eggs have hatched and few crawlers have settled onto the leaves.

**Chemical Control**

**Horticultural mineral oils** are the most important scale control materials. These products are usually applied in the early spring, shortly after the tree has commenced growth, but prior to blooming, after the overwintering scale have broken their dormancy. The infested trees are usually sprayed with a 1 to 1.5 percent suspension of oil in water carrier adequate to fully cover the tree behind bark scales, crevices, pruning stubs, and other hard-to-contact areas where scales may be sheltered. The volume of water/pesticide mix varies from 60 to 400 gallons per acre, depending on tree size. Usual spray volume per acre is about 200-400 gallons. In almost all instances, the oil is mixed with an insecticide to improve the percentage control. This mixture is much more effective than either component used alone. This oil-insecticide mixture is also a very important part of the integrated mite management process.

**Chlorpyrifos** *(Lorsban 4EC)* - Chlorpyrifos is used at the delayed dormant stage for scale control. Spraying occurs prior to green leaf tissue emergence; later sprays may be phytotoxic to young leaves. Chlorpyrifos is usually applied with an oil. When it is mixed with oil and applied at this time, the mixture is also effective against many other important pests, especially European red mites. The emulsifiable concentrate formulation is usually used, as it is more practical to mix with horticultural oils. The recommended rate is 1 pint (0.5 lb. a.i.) per 100 gallons of water carrier, or up to 2.0 lbs. a.i./acre.

**Methidathion** *(Supracide 25WP)* - Methidathion can be applied at 1.5 lbs. a.i./acre with the mineral oil at the delayed dormant tree stage. This product is effective, but is seldom used as it is far more expensive than equally effective alternative products.

**Diazinon** *(Diazinon 50WP)* - Diazinon is used at 2 lbs. a.i./acre. This product may be used immediately pre-bloom to control black cherry aphid and will have an effect on scales if used at that time.

**Azinphos-methyl and carbaryl**, when used to control cherry fruit fly, may suppress scale in the summer crawler phase, but will not result in complete control.

**Alternatives**

Organic growers often spray with a fish oil emulsion in the spring, instead of horticultural mineral oil. The fish oil is very limited in supply, inconsistent in quality, and expensive. However, it works.

**Cultural Control Practices**

Pruning to keep trees in an open habit to improve spray coverage is the most effective cultural control practices. Small, young, well-sprayed trees rarely have scale problems.
Biological Controls

Some natural predators and parasites suppress, but do not control, San Jose scale. In regard to this insect, biological control is only supplemental to chemical control. On the other hand, European fruit lecanium is often held in check by predators and parasites, and increases to damaging levels only when these beneficial insects are suppressed by other spray programs.

TRUE BUGS

Lygus Bug, *Lygus lineolaris* (Beauvois)
Consperser Stink Bug, *Euschistus conspersus* (Uhler)
Green Stink Bug, *Acrosternum hilare* (Say)
Conchuela Stink Bug, *Chlorochroa ligata*

Insects in the true bug family that feed directly on fruit are a sporadic but especially difficult pest complex. They have been an increasing problem in Washington orchards grown near forest or brushy non-crop land. Some orchards have sustained damage in the rows adjacent to brush land. As the stink bugs usually move into orchards during the latter half of the growing season, cherries are often much less damaged than crops harvested later such as peach, pear, and apple.

This group of true bugs usually overwinters as adults and has one or two generations during the spring through late summer. They live mostly on native plant species in native brush land outside of the orchard, flying into the orchard as adults when their native hosts begin to dry and lose their fruits or other feeding sites. The adults damage the ripening fruit by piercing the skin with their beaks and sucking fluids from the flesh during the final two weeks prior to harvest. Damage appears as shallow, circular, spongy pockets in the fruit flesh, usually from 5-10 mm in circumference, and 5-8 mm in depth. The damage is often mistaken for pitting or bruising, and is easily overlooked on the tree, as only a few limbs of fruit on any tree may be affected.

Assessment of true bug population levels in the orchard is very difficult. Thresholds are not well established. There is no effective trap for most bugs; sweep nets or beating trays are not practical on trees with full-sized fruit. The bugs have good eyesight and move out of view if they see movement. Most pest scouts believe that if you see a few bugs there are likely many more present.

Control

Since this group of bugs matures outside of the orchard, growers have little opportunity to control them during the bugs’ nymph stages, when they are more vulnerable to sprays. Research has not yet developed a reliable trap to monitor populations in the non-crop land around orchards. There is some hope that adult bugs may be attracted by aggregation pheromones or by "trap crops" that are more
attractive to the population than the ripening apples, then killed by relatively inexpensive insecticides outside of the orchard. This process is being researched and has not yet been demonstrated to be effective.

Most control requires repeated applications of insecticide, especially along the borders of orchards, during the period of adult in-flight.

**Chemical Control**

**Endosulfan** (Thiodan 50WP) - Endosulfan is the only registered product that provides adequate control of true bugs. This product is used only rarely. Most growers do not spray to control this pest, as populations are low in the earlier part of the growing season when fruit is ripening. When it is used it is applied at 2.0 lbs. a.i./acre, usually only once a season. Application is made in early May, as the pre-harvest interval is 21 days.

**Alternatives**

None have been shown effective, though research continues.

**Cultural Control Practices**

Some growers have attempted to remove host plants from the brush lands bordering the orchard in an effort to reduce the build-up of the bug population during the spring and summer. This approach has had some very limited effect but does not provide adequate control.

**Biological Controls**

Bugs have many predators, parasites, and parasitiods, but seem to withstand them well. There are variations in the numbers of bugs moving into orchards from one season to another; it is possible that weather and biological factors influence these differences.

**TETRANYCHID MITES**

European Red Mite, *Panonychus ulmi* (Koch)
Two-Spotted Spider Mite, *Tetranychus urticae* (Koch)
McDaniel Mite, *Tetranychus mcdanieli* (McGregor)

The European red mite is the most common and potentially serious mite that attacks tree fruits in Washington. It was introduced into the state in the early 1900s and caused significant damage until the
1960s. It is currently present in most orchards, causing sporadic damage when biological control is disrupted.

