

Chapter Five

DISEASES OF ORNAMENTALS

Facts on Ramorum Blight and Dieback (Sudden Oak Death-SOD) - A Quarantine Disease	3
AMELANCHIER spp. (Saskatoon berry)	5
Rust	5
Leaf and Berry Spot	5
ASH (<i>Fraxinus</i> spp.).....	5
Anthracnose.....	5
AZALEA (<i>Rhododendron</i> spp.) see <i>Rhododendron</i> page 24 and <i>Azalea</i> in Chapter 3	5
BULBS - GLADIOLUS (<i>Gladiolus hortulanus</i>).....	6
Corm Rot, Leaf and Flower Spot (Botrytis Rot).....	6
Stromatinia Neck Rot, Corm Rot or Dry Rot	6
Scab	6
Yellows and Corm Rot	7
BULBS - IRIS (<i>Iris</i> spp.).....	7
Bulb Nematode.....	7
Bulb Rot	7
BULBS - LILY (<i>Lilium</i> spp.)	8
Virus Diseases	8
BULBS - NARCISSUS (<i>Narcissus</i> spp.)	8
Basal Rot	8
Nematodes.....	9
BULBS - TULIP (<i>Tulipa</i> spp.)	9
Basal Rot	9
Breaking	9
Bulb Rot	10
Fire (Botrytis Blight)	10
Gray Bulb Rot	10
CLEMATIS (<i>Clematis</i> spp.).....	11
Leaf Spot and Stem Rot (Clematis Wilt).....	11
COTONEASTER (<i>Cotoneaster</i> spp.).....	11
Dark Berry.....	11
Fire Blight	11
Rust	11
Scab.....	11
Silver Leaf.....	12
CRABAPPLE (<i>Malus</i> spp.).....	12
Fire Blight, Powdery Mildew, Scab	12
Crabapple Cultivar Susceptibility	13
Rust	14
Silver Leaf.....	14
DOGWOOD (<i>Cornus</i> spp.)	15
Anthracnose.....	15
Collar Rot (Crown Canker)	15
ELDER (<i>Sambucus</i> spp.).....	15
Crown Rot	15
Powdery Mildew	16
FALSE CYPRESS (<i>Chamaecyparis</i> spp.).....	16
Root and Crown Rot.....	16

FIRETHORN (<i>Pyracantha</i> spp.)	16
Fire Blight, Scab.....	16
Cultivar Susceptibility.....	17
HAWTHORN (<i>Crataegus</i> spp.)	17
Fire Blight	17
Leaf Blight/Fabraea Blight.....	17
Rust	18
HOLLY (<i>Ilex</i> spp.).....	18
Leaf and Twig Blight	18
HOLLYHOCK (<i>Alcea</i> or <i>Althaea</i> spp.).....	19
Rust	19
IRIS (<i>Iris germanica</i>)	19
Rhizome Rot.....	19
Leaf Spot	19
JUNIPER (<i>Juniperus</i> spp.)	20
Root Rot	20
Rust	20
Twig Blight and Dieback.....	21
LILAC (<i>Syringa</i> spp.).....	21
Bacterial Blight	21
Botrytis Flower Blight.....	22
Crown Rot and Shoot Blight	22
Powdery Mildew	22
MOUNTAIN ASH (<i>Sorbus</i> spp.)	23
Fire Blight	23
Scab.....	23
Silver Leaf.....	23
PEONY (<i>Paeonia</i> spp.)	23
Gray Mold, Botrytis Blight.....	23
Viruses.....	23
RHODODENDRON (<i>Rhododendron</i> spp.).....	24
Leaf Gall.....	24
Ramorum Blight and Dieback (Sod)	24
Root Rot	24
Rust	25
ROSE (<i>Rosa</i> spp.).....	25
Black Spot, Powdery Mildew, Rust.....	25
Downy Mildew.....	26
THUJA (<i>Thuja</i> spp.).....	27
Needle Blight (Keithia Blight)	27
Root Rot	27
GENERAL REFERENCES.....	28
APPENDIX 1. Fungicides Registered for Use on Ornamentals	29
APPENDIX 2. Fungicides Registered for Use on Bulbs in Canada	35
APPENDIX 3. General Ornamental Registrations in Canada	36

Facts on Ramorum Blight and Dieback (Sudden Oak Death-SOD) - A Quarantine Disease

What is Ramorum Blight and Dieback?

Phytophthora ramorum, causal agent of Ramorum leaf blight and shoot dieback, is an oomycete (Kingdom Chromista) plant pathogen that can infect nearly seventy plant genera, including many ornamental crops. It was first known to cause sudden oak death (SOD), killing a large number of tanoak and coastal live oak trees in California. SOD was first reported in California in 1995 and later in Oregon where it is confined to pockets of forest lands of central coastal California and south-western Oregon. In 2004, the pathogen was detected in a nursery in California. Thereafter, in the subsequent years, the pathogen has been detected in nurseries in British Columbia and several states, particularly California, Oregon and Washington, in the USA through national surveys and provincial/state *P. ramorum* Nursery Certification Programs. Strict regulatory control measures have been taken by both Canada and the USA to destroy all identified plant materials and sanitation measures are in place to prevent the spread of the disease. Canadian and USA officials are involved in bilateral discussions to harmonize regulatory protocols.