European red mite larvae feed on the emerging leaf and flower tissue, preferring the undersides of the oldest leaves. The mites develop through two more nymph stages and mature into adults starting about the time of petal fall. When weather conditions warm in early summer, populations can develop rapidly. When numbers are high, the mites can spread downwind by "ballooning" on silken webbing.

The two-spotted and McDaniel mite species have very similar histories and life cycles, and they damage orchards in much the same way. Both have a relatively wide host range, especially the two-spotted mite. While two-spotted mite is recognized as a pest worldwide, the McDaniel mite is a problem mainly in the Pacific Northwest. Neither mite commonly causes problems in sweet cherries unless biological control is disrupted.

A relatively slow egg-laying rate combined with low numbers of overwintering adults leads to relatively successful biological control of these two mite pests by the Western predatory mite (*Typhlodromus occidentalis*) during the early growing stages. Numbers of two-spotted and McDaniel mites increase rapidly on the tree only if populations are not held in check by predators, if leaf surfaces become dusty, or if high populations build on excessive weed growth, then move up into the tree after the weeds are killed by herbicides. During warm summer months, the females can lay about 100 eggs during their 30-day lifetime, which greatly increases potential for flare-ups in mite numbers. Generations may take as few as 10 days to complete during warm weather, therefore may begin to overlap throughout the summer and fall. When weather cools in the fall, the orange overwintering females begin to form and migrate down the tree. If populations are very high, clusters of these females may form on the lower ends of pendant limbs, spinning heavy mats of webbing and dropping to the soil surface in clumps.

**Control**

Control of all mites on cherries depends mainly on the maintenance of predators; oils and miticides are used only when damage threatens to become economic. Note that the oils applied to control pest mites do not control the cherry rust mite (*Aculus fockeui*), which is not considered a pest unless populations become abnormally excessive. These rust mites serve as a food source for the Western predatory mite. The predatory mite population increases with this plentiful food supply and is high when the weather warms and red, two-spotted, and McDaniel mite populations begin to build.

The keys to a successful mite pest control program are:

1. reduce European red mite populations early with dormant oil,
2. maintain cherry rust mites as a food source for predators, and
3. maintain the predator mites with the application of appropriate insecticides or moderate rates of products that may be otherwise safe to predators.
This program of biological mite control was initiated on apples in the 1960s and is the standard in most Washington tree fruit orchards.

In the 1960s and 70s, many products killed predator mites when applied to orchards. Since the 1980s, these beneficial mites seem to have developed a variable degree of resistance to commonly sprayed products in many orchards. The use of most pyrethroid insecticides or the carbamate insecticide methomyl (Lannate) will currently disrupt mite control in most orchards, but higher rates of carbaryl or azinphos-methyl rarely cause problems. Today, growers use only those products and rates that will maintain mite predators in the orchard. The more common biocontrol disruption occurs following the over-control of rust mites in the early spring caused by repeated use of sulfur-containing materials, endosulfan, and carbaryl. None of these products used singly cause undue mite flare-ups, but when they are used in series, they may leave the trees relatively free of rust mites, leading to a lower food supply for the beneficial predator mites.

Chemical Control

**Horticultural Mineral Oil**, mixed at about 1.5 to 2 percent by volume in water, is applied in a volume that fully wets the tree surface (including sheltered areas) during the delayed dormant growth stage in late winter or early spring for control of European red mites. Dormant oil is often applied with an insecticide for control of San Jose scale at this time and the oil smothers the European red mite eggs, greatly reducing their survival. Lighter-weight mineral oils are sometimes applied during summer months to control excessive populations of two-spotted and/or McDaniel mites. About one percent oil by volume is the common application rate if oils are applied in the summer.

**Fenbutatin-oxide** (Vendex 50WP) - This product may be used in the summer at 0.5-1.0 lbs. a.i./acre for control of spider mites.

Cultural Control Practices

Growers pave or oil roads to reduce the amount of dust on orchard trees. Over-tree irrigation also seems to greatly reduce the numbers of mites and the damage that they do. Additionally, controlling weeds in the fall, greatly reduces the migration of two-spotted mites into orchard trees the following spring.

**APHID**

**Black Cherry Aphid, *Myzus cerasi* (Fabricius)**

Aphids are sporadic pests of cherries, but cause significant economic losses in some orchards almost every season, if not controlled. The black cherry aphid is the only aphid that commonly attacks cherry trees. Young, vigorously growing trees may develop high aphid populations on portions of the tree that
are developing into long-term structural wood, possibly reducing the value of that tree during its developmental years.

The black cherry aphid adult is black and is larger than most tree fruit-infesting aphids. Infested young leaves curl around the aphid colonies, protecting them somewhat from predators and sprays. Aphid colonies may seriously damage the fruit by deposition of honeydew, a sticky excretion that may lead to the growth of sooty mold. Heavy aphid populations can also damage fruit buds, reducing the crop potential for the next season. Plants of the mustard family act as alternate summer hosts for the black cherry aphid. The summer aphid colonies stay on the mustard hosts until fall, when they develop sexual stages, then move back onto the cherry trees to mate and lay eggs.

Early season monitoring and control is critical for the management of this insect. These aphids are more easily controlled when small and prior to the development of protective leaf curling. There is no research-based control threshold. Most managers spray if the orchard has a history of damage and aphids are evident.

**Chemical Control**

Chemical control options are limited and often have marginal effect on the target insect. Cherry trees break dormancy relatively early in the spring and growers may be reluctant or incapable of spraying at the optimum timing to control this pest. Cherry trees are somewhat sensitive to application of horticultural mineral oil when the weather is cold, so growers often wait until trees’ buds are well developed before they apply their first dormant spray. They often attempt to control multiple pests at this time, including scales, mites, bark beetles, and aphid.

**Endosulfan** (Thiodan 50WP) - Endosulfan is applied at 2.0 lbs. a.i./acre, usually only once a season, as the pre-harvest interval is 21 days. If applied to the tree as it breaks dormancy, this product will also control shot hole and ambrosia beetle, two other serious pests.

**Diazinon** 50WP is the other product most commonly used for black cherry aphid, as it is also effective in controlling scales when mixed with mineral oil. Diazinon is applied at 2.0 lbs. a.i./acre.

**Malathion** 8EC is registered but rarely used by the growers because it is phytotoxic to leaf and flower tissue. When it is used, it is applied at 3.0 lbs. a.i./acre.

**Cultural Control Practices**

Trees may be grown at a lower vigor level, a difficult balance between continued productivity of the tree, fruit quality, and reduced pest pressure. Low vigor trees are more likely to set lighter crops of smaller fruit.

**Biological Controls**
Lacewings, snakeflies, lady bird beetles, syrphid and other predaceous flies, earwigs, wasps, and numerous other insects all feed on aphids and play an important role in keeping their numbers in check. Some seasons they are numerous enough to maintain aphid populations below fruit damaging thresholds in the spring and early summer. Other years, they are not.

**LEAFMINERS**

**Western Tentiform Leafminer, Phyllonorycter elmaella** (Doganlar)

This insect was introduced into the Pacific Northwest in the late 1970s and spread throughout the apple production region during the 1980s and 90s. It can be found in all areas now. Its primary predator, the wasp *Pnigalio flavipes* (Ashmead) tended to spread with the leafminer across the state but did not build up to adequate levels until two or three years after the pest had entered a new region. Most areas of the production region have had a two- or three-year period over the past twenty when leaf damage due to this insect reached unacceptable levels in a high percentage of apple orchards. After the *Pnigalio* wasp built up in each region, outbreaks of the leafminer have been much less common. There have been sporadic but much less significant outbreaks of this pest in cherry orchards. The population of this insect is sometimes high early in the season but does not develop excessively during the summer and fall. If predators are present and not killed by poorly timed sprays during April and June, they will usually be sufficient to control the leafminers. Most advisors understand the threshold relationship between numbers of leafminers and their predator and take care to preserve the *Pnigalio* in the orchard. Few sprays are applied for the control of this insect.

**Chemical Control**

**Malathion/Methoxychlor Mixture** (2 lb./gallon of each active ingredient) - This mixture is applied at 2 quarts per acre (1 lb. a.i./acre each active ingredient) at the time of peak second-generation adult flight. This spray suppresses but does not completely control the adult population. Since adult leafminers emerge prior to emergence of the *Pnigalio* adults, the spray does not contact the beneficial insect, so most of the predators remain in the orchard to suppress escaped leafminers for the remainder of the growing season.

**Spinosad** (Success 2L) - This product has been used for cherry fruit fly control since 2001, and probably has incidental effect on leafminer populations in the cherry orchards. It appears quite effective when timed properly, is expected to be softer on beneficial arthropods, and is relatively easy to use around foliage-contacting orchard laborers. It is recommended at 0.0625-0.0125 lbs. a.i./acre.

**Biological Controls**
Biological control is the rule in most orchards, most seasons. Intervention is necessary only when the *Pnigalio flavipes* population is inadvertently killed or drops to very low numbers due to a lack of hosts. There are few alternate hosts for the *P. flavipes* in native plants and none within the orchard. This leads to a natural variation in the numbers of predators present, which may result in minor outbreaks that approach significant numbers in a low percentage of orchards about every three to five seasons. Careful timing of sprays aimed at the suppression of other pests and sprays that leave low populations of leafminers in the orchard maintain the biological control of this insect.

**BORERS**

**Shothole Borer, Scolytus rugulosus (Muller)**  
**Ambrosia Beetle, Xyleborus dispar (Fabricius)**

These insects are the major fruit tree bark beetles in Washington orchards. They cause far more damage in stone fruit than pome fruit orchards but can be found in any fruit species. Infested orchards can be economically damaged before the grower notices the shotholing signs of their presence. Both shothole borers and ambrosia beetles can cause significant tree damage every season in some orchards near native tree habitat. Otherwise, they are a sporadic pest that may build up in winter-injured trees or pruning woodpiles, then spread locally, damaging otherwise healthy trees in the neighborhood.

The shothole borer is the more common of the two insects. The larvae burrow as they exit the tree, causing extensive damage to the living interface between bark and wood. This can kill the tree or major limbs if the damage girdles the tree or the limb. The summer generation remains inside the bark to emerge the next spring or may emerge for a second, late-summer generation, causing damage in September and October.

Ambrosia beetles do not become active until daytime temperatures exceed 65° F. Females seek weaker trees or limbs, where they bore a main gallery tangentially into the wood. They lay eggs in short side galleries bored at right angles to the main access gallery. The young pupate, then develop into adults that remain inside the gallery until the next spring.

Control of these two pests is made difficult by the long periods they spend under the bark and by their extended emergence times. When adults begin flying in problem areas, sprays are applied every two weeks until the flight period is completed. Sprays that may kill adults usually control only a relatively small percentage of the generation, so must be regularly repeated in blocks that are under attack.

**Chemical Control**

**Endosulfan (Thiodan 50WP)** - Endosulfan is applied at 2.0 lbs. a.i./acre, usually only once or twice a season, due to label restrictions. It has a 21 day pre-harvest interval.
Other products may be used to control this pest, but have not been recommended due to lack of research-based information. The other possible choices include azinphos-methyl, chlorpyrifos, methoxychlor, and phosmet. These products are used by growers but are not recommended in the *WSU Crop Protection Guide For Tree Fruits*. It is impossible to legally spray endosulfan more than once or twice a season, so alternatives must be used when adult populations remain high over an extended period of time.