Geographical and host distribution

The current known distribution of *P. ramorum* includes the western USA, British Columbia and Europe. For the most recent information on the North American geographical distribution of *P. ramorum*, see the Oak Mortality Task Force Web Site <http://www.suddenoakdeath.org>. See latest host list at <http://www.inspection.gc.ca/english/plaveg/protect/dir/sodspe.shtml>. (accessed Feb 3, 2009)

The fungus is an aggressive organism capable of killing healthy, mature trees. The name Sudden Oak Death is used because of the rapid change of colour of leaves from green to brown. A tree may be infected with this pathogen for a year or more before exhibiting the sudden change in foliage. The damage on the hosts with foliar blights or leaf spots is variable ranging from cosmetic damage to eventual death of the host plant. Destruction of infected plants is the solution to avoid spread.

Causal organism

The causal organism is an oomycete (*Phytophthora ramorum*) that appears to be genetically distant to most other *Phytophthora* species. Researchers at the University of California have determined that *P. ramorum* is very closely related to *P. lateralis*, the cause of Port-Orford cedar root rot. Initially observed in a limited number of oak species, *P. ramorum* is now known to infect a wide range of hosts in several plant families, including *Rhododendron*, *Vaccinium* and *Viburnum* spp.

How does Sudden Oak Death/ Ramorum blight and dieback spread?

The pathogen produces spores which are blown by the wind or splashed in rainwater or dew onto leaves and branches of shrubs and trees nearby. Leaves, twigs, branches and even the trunks of some hosts may be infected. *Phytophthora ramorum* can be accidentally spread to new areas through transport of infected nursery plants, infested soil or plant parts like cuttings, foliage and firewood.

Symptoms

The SOD fungus is a cool temperature organism, with optimum growth at 20°C. Signs of infection may be different on each host and may be confused with similar symptoms caused by other plant diseases.

- Susceptible oaks exhibit the most dramatic and serious symptoms. Symptoms include bleeding cankers on the trunk and branches and the foliage changes very rapidly to yellow and finally brown. Infected trees die.
- Infected rhododendrons show brown leaf blotches with fuzzy margins, and dieback at the ends of twigs and branches.
- Symptoms on pieris and camellia are characterized by leaf blight and shoot dieback.
- On huckleberry, infected leaves often fall off very quickly. In severe cases, stem or twig dieback may extend down to the soil-line and kill the plant.
- Viburnum may be subject to leaf blight, shoot dieback and wilting.
- Symptoms on arbutus may include leaf spot, canker or shoot dieback.
- On big leaf maple, cockeye and pink honeysuckle, the organism may cause leaf spots.

For a complete list of symptoms and related information, visit the California Oak Mortality Task Force homepage at <http://www.suddenoakdeath.org/>.

Is Sudden Oak Death the only cause of oak mortality?

No. Many other pathogens can also kill oaks. In particular, some root rot fungi are common in landscape and garden settings. In addition to these and other pests and pathogens, improper cultural practices, such as soil compaction, root pruning, over-watering and herbicide use may contribute to the death of the trees.

How can you prevent the introduction of this disease into Canada?

To help prevent the introduction of Sudden Oak Death/Ramorum blight and dieback, do not transport infected or potentially infected host material and soil that is taken from areas where the pathogen is known to occur. Contact the Canadian Food Inspection Agency's (CFIA) local office regarding quarantine restriction information on movement of hosts and associated materials. Be aware of the symptoms, visually inspect host plants, and report possible cases to your local office of the CFIA or Canadian Forestry Service or your local Provincial Ministry of Agriculture office/diagnostic lab.

Control

No effective chemical controls are currently available. Prevention, sanitation and eradication measures are the current strategies. An import policy D-01-01 titled, "Phytosanitary Requirements to Prevent the Entry of *Phytophthora ramorum* Associated with Sudden Oak Death into Canada" has been implemented.

<http://www.inspection.gc.ca/english/plaveg/protect/dir/d-01-01e.shtml> (accessed Feb 3, 2009)

Areas Regulated for the Control of *Phytophthora ramorum* Associated with Sudden Oak Death (March 12, 2007)

<http://www.inspection.gc.ca/english/plaveg/protect/dir/sodmsce.shtml>

Further Information and References

Davidson, J. M., Werres, S., Garbelotto, M., Hansen, E. M., and Rizzo, D. M. 2003. Sudden oak death and associated diseases caused by *Phytophthora ramorum*. Online. Plant Health Progress DOI:10.1094/PHP-2003-0707-01-DG.

Sudden Oak Death Import Policy, Canadian Food Inspection Agency.

Sudden Oak Death fact sheet, Canadian Food Inspection Agency.

The California Oak Mortality Task Force, <http://www.suddenoakdeath.org>

AMELANCHIER spp. (Saskatoon berry)

RUST

Gymnosporangium spp.

Cultural: Spores produced on amelanchier do not re-infect this host. Do not grow near junipers or cedars that are alternate hosts. Witches brooms, stem swellings or galls are symptoms on alternate hosts.

Resistant Varieties: No information available.

Chemical: Apply myclobutanil (COM) WP at 10-14 day intervals when disease is first observed, overuse may lead to disease resistance; apply propiconazole (COM) EC at white tip, petal fall and green fruit stages, maximum 3 applications per season; apply triforine (COM) EC, one application between flower bud break and white tip stage.

LEAF and BERRY SPOT

Entomosporium mespili

Cultural: Increase air circulation and reduce leaf wetness by spacing nursery plants, controlling weeds, and avoiding overhead irrigation. Remove and burn, bury or compost fallen leaves if severe disease occurs.

Resistant Varieties: No information available.

Chemical: Apply triforine (COM) EC or propiconazole (COM) EC. See labels for details and limitations.

ASH (*Fraxinus* spp.)