**Cultural Control**

These insects prefer weak or dying trees, so growers are advised to remove such trees or portions of trees. They are also advised to keep trees healthy and vigorous. When pest populations are high, even healthy trees will be attacked and may become vulnerable to subsequent infestations. There does not seem to be any significant biological control, as these pests are resident in natural, unsprayed trees outside of the orchard.

**Other Less Common Insects of Economic Importance**

Other insects cause sporadic damage to sweet cherries in some areas of Washington, including a number of leafrollers, fruitworms (green, *lacanobia*), cutworms, ten-lined June beetle, grape mealybug, fall webworm, oystershell scale, Pacific flathead borer, and grasshoppers.

A number of insects of great economic importance are not yet established in the commercial tree fruit production regions in Washington, including cherry bark tortrix and plum curculio.

**Diseases**

Cherries grown in the relatively dry climate of eastern Washington are generally much less affected by disease than those grown in warm, more humid, wet-summer regions. Diseases can cause severe losses in some seasons and in various growing areas. The most important economic losses usually occur as fruit rots in storage, many of which may be initiated on the fruit during the growing season. Some of the diseases discussed below damage fruit by marking it, some damage fruit by rotting it, and others damage or kill the tree. Generally speaking, control materials for diseases tend to be fairly specific to a limited number of diseases, and may have little or no effect on others. Control is often marginal, timing of application to prevent disease is critical, and control provided by spray materials may be of short duration. In many instances, the grower must treat before any signs of the disease are present, as sudden highly damaging epidemics can result from one skipped critical control application.

Powdery mildew of cherry is a potentially destructive disease in eastern Washington. Severe outbreaks occurred in Washington in 1987 and 1988, resulting in significant financial losses for many growers. The disease is common on cherry foliage, but can also attack fruit if rains occur late in fruit development. Although all commonly grown sweet cherry cultivars are susceptible to powdery mildew, in Washington the disease is most severe on the most widely planted cultivar, Bing. The severe epidemics that have occurred in the Wenatchee area have taken place during years with periods of excessive spring and early summer rainfall. In 1992, early spring was relatively dry; however, a significant rain period in early June resulted in the explosion of the fungus on cherry foliage.

Foliage, shoots, and fruit are susceptible to powdery mildew infection. The initial symptoms, frequently observed several days after shuck fall, are light-colored, roughly circular lesions on the surfaces of leaves in the inner portions of the tree. As the infections progress, sporulating mildew colonies appear on the leaf surfaces. Severely infected shoots are stunted and assume a contorted and/or blighted appearance. On ripe fruit, powdery mildew appears as a roughly circular, slightly depressed area on the fruit surface containing hyphae of the fungus. The fungus can be present in small, restricted areas or can cover the entire fruit. The disease does not spread in storage.

Infected leaves support the mildew spores that infect and ruin a fruit crop. Thus, to keep fruit free of powdery mildew, infection of the leaves must be prevented. There is no totally effective prevention or cure, but following a recommended fungicide spray program can forestall destructive epidemics. Growers access remote weather stations via WSU’s Public Agriculture Weather System, PAWS (http://index.prosser.wsu.edu/) to track rainfall and temperature. This data is fed into models to predict powdery mildew infection risk. Growers use this information to set preventative spray schedules. In other states where more effective fungicides are registered, the initial fungicide application can be made when foliar mildew symptoms appear. Applications of most fungicides commence at shuck fall and continue at 7-14 day intervals until harvest.

**Chemical Control**

**Sterol Inhibitor Fungicides** - This group includes myclobutanil (Rally) used at 2 ounces a.i./acre; fenarimol (Rubigan) 1.5 ounces a.i./acre; and propiconazole (Orbit) at 4 ounces product/acre. Fenarimol has lost popularity, as the powdery mildew fungus has developed resistance to the product in many areas. Myclobutanil may soon suffer the same fate. Horticultural oil, 0.25 to 0.5 percent by volume, in combination with these materials, enhances the activity of both products.

**Horticultural Mineral Oils** - Light, relatively safe, summer-weight horticultural mineral oils such as Stylet Oil, Omni-oil, and Saf-T-Side are rapidly gaining popularity as powdery mildew management tools in sweet cherry orchards. These oils are applied at 0.75 to 1.0 percent of spray volume, and 200 to 400 gallons of spray mixture per acre. Time of application is from early post-bloom through pit hardening and again within ten days after harvest. The post-harvest application greatly reduces the
carryover of the disease to the next season. Application to cherry fruit during the ripening period after pit hardening greatly reduces the gloss of the skin, rendering the fruit almost worthless. Certain cultivars, especially Lapins and Sweetheart, when sprayed with oil, are much more likely to excessively drop leaves when subsequently sprayed with insecticides.

**Sulfur Products** (numerous forms and rates) - Elemental sulfur products are usually applied at rates equivalent to 6 - 12 pounds of sulfur/acre. Lime sulfur is applied at 7.5 gallons product/acre and calcium polysulfide (Sulforix 27.5) at 2 gallons product/acre. During rainy years when disease pressure is high, more than two applications are needed as sulfur is only a protective fungicide and must be applied before the mildew spores reach the leaves or fruit. Products containing sulfur are often used in rotation with other fungicides to help prevent resistance development in the pathogen. Wetable or micronized sulfur must be used when temperatures are over 60° F to be effective, but use when temperatures are above 85° F may lead to fruit and foliage damage. Lime-sulfur or calcium polysulfide may be effective at lower temperatures, but are not recommended when temperatures exceed 75° F. Excessive use of sulfur products can reduce rust mite populations to levels incapable of supporting the beneficial Western predatory mites, leading to temporarily increased red or two-spotted mite populations.

**Azoxystrobin** (Abound) - This product is newly registered in Washington. While experience is limited, Abound is reported to be effective. Resistance management will be important. As the product is extremely phytotoxic to certain important apple varieties, it can not be applied where it might drift to adjacent apple orchards, nor in the same sprayer that might be used later to spray apples. Due to this, use is limited.