See also ASH in Chapter 6.

ANTHRACNOSE

Discula sp. (*Apiognomonium errabunda*)

Cultural: Rake up and destroy fallen leaves and prune out dead branches if practical. Control measures are warranted only when the disease occurs annually.

Resistant Cultivars: 'Modesto' ash is highly susceptible and should not be grown in coastal areas. Other cultivars have some resistance or tolerance.

Chemical: Mancozeb (COM) WG. Begin at bud-break and repeat every 7-14 days in wet weather.

AZALEA (*Rhododendron* spp.)

See *Rhododendron* page 24 and *Azalea* in Chapter 3.

BULBS - GLADIOLUS (*Gladiolus hortulanus*)

CORM ROT, LEAF and FLOWER SPOT (BOTRYTIS ROT)

Botrytis gladiolorum

Cultural: Avoid continuous cropping in the same field. Rogue diseased plants when they are seen. Harvest, clean, and cure corms promptly. Remove diseased corms when they are seen during storage.

Resistant Cultivars: None.

Chemical: Captan (COM) WP, (DOM) DU as a post-harvest dip or dust may be helpful. Limitations: As per label.

STROMATINIA NECK ROT, CORM ROT or DRY ROT

Stromatinia gladioli

Cultural: Avoid planting infected corms. Once established in a field, the fungus can persist indefinitely. Avoid 'old' gladiolus soil. Rogue crops; cure and grade corms carefully before storage.

Resistant Cultivars: None.

Chemical: Dip corms for 30 minutes in water at 57-58°C to which formaldehyde (COM) 37% SN has been added at the rate of 500 mL/100 L. Dry quickly and store at cool temperatures until replanting. Fumigate with dazomet (COM) 98% GR or metam sodium (COM) LI if it is necessary to replant into infested soil.

References:

1. Ormrod, D.J. 1995. Personal communication. BC Ministry of Agriculture, Fisheries & Food, Abbotsford.

SCAB

Pseudomonas gladioli pv. *gladioli*

Cultural: Do not grow gladioli in the same field more than 1 year in 3. Avoid heavy, poorly drained soils. Carefully examine corms before planting and discard those with scab lesions. Rogue out infected plants as they are seen. Crocus and freesia can also be infected by this bacterium.

Resistant Cultivars: None.

Chemical: None.

YELLOWS and CORM ROT*Fusarium oxysporum* f. sp. *gladioli*

Cultural: Do not grow gladiolus, bulbous iris, or crocus in the same field more than 1 year in 4. Carefully examine corms and discard those with signs of infection. Cure corms promptly after harvest.

Resistant Cultivars: None.

Chemical: Captan (COM) WP as a post-harvest dip at 30°C for 30 minutes to cleaned corms prior to curing and storage. For smaller quantities, use captan (DOM) DU prior to storage and/or just before planting.
Limitations: As per label.

References:

1. Elmer, W.H. 2006. Efficacy of preplant treatments of gladiolus corms with combinations of acibenzolar-S-methyl and biological or chemical fungicides for suppression of fusarium corm rot [*Fusarium oxysporum* f. sp. *gladioli*]. Can. J. Plant Path. 28: 609-614
2. Paulus, A.O. *et al.* 1970. Fungicides and dipping interval for control of fusarium corm rot of gladiolus. Plant Dis. Rep. 54: 689-691.

BULBS - IRIS (*Iris* spp.)**BULB NEMATODE***Ditylenchus destructor*

Cultural: Harvest bulbs promptly when mature. Destroy infected debris. Avoid infested soils.

Resistant Cultivars: None.

Chemical: Within 2 weeks of harvest, treat bulbs at 48°C for 3 hours with formaldehyde (COM) 37% SN diluted 1:200 with water. When necessary to plant in infested soil, fumigate thoroughly cultivated, warm soil with dazomet (COM) 98% GR, metam sodium (COM) LI or other effective nematicide. Allow at least 30 days after fumigation before planting.

Limitations: Follow all label precautions when using fumigants.

Notes: This nematode also attacks potato tubers.

References:

1. B.C. Min. of Agri. & Lands. 2004. BC Floriculture Production Guide - Best Management Practices.
2. Gould, C.J. and R.S. Byther. 1979. Diseases of bulbous iris. West Wash. Res. Ext. Center, Puyallup. Pp. 19-20.

BULB ROT*Penicillium* spp.

Cultural: Avoid sunburning, overheating, or bruising bulbs at all stages of handling. Dry harvested bulbs rapidly and keep humidity between 70 and 85% in storage. Disinfect trays with a 1% solution of formaldehyde (COM) 37% SN.

Resistant Cultivars: Emperor, Van Vliet.

Intermediate: Wedgewood.

Susceptible: Blue Ribbon.

Chemical: Dip cleaned bulbs in a solution of captan (COM) WG as soon as possible after harvest and/or just before forcing. Dip bulbs for 1 to 15 minutes. For smaller quantities, use captan (DOM) DU prior to storage and/or forcing. Limitations: As per label.

References:

1. Gould, C.J. and R.S. Byther. 1979. Diseases of bulbous iris. West Wash. Res. Ext. Center, Puyallup. Pp. 10-11.

BULBS - LILY (*Lilium* spp.)

See also LILY in Chapter 3.

VIRUS DISEASES

Lily mosaic virus and others

Cultural: Do not plant bulbs that are believed to be infected with viruses in the vicinity of plantings that are believed to be virus-free. Control aphids. Rogue obviously infected plants from otherwise healthy appearing plantings.

Resistant Cultivars: None.

Chemical: None.

BULBS - NARCISSUS (*Narcissus* spp.)

BASAL ROT

Fusarium oxysporum f. sp. *narcissi*

Cultural: Harvest promptly in dry weather if possible. Discard infected bulbs. Provide cool, well ventilated storage and replant as soon as possible.

Resistant Cultivars: The Jonquilla, Tazetta, Triandrus, and cup types are resistant (1). The large trumpet varieties are most susceptible and of these Golden Harvest is much more susceptible than King Alfred.

Chemical: Dip bulbs in captan (COM) WG as soon as possible after harvest (see Notes) or use formaldehyde (COM) 37% SN (1 part in 200 parts of water) during hot water treatment for nematode control. For smaller quantities, use captan (DOM) DU prior to storage and/or just before planting. Limitations: As per label.

References:

1. Gould, C.J. and R.S. Byther. 1979. Diseases of narcissus. West. Wash. Res. Ext. Center, Puyallup. Pp. 5-7.

NEMATODES

Ditylenchus dipsaci, *Pratylenchus* spp.

Cultural: Avoid infested fields. Follow a 3 to 4 year rotation between crops. During this time, control weeds and remove all volunteer bulbs. Rogue out and destroy suspicious plants while they are still green.

Resistant Cultivars: None.

Chemical: For control of *Ditylenchus* in bulbs, use hot water-formalin treatment at 43-44°C for 3-4 hours as soon as possible after harvest (see Notes). *Pratylenchus* spp. are not carried on bulbs. Wash all tools and equipment which come into contact with infested soil or bulbs with a solution of 1 part formaldehyde (COM) 37% SN and 9 parts water. Fumigate thoroughly cultivated warm soil with dazomet (COM) 98% GR or metam sodium (COM) LI. Allow at least 30 days after fumigation before planting. For hot water treatment guidelines see USDA-APHIS Schedules for Plant Pests or Pathogens (T500) http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment_pdf/05_06_t500schedules.pdf (accessed Feb 3, 2009).

Limitations: Follow all label precautions when using fumigants.

Notes: Cultivars vary in their sensitivity to hot water treatment. Flower production in the first year after treatment may be severely damaged.

References:

1. Gould, C.J. and R.S. Byther. 1979. Diseases of narcissus. West Wash. Res. Ext. Center Puyallup. Pg. 7-10.

BULBS - TULIP (*Tulipa* spp.)**BASAL ROT**

See Narcissus, BASAL ROT, page 8. Do not use hot water treatment on tulips as they damage too easily.

BREAKING

Tulip breaking virus, Tulip band breaking virus and others.

Cultural: Control aphids. Avoid planting tulips and lilies in close proximity. Rogue early, removing plants exhibiting mottled or streaked foliage or 'off-type' flower color.

Resistant Cultivars: None.

Chemical: None.

Notes: Pink and red flowered cvs. show most pronounced symptoms and are easiest to rogue. White and yellow cultivars do not show symptoms and thus may increase the risk that this disease spread to others.

References:

1. Gould, C.J. and R.S. Byther. 1979. Diseases of tulips. West Wash. Res. Ext. Center, Puyallup. Pp. 15-17.
2. Pscheidt, J.W. and C.W. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis.

BULB ROT

See Iris, BULB ROT, page 7.

FIRE (BOTRYTIS BLIGHT)

Botrytis tulipae

Cultural: Clean bulbs before planting and discard any showing spots. Plant in areas with good soil and air drainage. Avoid overcrowding. Carefully remove and destroy fireheads (infected primary shoots) as soon as they are detected. Do not replant in soils known to be infested with sclerotia for at least 3 years.

Resistant Cultivars: None.

Chemical: Captan (COM) WP, (DOM) DU; fenhexamid (COM) WG; iprodione (COM) WP, WG. Apply before disease appears and at intervals of 7-10 days as needed. Limitations: As per label. Fenhexamid and iprodione have a general label for control of Botrytis on ornamentals: test on a small area first for phytotoxicity. Efficacy on tulip fire is unknown.

References:

1. Gould, C.J. 1979. Diseases of tulips. West Wash. Res. Ext. Center, Puyallup. Pp. 15-17.
2. Pscheidt, J.W. and C.W. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis.

GRAY BULB ROT

Rhizoctonia tuliparum

Cultural: Sort bulbs carefully after harvest and before planting. Destroy infected bulbs. Avoid infested fields. Follow 3 to 5 year rotation avoiding other bulbs, especially iris.

Resistant Cultivars: None.

Chemical: Dip bulbs in a suspension of 7.5% quitozene (COM) WP for 5 min. before planting stock of questionable health or use *Trichoderma harzianum* (Root Shield) or thiophanate-methyl. Limitations: As per label.

Notes: Soil treatment with quitozene is not registered in Canada, but is used elsewhere.

References:

1. Gould, C.J. and R.S. Byther. 1979. Diseases of tulips. West Wash. Res. Ext. Center, Puyallup, WA. P. 12.

CLEMATIS (*Clematis* spp.)

LEAF SPOT and STEM ROT (CLEMATIS WILT)

Ascochyta clematidina

Cultural: In propagation, use disease free stock, maintain strict sanitation, remove and destroy diseased cuttings when they appear. Prune out diseased vines.

Resistant Cultivars: None.

Chemical: Thiophanate-methyl (COM) WP for leaf spot; water soil thoroughly with spray solution and repeat at 7 day intervals as required.

Limitations: As per label.

COTONEASTER (*Cotoneaster* spp.)