**Alternatives**

Soaps are sometimes applied to control powdery mildew. Results for soaps vary, but they provide a tank-mix option to both organic and conventional growers. Soaps are not commonly applied, as mineral oils have been far more effective, and safer to the fruit skin finish. Baking soda has proven to be quite ineffective. "Compost teas" have also failed to control this pest in replicated research trials.

**Cultural Control Practices**

The following practices aid in powdery mildew control: pruning trees to be more open to sprays, sunlight, and air movement; keeping irrigation water off developing fruit; and removing diseased sucker shoots about one month before harvest.

**Specific Replant Disorder** (a complex of pathogens)

Pathogenic soil organisms present in the soils of most mature orchards often reduce root growth of young fruit trees when the site is replanted. Poor root development leads to reduced vegetative growth
and poor fruit yields throughout the life of the replanted orchard. Replant disease is most common when cherries are planted after cherries or other stone fruits. Trees may be affected to varying degrees by this disease, which leads to more or less stunting of growth and lesser yields and fruit quality during the rest of the years the orchard remains in production. Although this disease may have a major impact to an orchard, trees never die as a direct result of this disease. Trees that are significantly affected by this disease are very unlikely to ever recover to produce average yields. Replant disease control can also be variable, leading to improved, but not adequate, tree growth.

There is a strong interaction between the quality of the soil, management of the young orchard, and pre-plant treatment relative to replanting success. While many soil fumigants, fungicides, fertilizers, and soil amendments have been tested for effect on the orchard replant disease, only three have so far shown long-term growth and yield benefits in Washington orchard trials: methyl bromide, metam sodium (or metam potassium), and fumigants containing chloropicrin. While other treatments may help early tree growth, the effect of replant disease becomes apparent again during the second or third season of growth. The end result of these temporary at-planting treatments is slightly larger, but still sick, trees.

**Chemical Control**

Certain soil fumigants have controlled Specific Orchard Replant Disease when properly applied. The positive effect of controlling this disease can be measured the first season and continues to be evident even 20 years after treatment. No soil treatments will effectively control replant disease problems after planting. Demonstration trials and thousands of acres of grower experience since the late 1960s have shown that soil fumigation usually, but not always, leads to excellent tree growth. Some fumigants must be custom applied, others may be applied by a certified private applicator.

**Metam Sodium** (Vapam, Soil Prep, Nemasol, etc.) or **Metam Potassium** (K-Pam) - The use rate for treatment of replant disorder is 31.5 gallons (104 pounds) a.i./acre. The entire orchard surface may be treated or, most often, the products are banded on about 40-50 percent of the orchard soil surface, i.e., where the trees will be planted. (The drive rows, in between trees, are left untreated when banding in this manner.) The product is carried into the soil by or mixed with sprinkler irrigation water. The rate of water carrier is adjusted to keep the product in the surface two or three feet of soil. Shortly after application, the product breaks down into the more active soil fumigant, methyl-isothiocyanate (MIT). This substance has low soil mobility, and breaks down into relatively non-toxic substances within several days after application. This product is the most practical for treatment of relatively small replant areas or in very rocky soils that cannot easily be treated by the shank injectors necessary with the other alternative fumigants. This will soon be the only product that may be applied by the grower. If properly applied, this product is generally as effective as other fumigants for the control of replant disorder.

**Chloropicrin** (usually applied in mixtures with 1,3-dichloropropene as Telone C-17 or Triform-35) - This product is shanked into the soil with special, custom-operated equipment at the rate of 45 to 100 pounds per acre. The rate depends on the history of replant problems in the block, the quality of soil preparation, and soil temperature. Because the chloropicrin moves only 6-9 inches from the point of
injection, it must be applied with equipment that places the product in numerous bands along and at various depths in the treated row. The 1,3-DD portion of the mixture will travel 3-4 feet from the point of injection, which provides control of more mobile organisms, such as nematodes and ten-lined June beetles that could rapidly move from the otherwise untreated drive-row area to re-colonize the treated tree row.

**Methyl Bromide** (Brom-o-gas) - Methyl bromide is usually applied at 400-600 pounds per broadcast acre. The fumigant is applied in bands, reducing this rate by half to a rate of one-half to one pound per tree planting site (55-110 pounds per acre). The broadcast applications are done by hired, professional, certified applicators. Tree-point applications can be done by the grower, but this is becoming less common, due to greatly increased cost of the product. This product is highly effective for the control of replant disorder and is the only one that can be applied easily to single tree sites, without expensive specialized equipment. Because it has longer residual effectiveness in soil than the other fumigant choices, methyl bromide is most often applied in late September or October of the season preceding planting.

**Other Options**

**Cultural**

If land is not replanted to orchard for about five seasons, tree roots are removed, and the land is either allowed to fallow or is planted to wheat or green manures, the replant disorder usually is no longer a danger. As family farms have limited acreage and may not have equipment to grow alternative crops, this is not an economically viable option for many farmers. Non-chemical control options include the replacement of soil in the planting hole with good quality soil from a non-orchard source. To be effective, research has shown the soil replacement should fill a planting hole 7 feet by 7 feet square and 2-1/2 feet deep. Soil replacement is not at all practical on a larger scale. Using less soil in a smaller planting hole helps the first season or two, but is not effective in the long term.

**Biological**

There are numerous theories in the popular press about potential biological and cultural control of Specific Replant Disorder. To date, no researcher has outlined an economical, successful alternative replanting method, proven over time in larger scale replanting of orchards that is nearly as effective as soil fumigation.

**Verticillium Wilt, *Verticillium dahliae***

This disease has caused damage in Washington sweet cherry orchards, but has been infrequent due to geographical separation between the historical sweet cherry production areas and the regions where this pathogen is most common. This fungus most often attacks potatoes and mint, two crops commonly
produced in the irrigated Columbia Basin district, a region that has recently planted thousands of acres of cherries. During the production of susceptible crops, the fungus builds to high levels in the soil. It is very likely that planting sweet cherries on land that once produced potatoes or mint will result in increasing problems with Verticillium wilt.