DARK BERRY

Phytophthora cactorum

Cultural: Avoid planting in areas where soil splashing may be a problem or mulch the plants to prevent soil splashing. Plant in sunny locations with good air circulation.

Resistant Cultivars: None.

Chemical: None.

FIRE BLIGHT

See Pear, FIRE BLIGHT in Chapter 9.

RUST

See Juniper, RUST on page [20](#).

SCAB

See Apple, SCAB in Chapter 9.

SILVER LEAF*Chondrostereum purpureum*

Cultural: Prune out diseased or damaged branches well below the affected area and protect cut surface with pruning paint. Badly diseased plants should be removed. Do heavy pruning during dormant season.

Resistant Cultivars: None.

Chemical: None.

Notes: The fungus infects only through wounds on wood that is more than 1 year old.

References:

1. Duczek, L.J. 1975. Silver leaf (sapwood rot). Sask. Dep. Agric., Fact sheet. P. 12 *in* Garden clippings, Sask. Hort. Soc., June, 1975.
2. PFRA. 2003. Silverleaf disease of trees and shrubs. <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1198274535415&lang=e> (accessed Dec 18, 2008).

CRABAPPLE (*Malus* spp.)**FIRE BLIGHT, POWDERY MILDEW, SCAB***Erwinia amylovora, Podosphaera leucotricha, Venturia inaequalis*

Cultural: See Pear, FIRE BLIGHT; Apple, POWDERY MILDEW and Apple, SCAB in Chapter 9.

Resistant Cultivars: See references and notes. Some of these cultivars may not be hardy in the prairie region.

Crabapple Cultivar Susceptibility:

	<u>Fire blight</u>	<u>Powdery mildew</u>	<u>Scab</u>
Almey	Res.	Res.	H. susc.
<i>M. baccata</i>	Res.	?	Res.
<i>M. baccata columnaris</i>	H. susc.	?	Res.
<i>M. coronaria</i>	Susc.	?	Susc.
Dolgo	Res.	Res.	Susc.
<i>M. floribunda</i>	Res.*	Res.	Res.
Hopa	?	?	H. susc.
Jacki	Susc.	Susc.	Res.
Kelsey	Res.	?	Susc.
Liset	Res.	Res.	H. res.
Makamik	Res.	?	Res.
Prince Georges	Res.	?	Susc.
Profusion	Res.	Susc. to Mod. res.	Res.
Radiant	Res.	?	Susc.
Red Jade	Res.	?	Mod. Res.*
Red Splendor	Res.	Res.	Res*.
<i>M. robusta persicifolia</i>	Res.	Res.	Res.
Royalty	H. susc.	Susc.	Susc.
Selkirk	Res.	?	Res.
Strathmore	?	?	Susc.
Thunderchild	Res.	?	?*
Van Eseltine	?	?	H. res.

*Reported at a greater level of disease in some studies (1).

H (Res)	High disease resistance; some leaves may be affected
M (Mod)	Moderate disease resistance; leaves and shoots affected but no defoliation.
Susc.	Low disease resistance; heavy infection, defoliation
?	Information not available

Chemical: For scab, chlorothalonil (COM) SU, WG at spring budbreak and every 7-14 days thereafter until dry weather begins. (See also: Pear, FIRE BLIGHT; Apple, POWDERY MILDEW; Apple, SCAB; in Chapter 9.) Myclobutanil (COM) WP applied at 10-14 day intervals will also control powdery mildew, scab and rust (see RUST page 14). Trifloxystrobin (COM) WG at 7-14 day intervals for control of powdery mildew or scab. Limitations: As per label.

Notes: Cultivars may react differently to disease in locations other than where the reaction tests were conducted due to presence of different strains or races of the disease organism. Changes in the pathogen population can also occur over time resulting in loss of resistance.

References:

1. Chatfield, J.A. 2002. Incidence of apple scab on ornamental crabapples, 2000. Biological & Cultural Tests for Control of Plant Diseases (online) Report 17: O001 DOI: 10.1094/BC17. APS, St. Paul, MN.
2. Nichols, L.P. 1975. Disease resistant crabapples. Pa. State Univ., University Park.
3. Pscheidt, J.W. and C.M. Ocamb. 1999. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis, which cites references A-D below:
 - A. Benson, D.M. and B.I. Daughtry. 1993. "Crabapple" in Biological and Cultural Tests for Control of Plant Diseases. St. Paul, MN: APS Press, 8: 127. L=0-1; M=2; H=3-4 in Benson *et al.* evaluation.
 - B. Hartman, J., J. Doney, and R. McNeil. 1991. "Crabapple" in Biological and Cultural Tests for Control of Plant Diseases. St. Paul, MN: APS Press, 6: 107. L=0-2; M=3; H=4 in Hartman *et al.* evaluation.
 - C. Norton, R.A. and J. King. 1993. "Crab Apples Revisited" Washington Park Arboretum Bulletin 55: 10-13.
 - D. Unpublished field evaluations from the Pacific Northwest.
4. Smith, E.M. 1979. A 10-year evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Ag. Res. Dev. Center. Wooster, Ohio.
5. Smith, E.M. and S. Treaster. 1986. Evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Ag. Res. Dev. Centre, Wooster, Ohio.
6. BC Ministry of Agriculture and Lands. 2008. Nursery and Landscape Pest Management and Production Guide 8th Edition.

RUST

Gymnosporangium spp.

Cultural: Alternate hosts of crabapple rusts are juniper, incense cedar (*Calocedrus decurrens*) and yellow cedar (*Chamaecyparis nootkatensis*). Cedar-apple rust, common in the east, has not been reported in the west. Remove alternate hosts near crabapples. Prune out rust galls when seen on alternate hosts.