The pathogen, once established in the soil, remains dormant as tightly compressed fungal strands in small particles called "microsclerotia." These resting bodies may remain dormant from several to twenty years. Additionally, as certain common weeds are alternate hosts to Verticillium, populations can be maintained indefinitely.

*Verticillium dahliae* attacks the roots of host plants in the spring and infests the xylem. The fungus moves up the tree in the xylem tube, which often becomes blocked by the pathogen and the natural defensive structures formed by the tree. Low levels of infection may only cause minor damage that may be overgrown by the tree yearly, so disease symptoms may not appear. However, if a critical percentage of the xylem becomes blocked, the portion of the tree above that point may suddenly wilt in mid-summer, and leaves may turn yellow and brown, then drop as the season progresses. Other portions of the affected tree may appear perfectly healthy.

The amount of disease that appears in the orchard depends on the vigor of the trees, the relative number of Verticillium microsclerotia in the soil, and the age of the trees. Trees only show symptoms during their first few years of growth if disease pressure is extreme. Symptoms typically appear as the orchard comes into bearing and tree growth slows. The first significant losses are usually experienced in the fifth to seventh year after planting.

There is no cure for Verticillium wilt. Growers usually remove the dead and dying portions of affected trees. In this way orchards can continue with some tree loss, and declining yields. As portions of the trees are weakened by the disease, shot hole borer and ambrosia beetle may become special problems in affected orchards.

**Chemical Control**

Prior to planting sweet cherries on sites possibly contaminated by Verticillium, some growers are fumigating in the effort to reduce disease pressure. All of the fumigants described above in the Specific Replant Disorder section are possible choices for this effort. Experience with other host crops, such as potato, would indicate that fumigation will not eliminate the fungus from the soil. While there has been no research on this situation, it is likely that fumigation is beneficial in reducing the potential for and severity of this disease.

**Cultural**

None.
Bacterial Canker

*Pseudomonas syringae pv. syringae*

*Pseudomonas syringae pv. morsprunorum*

Bacterial canker is a significant disease affecting stone fruits in all world production areas. The same pathogen also may attack apples and pears and a wide range of hosts other than tree fruits. The disease is also called bacterial gummosis, *Pseudomonas* canker, and *Pseudomonas* blight. The pathogen may attack various parts of the tree, where it may be called blossom blast, twig blight, shoot dieback, or bacterial shothole. This disease has been difficult to study and control, as the pathogen is very widespread, lives as an epiphyte on the host and weeds, invades host tissues without inducing symptoms, and causes disease that has symptoms similar to those caused by other pathogens. Cherry trees are commonly hosts of the causal organism, but disease does not occur unless the climate is conducive and the host predisposed. Young cherry trees are the most seriously affected, as trunks are often girdled or severely damaged. Trees affected during the first three seasons after planting are often killed outright or grow so poorly that they must be removed.

There are two variants (pathovars) of the causal bacteria: *Pseudomonas syringae pv. syringae* attacks a wide range of commercial stone fruit cultivars and *Pseudomonas syringae pv. morsprunorum* attacks mostly cherry (sweet and sour) and plum. *P. syringae pv. syringae* is the more common pathovar in Washington.

The bacteria overwinter inside of host plants, usually along the edge of cankers that grew the previous season, or in infected but symptomless buds or other host tissue. Bacteria spread from overwintering sites to grow epiphytically on tree, leaf, flower and weed leaf surfaces. Moist, cool weather favors the spread and growth of bacterial colonies. Rain and wind serve as the primary means of local dispersal. Temperatures above the low 80s°F, dry weather, and low relative humidity cause a rapid decline in epiphytic populations of the bacteria, which survive the summer inside of host tissues. Temperatures over 95°F may greatly reduce the numbers of bacteria surviving inside of plant tissues.

Winter cold or spring frost injury may weaken plant parts and give systemic, symptomless bacterial colonies the conditions conducive to rapid growth, leading to disease symptoms. Frost, especially when closely followed by rain or heavy dew, leads to bacterial blast of blossoms. Winter injury, pruning during or within a few days prior to wet weather, or wounds may provide bacteria access to the cambium, where infections may lead to canker development. In areas of the world that have cool, wet winters, infection of pruning wounds during the fall or winter is common. Washington winters are cold, with precipitation falling mostly as snow. Infection is unlikely during below-freezing temperatures. Wounds are more likely to be infected in late winter through spring when temperatures are mild and trees may be wetted for several hours. Serious infections have occurred on young trees that were wetted by rain or irrigation within a few days of planting or after suckers were removed from trunks.
Symptoms caused by this pathogen on leaves, blossoms, and fruit, reported as common elsewhere, are rare in Washington cherry orchards.

**Chemical Control**

**Copper Hydroxide** - Most chemical control of this disease in Washington is based on fungicides containing copper. While there are many copper fungicides, a typical spray would be a 53% copper hydroxide at a rate of about 6 to 8 pounds per acre. Sprays are applied in late autumn, about the time that about half of the leaves have dropped from the trees. As infection is more likely to occur in spring in the drier parts of the state, some growers have applied all or part of their copper sprays in the late winter or pre-bloom in early spring. Recent tests, however, have shown that, depending on the area of the state, from 20 to 80 percent of *Pseudomonas* bacterial colonies are resistant to copper.

**Cultural**

As chemical control appears impractical, most growers try to prevent infection of their trees through cultural methods. Growers avoid training methods that require nails to tie down or spread young tree limbs. Planting, pruning, and training of trees is carried out during dry weather periods. Cherries are planted on sites with good air drainage, so as to avoid severe winter cold, frost, and heavy spring dews. Spring and early summer tree training is carried out after irrigation, so fresh wounds will not be wetted for at least three or four days.