Resistant Varieties: No information available.

Chemical: Myclobutanil (COM) WP applied at 10-14 day intervals when the disease is first seen will help to control rust. Do not apply more than six applications per year. Chlorothalonil applied for powdery mildew and scab (see above) will also help to control rust. However, the only permanent control is removal of the alternate host.

SILVER LEAF

See Cotoneaster, SILVER LEAF, page 12.

DOGWOOD (*Cornus* spp.)

ANTHRACNOSE

Discula destructiva

Cultural: On small plants isolated from large, infected trees, picking off the first diseased leaves seen in spring may be beneficial. Rake and burn fallen leaves to reduce overwintering inoculum.

Resistant Cultivars: *Cornus* 'Eddie's White Wonder', *C. florida* (Eastern dogwood) and *C. kousa* (Japanese dogwood) have more resistance than *C. nuttallii* (Western dogwood).

Chemical: Myclobutanil (COM) WP, every 14 days; maximum 4 applications per year. Chlorothalonil (COM) for Septoria leaf spot also helps to reduce anthracnose infection. Limitations: As per label.

Notes: This disease is now well established in the B.C. Lower Mainland and Vancouver Island and in many other parts of North America where *Cornus* is grown.

References:

1. Byther, R.S. and R.M. Davidson. 1979. Dogwood anthracnose. Ornamentals Northwest. V.3-2 Oreg. State Univ., Corvallis.
2. Hibben, C.R. and M.L. Daughtrey. 1988. Dogwood anthracnose in northeastern United States. Plant Dis. 72: 199-203.

COLLAR ROT (CROWN CANKER)

Phytophthora cactorum and other spp.

Cultural: Avoid soils known to be contaminated with *Phytophthora*. Avoid damage to the crown area. Surgery of small cankers can prolong tree life. Clean out cankers during dry weather, paint with shellac, then with tree emulsion. Leave wounds exposed to air during summer. Do not cover with soil.

Resistant Cultivars: None.

Chemical: None.

ELDER (*Sambucus* spp.)

CROWN ROT

Phytophthora citricola, *P. cactorum*

Cultural: Obtain disease-free stock from a reliable nursery and plant in clean soil that has not previously grown elders or lilacs.

Resistant Cultivars: None.

Chemical: None.

POWDERY MILDEW

Microsphaera spp.

Cultural: Avoid overcrowding of nursery plants.

Resistant Cultivars: None.

Chemical: Sulphur (DOM) SN. Limitations: As per label.

FALSE CYPRESS (*Chamaecyparis* spp.)

ROOT and CROWN ROT

Phytophthora lateralis (primarily), also *P. cinnamomi* and other spp.

Cultural: Avoid poorly drained soils especially for hedge plantings and do not water with drip irrigation.

Resistant Cultivars: *C. nootkatensis*, *C. pisifera*, *C. thyoides*, *Thuja* spp., and *Juniperus* spp. are all resistant to *P. lateralis* but may be susceptible to other *Phytophthora* spp..

Susceptible: All varieties of Lawson's cypress (*C. lawsoniana*) and Hinoki cypress (*C. obtusa*) are highly susceptible to *P. lateralis*.

Chemical: None.

FIRETHORN (*Pyracantha* spp.)

FIRE BLIGHT, SCAB

Erwinia amylovora, *Venturia pyracanthae*

Cultural: See Pear, FIRE BLIGHT and Apple, SCAB in Chapter 9.

Resistant Cultivars:**Cultivar Susceptibility:**

	<u>Fire blight</u>	<u>Scab</u>
<i>P. atalantoides</i> Aurea	Susc.	Res.
<i>P. coccinea</i>	M. S.	S.
<i>P. koidzumii</i> Santa Cruz Prostrata	M. R.	R.
<i>P. rogersiana</i> Watereri	M. Res.	Res.
<i>P.</i> × Golden Charmer	M. Res.	Res.
<i>P.</i> × Orange Glow	M. Res.	Res.

Chemical: For scab apply chlorothalonil (COM) SU at spring bud break and repeat at 7-14 day intervals while wet weather occurs; apply propiconazole (COM) EC at 14 day intervals beginning at green tip. (See Pear, FIRE BLIGHT and Apple, SCAB in Chapter 9). Limitations: As per label.

References:

1. BC Ministry of Agriculture and Lands. 2008. Nursery and Landscape Pest Management and Production Guide 8th Edition.
2. Pscheidt, J.W. and C.M. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State. Univ. Corvallis.
3. Vassey, W.E., C.J. Gould and G.F. Ryan. 1977. Disease-resistant pyracantha for the Pacific Northwest. Ornamentals Northwest 1(18): 4-6.

HAWTHORN (*Crataegus* spp.)**FIRE BLIGHT**

See Pear, FIRE BLIGHT in Chapter 9.

LEAF BLIGHT/FABRAEA BLIGHT

Diplocarpon mespili (*Entomosporium mespili*, *Fabraea maculata*)

Cultural: Rake and burn or dispose of fallen leaves to remove the overwintering fungus.

Resistant Cultivars: None.

Chemical: During the leaf emergence and enlargement period apply - chlorothalonil (COM) SU, WG; mancozeb (COM) WG. Tribasic copper sulphate (DOM) WP may be applied at 10 day intervals.
Limitations: As per label instructions for ornamentals.

Notes: This is primarily a disease of the English hawthorn (*C. oxyacantha*) in the coastal area.