**Other, Less Common Diseases of Economic Importance**

**Brown Rot (*Monilinia fructicola, or M. laxa*)**

The dry climate experienced in most Washington cherry production areas does not commonly bring brown rot infection conditions during the cherry bloom period. Most growers do not spray for this disease and have never seen it in their orchard. Brown rot can be a problem in the cooler, wetter parts of the state. Cherry production has recently expanded into the northern areas of central Washington, where spring rains are more usual. Here, brown rot has been a serious problem, especially in the tight-clustering late cherry varieties. During cherry blossom, when rain is expected, or has very recently occurred, growers in this brown rot-prone region apply fungicides. During the fruit ripening period, when brown rot may express symptoms by rotting fruit, some of the fungicides being applied to control powdery mildew may also control brown rot. However, spray material may not penetrate the tight clusters of cherries, therefore potentially infected cherries may not be treated.

When treatment is necessary, growers may apply one of the following fungicides: azoxystrobin (Abound), captan, fenbuconazole (Indar), iprodione (Rovral), sulfur, myclobutanil (Rally), or propiconazole (Orbit) at labeled rates.
Collar Rot (*Phytophthora* species)

This disease is caused by a fungus, *Phytophthora*, that lives in almost all soils. It attacks the roots and the trunk in the area immediately below the soil surface. The fungus kills the cambium of the roots and collar, cutting the roots’ access to the upper portion of the tree, causing gradual starvation and death of the tree. Symptoms include rust-colored darkening of the cambium just below the soil line and early purple coloration of the tree in the fall. This disease is most common on young trees. All common rootstocks may be attacked if the trees are in poorly drained soils, or if cold winters damage the roots and collar. Treatment options are usually started after symptoms are noticed in the orchard, which is often too late to save the more affected trees. The two products that seem to work best are fosetyl-aluminum (Aliette) and mefenoxam (Ridomil). Aliette is only registered for use on non-bearing cherry trees, so its applicability is limited. The mefenoxam must be applied as a drench around the root collar, which is almost impossible in an orchard. Because a drench is a relatively large volume of the mixture applied over a short amount of time, the liquid tends to run off as opposed to soak into the ground around the crown. If the product does not soak in deeply around the trunk area below the soil line, it is not effective. While the product does show as effective in research trials where the researcher applies it carefully a few times, it is not effective in the field. Fosetyl-aluminum may be applied to the foliage via sprayers, which is more efficient and appears to be effective.

Growth Regulators

**Gibberellic Acid**

Cherries treated about 3 weeks before harvest with gibberellic acid (GA$_3$) will be firmer, sweeter, larger, and less likely to develop pitting. However, GA delays fruit coloring, so harvest will commence a few days (3-5) later than in untreated blocks. This product is widely used by growers when earliness in the marketplace is not a major consideration. Its effects on harvest timing and product durability make it an important tool in lengthening harvest. GA$_3$ (Progibb 4%L or Progibb 40WSG) is applied at 10-30 ppm in sufficient water to fully wet the tree and fruit. This requires 1 to 3 pints of the 4% liquid or 3 - 4 ounces of the 40% WSG formulation per acre.

Weeds

Weeds are controlled in orchards to reduce crop competition for nutrients, improve irrigation patterns, improve water management, and improve pest management, including rodents, insects, and diseases. Weed control also includes preventing or removing blooming weeds from orchard floors to prevent bee kills when pesticides are applied.
Background

In orchards, herbicides are applied at a per-surface treated acre rate, but are banded only under the tree row, so actual rates applied per orchard acre are about 30-40% of the amount allowed per acre on the label. Herbicides are generally applied at lower than allowed per-acre rates to increase the margin of tree safety. The normal weed control program includes a combination of soil residual plus contact herbicides applied in the fall and possibly a mid-summer contact systemic if perennial weeds are a problem.

Most orchards are sprayed with a single-sided boom sprayer, with three or four flat fan nozzles placed about a foot apart, starting at the distant tip of the boom. The boom is adjusted so that the spray from each nozzle overlaps about 1/3 with its neighbor on both sides at the level of the target. The target can be either the weed growth (if growers are spraying contact herbicides) or the soil surface (if applying soil residual products). Some growers use single flood-jet style nozzles to apply contact materials on both sides of a tree row with a single pass by the sprayer.

Residuals

Cherries and other stone fruits are generally less tolerant of soil-active herbicides, therefore have fewer safe, registered product choices than other tree fruits.

Norflurazon (Solicam) - Norflurazon is usually applied at 1.6 to 2.4 lbs. a.i./acre (0.64 to 0.96 lbs. a.i./orchard acre). This product is most useful as a control for summer annual grasses, which are difficult to control with other available products. The product has a long residual so growers can reduce their application rate to 1.6 lbs. a.i./sprayed acre, 0.64 a.i./orchard acre, after the first year of use.

Oryzalin (Surflan) - This product is applied at 2.0 to 4.0 lbs. a.i./acre (0.8 to 1.6 lbs. per orchard acre). Oryzalin is the most effective and tree-safe product for use on newly planted or young orchards. It is often used where soils are sandy, rocky, and shallow, where a number of other residual herbicides would possibly cause tree injury. Manufacturing difficulties have made this product unavailable to growers during the 1998-2002 growing seasons.

Other residuals are not commonly used for the following reasons:

- Poor performance: pronamide (Kerb) and napropamide (Devrinol)
- Expense: dichobenil (Casoron) and isoxaben (Gallery)
- Difficulty of application: dichlobenil (Casoron) and oxyfluorfen (Goal)
- Use restricted to non-bearing orchards: pendimethalin (Prowl) and isoxaben (Gallery)

Contact, Non-Residuals
**Glyphosate** (Roundup, Touchdown, Glyphomax, others) - Glyphosate is usually applied at rates from 0.75 to 3.0 lbs. a.e./acre (0.3 to 1.2 lbs. a.e./orchard acre). Proper use of this product has eliminated most perennial weeds as a problem in most orchards. Glyphosate has been especially useful in control of perennial grasses and field bindweed, allowing growers to reduce the rates of residual herbicides. Some growers apply this product at very low rates in mid-summer to control weeds that have escaped earlier control efforts so that weeds remain small during the critical mid-summer harvest time. This product can not be safely applied to the trunks of younger, smaller orchard trees.