RUST

Gymnosporangium spp.

Cultural: In the prairie region, avoid planting in close proximity to *Juniperus communis*, *J. horizontalis* and *J. scopulorum*, the alternate host for *Gymnosporangium* rusts of *Crataegus* and *Amelanchier* spp.

Resistant Cultivars: See Notes.

Chemical: Chlorothalonil (COM) SU, WG starting before bloom or myclobutanil (COM) WP every 14 days when disease appears. Limitations: As per label for ornamentals.

Notes: In most areas, Rocky Mountain juniper (*J. scopulorum*) is a greater hazard as an alternate host than low growing species such as *J. horizontalis* and *J. communis*.

References:

1. Parmelee, J.A. 1971. The genus *Gymnosporangium* in Western Canada. Can. J. Bot. 49: 903-926.
2. Ziller, W.G. 1974. The Tree Rusts of Western Canada. Can. For. Serv., Publ. 1329. 272 pp.

HOLLY (*Ilex* spp.)**LEAF and TWIG BLIGHT**

Phytophthora ilicis

Cultural: Select a site with good air drainage. Prune out diseased branches and remove fallen leaves and plant debris where practical. Space trees to encourage air circulation.

Resistant Cultivars: Unknown.

Chemical: Apply mancozeb (COM) WG in the fall before the onset of fall rains. Avoid applications close to harvest to reduce visible residues from the fungicide. See notes.

Notes: These applications will also reduce green algae.

HOLLYHOCK (*Alcea* or *Althaea* spp.)

RUST

Puccinia malvacearum

Cultural: Remove and burn all above-ground plant parts at end of season. Remove and destroy infected leaves as they are seen. Do not use seed from infected plants. Destroy common mallow weeds in the vicinity as the disease will also overwinter on them.

Resistant Cultivars: None.

Chemical: Apply chlorothalonil (COM) SU, WG beginning in the early seedling stage. Rotate with applications of myclobutanil (COM) WP at 10-14 day intervals. This fungicide is also registered for control of powdery mildew on hollyhock. Apply sulphur (DOM) DU, LC, WG, WP. Limitations: As per label.

Notes: Sulphur may be phytotoxic under certain conditions.

IRIS (*Iris germanica*)

RHIZOME ROT

Botrytis convoluta

Cultural: Control iris borer. Avoid continuous plantings of iris in the same area. Rogue diseased plants when seen.

Resistant Cultivars: None.

Chemical: None.

Notes: Fungus infects in late fall or early spring.

References:

1. Jackson, R.S. 1972. Botrytis rhizome rot, review. Bull. Am. Iris Soc. 204: 35-40.

LEAF SPOT

Didymellina macrospora

Cultural: Remove and destroy all diseased leaves.

Resistant Cultivars: None.

Chemical: Chlorothalonil (COM) SU, WG every 7-14 days under cool, moist conditions. Limitations: As per label. Myclobutanil (COM) WP applied as for rust control may also help to control leaf spot.

References:

1. Randolph, L.F. 1959. Garden irises. Am. Iris Soc., St. Louis

JUNIPER (*Juniperus* spp.)

ROOT ROT

Phytophthora spp., *Pythium* spp.

Cultural: Container grown plants purchased from nurseries may have partially infected root systems. To prevent subsequent losses in the landscape, avoid deep planting in heavy or poorly drained soils. Avoid excessive irrigation. Do not allow containerized plants to stand in water.

Resistant Cultivars: The following are reported to be susceptible or very susceptible in Oregon: *J. chinensis* 'Pfitzeriana', 'Aurea Gold Coast', *J. horizontalis* 'Prince of Wales' and 'Wiltonii'; *J. procumbens* 'Nana' and *J. sabina* 'Tamariscifolia'.

Chemical: For greenhouse-grown container plants, metalaxyl (COM) GR added to the potting mix at transplanting or applied to the surface and watered in may help to prevent infection. Overuse will lead to resistance.

References: See reference 9 in GENERAL REFERENCES, p. 28.

RUST

Gymnosporangium spp.

Cultural: Prune out and destroy rust galls. In the prairie region, avoid planting junipers - especially *J. scopulorum* - in close proximity to *Amelanchier*, *Cotoneaster*, *Crataegus*, *Malus*, *Pyrus*, or *Sorbus*. In coastal B.C., do not plant any species except *J. communis* and *J. horizontalis* within 30 m of *Pyrus*.

Resistant Cultivars: Some species of junipers are resistant to some species of *Gymnosporangium* but none are resistant to all.

Chemical: Myclobutanil (COM) SG in a tank-mix with mancozeb (COM) DG, every 14 days in late summer/early fall. Maximum 6 applications per year. See Hawthorn, RUST on page 18. In coastal B.C., junipers grown for shipment to other areas must be protected with mancozeb in the fall during the time when *G. fuscum* aeciospores are being shed from infected pear leaves.

References:

1. B.C. Ministry of Agriculture and Food. 1994. Pear trellis rust in British Columbia. 20 pp.
2. Parmelee, J.A. 1971. The genus *Gymnosporangium* in Western Canada. Can. J. Bot. 49: 903-926.
3. Ziller, W.G. 1974. The Tree Rusts of Western Canada. Can. For. Serv., Publ. 1329. 272 pp.

TWIG BLIGHT and DIEBACK

Kabatina juniperi, *Phoma* spp., *Phomopsis* spp., *Sclerophoma* spp., *Coniothyrium* spp., other fungi and physiological

Cultural: Propagate only from disease-free mother plants. Avoid planting out in heavy clay soils that tend to crack in dry weather. Avoid injury to established plants. Minimize frequency and duration of overhead irrigation.