**Paraquat** (Gramoxone) - Paraquat is applied at 0.31 to 0.94 lbs. a.i./acre (0.125 to 0.38 lbs. a.i./orchard acre). This product is commonly used as a "chemical hoe" in younger orchards because lower rates and dilute solutions can be applied to the tree trunks safely. As it controls only small, emerged annual weeds, it must be applied to newly emerged weeds no more than 4-6 inches in height. Unless it is tank mixed with a residual herbicide, it must be applied as many as three to four times per growing season to maintain weed control in the young orchard. Because of the expense and because paraquat will not adequately control perennial weeds, it is rarely used in mature orchards.

**2,4-D** (amine formulations) - 2,4-D is used at a rate of 1.4 lbs. acid equivalent/acre (0.56 lbs. acid equivalent/orchard acre). As this product will not kill target weeds when applied at this rate at the proper timing, its use is declining. It is most used at the lower rate range in combination with other products, such as glyphosate, to enhance control.

**Cultural Control**

Mechanical weed control is used as an alternative to chemical control only in organic orchards or those converting to organic. Mechanical control disturbs soil, increasing the threat of soil erosion, and increasing the rate of organic matter breakdown. In addition, because orchard sprinkler systems must be designed to hang above the soil surface to allow mechanical weed control, most growers find it difficult to implement this method in a conventional orchard. Other weed control alternatives include plastic mulches. These have not worked well past the second season of use because they are very expensive and pose a waste disposal problem after they deteriorate. Some growers are experimenting with flaming, steam, or hot water sprays, which have not worked well yet. These methods may damage the trees, pollute the air, and lead to high use of fossil fuels. Flaming, for instance, requires about 20 gallons of propane per acre per application and as many as four applications per season.

**Biological Control**

Biological weed control plays almost no role in orchards.

**Rodents**
Short-tailed meadow mice (voles) can cause great damage to an orchard. During snowy winters they sometimes chew the bark off of the lower portions of trunks, especially on younger trees. While growers try to save these damaged trees with approach grafts or bridge grafts, these methods are very slow and expensive and do not always work well. Pocket gophers can also be a problem. There are no rodent poisons on the market that will economically control large populations of mice in the fall (as Endrin once did). Rodent control is a season-long effort, with the reduction of protection (i.e., cover) being the key component. Chemicals are employed infrequently in orchards or areas of orchard experiencing abnormally high rodent populations, typically in the fall.

Cultural Controls

The grass and weed cover crop within the orchard provides cover and habitat for rodents. As rodents do not travel far, well-mowed grass and a fairly clean weed strip is the most effective management program.

Trapping may be employed, but is a relatively labor-intensive way to reduce rodent populations. It can be useful in newly infested areas of the orchard where populations are low. Rodents migrating in from the non-orchard land near the orchard will usually penetrate no farther than the first row or two of the orchard, so added control efforts are often concentrated in this part of the block.

Chemical Controls

Zinc phosphide - Treated baits containing zinc phosphide are most commonly used for short-term, spot reduction of meadow mice in higher population areas of the orchard. These baits are applied in the fall, prior to wet weather. If the soil surface is wet, the active ingredient is rapidly diminished. Good coverage is important. If the bait is spread thinly, non-target animals are rarely excessively exposed. However, if the mice are under-exposed at first feeding, they become bait-shy and difficult to control.

Anticoagulants - A number of anticoagulant products are registered, mostly as baits, but one as a spray. The rodents must feed repeatedly to obtain a critical dose. These products are more active than zinc phosphide-based baits in wetter weather, but are generally considered less effective. The sprayed product is used in areas with high populations and poor prospects of adequate bait exposure. These baits are generally considered safe to non-target animals, but may cause occasional problems when pet dogs or cats consume an overdose of dead mice.

Strychnine - This product is available as a pocket gopher bait. It is placed by hand-held applicator inside the underground runways. This prevents the exposure of non-target animals to either the bait or the gopher carcass.

Biological Controls

Cats, dogs, snakes, predatory birds, and coyotes all help reduce the population of rodents. Without
biological controls, there would soon be many thousands of mice per acre of orchard. Cover management allows biological control to take place. The fear of predators keeps mice from living in relatively well-groomed orchards. The traps and chemical controls are necessary to lower the rodent population in those areas where biological controls have fallen short.

Critical Issues

Cherry fruit fly control, both in commercial and home orchards, is a critical issue for Washington sweet cherry production. As biological controls have been ineffective to date, improvements in cherry fruit fly control have recently centered on the assessment and registration of alternative spray control products. While formerly organic products such as rotenone and piperonyl butoxide have recently been taken off of the market, effective but less toxic products such as spinosad and chloronicotinyl-class insecticides are being registered. Horticultural summer weight mineral oils will control cherry fruit fly. However, use of these oils dulls the skin of the fruit, rendering it commercially unacceptable. Because most newly registered products have pre-harvest spray intervals of at least seven days, growers are left with few choices for cherry fruit fly control near and during harvest.

Most cherry fruit flies in the Pacific Northwest are found in non-commercial sweet or tart cherry trees planted in home orchards; control of these trees is a critical issue for Washington sweet cherry production. Few hobby orchardists have the knowledge, motivation, or equipment necessary to control this pest. Pest populations can be greatly reduced in a region by organized efforts to identify and remove these wild or neglected host trees. Local pest control boards play an important role in the control of cherry fruit fly in home landscapes.

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