Resistant Cultivars: Cultivars that break easily under weight of snow or traffic are most subject to dieback.

Chemical: Cuttings and young plants should be protected in April, May and June on a 10 day spray schedule using mancozeb (COM) WG; or copper oxychloride (COM, DOM) WP. Limitations: As per label for ornamentals.

References:

1. Brener, W.D. *et al.* 1974. *Sclerophoma pythiophila* associated with a tip dieback of juniper in Wisconsin. Plant Dis. Rep. 58: 653-657.
2. Hall, R. 1971. Juniper Dieback. Ont. Dep. Agric. Food, Agdex 276/636.
3. Peterson, G.W. *et al.* 1965. Control of phomopsis blight of eastern red cedar seedlings. Plant. Dis. Rep. 9: 529-531.

LILAC (*Syringa* spp.)

BACTERIAL BLIGHT

Pseudomonas syringae pv. *syringae*

Cultural: Prune out infected shoots as they are seen. Space nursery plants to obtain good air circulation. Individual plastic hoop houses or covers staked down and open at the bottom, are effective in protecting small outdoor nursery shrubs if put on in January and removed in April after risk of late frost has passed but before flower buds open. Rainy spring weather favours disease.

Resistant Cultivars: White-flowered cultivars are the most susceptible. Most cultivars of *S. vulgaris* are susceptible but 'Edith Cavell', 'Glory', 'Ludwig Spaeth' and 'Pink Elizabeth' have shown some resistance when planted in gardens. 'Ludwig Spaeth' is highly susceptible in crowded nursery conditions. Resistance has been observed in western Washington in species *S. josikaea*, *S. Komarowii*, *S. microphylla*, *S. pekinensis* and *S. reflexa*.

Chemical: Apply copper oxychloride (COM, DOM) WP at leaf drop before fall rains and at 7- to 10-day intervals during bud opening and shoot elongation in spring. Limitations: As per label.

Notes: Bacterial blight is a common problem on a number of woody ornamentals in coastal B.C. including *Acer*, *Cornus*, *Cotoneaster*, *Eunonymus*, *Forsythia*, *Magnolia*, *Populus*, *Prunus*, *Pyrus*, *Rosa*, *Rubus*, *Syringa* and *Vaccinium* spp.

References:

1. Canfield, M.L., S. Baca and L.W. Moore. 1986. Isolation of *Pseudomonas syringae* from 40 cultivars of diseased woody plants with tip dieback in Pacific Northwest nurseries. *Plant Dis.* 70(7): 647-650.
2. Delbridge, R.W. 1975. Lilac blight. N.S. Dep. Agric., Unnumbered Fact Sheet
3. Pscheidt, J. W and C. M. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis.

BOTRYTIS FLOWER BLIGHT

Botrytis cinerea

Cultural: Grow in a sunny location with good air circulation.

Resistant Cultivars: No information available.

Chemical: Captan (COM) WG or fenhexamid (COM) WG may be applied when disease first appears and repeated at intervals of 7 to 10 days as required.

CROWN ROT and SHOOT BLIGHT

See Elder, CROWN ROT, Page [15](#).

POWDERY MILDEW

Microsphaera sp.

Cultural: Avoid overcrowding of nursery plants.

Resistant Cultivars: None.

Chemical: Begin application in late summer before first appearance of mildew. Use: myclobutanil (COM) WP; sulphur (DOM) WP, SN, SU; thiophanate-methyl (COM) WP; triforine (COM) EC. Limitations: As per label. See Appendix 3 for labels with general registration for powdery mildew.

Notes: Late infection generally does not warrant a spray program. However, nursery plants should be protected to improve saleability.

MOUNTAIN ASH (*Sorbus* spp.)

FIRE BLIGHT

See Pear, FIRE BLIGHT in Chapter 9.

SCAB

See Apple, SCAB in Chapter 9.

SILVER LEAF

See Cotoneaster, SILVER LEAF, page [12](#).

PEONY (*Paeonia* spp.)

GRAY MOLD, BOTRYTIS BLIGHT

Botrytis cinerea, *B. paeoniae*

Cultural: Remove and destroy diseased parts as seen. Avoid dense plantings and plant in an area with good air circulation. Do not mulch in spring when shoots are emerging. Remove tops just below ground level in fall. Avoid overhead watering.

Resistant Cultivars: None.

Chemical: Apply fenhexamid (COM) WG or iprodione (COM) WG, WP at 7 to 10-day intervals during shoot elongation before flowering. Limitations: As per label.

VIRUSES

Peony ringspot virus, Tomato Spotted Wilt Virus

Cultural: Remove and destroy plants exhibiting symptoms of ringspot, mosaic, or stunting.

Resistant Cultivars: None.

Chemical: None.

References:

1. Smith, K.F. 1972. A Textbook of Plant Virus Diseases. Academic Press, New York. 388 pp.
2. Pscheidt, J. W and C. M. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis.

RHODODENDRON (*Rhododendron* spp.)

LEAF GALL

See Azalea, LEAF GALL in Chapter 3.

RAMORUM BLIGHT and DIEBACK (SOD)

Phytophthora ramorum

See general discussion on Ramorum blight and dieback (Sudden Oak Death) at the beginning of this chapter, page 3.

ROOT ROT

Phytophthora cinnamomi, *P. cactorum*, *P. citricola*

Cultural: Use disease-free propagating stock. Follow strict hygiene in media preparation and potting. Disinfect all tools and equipment used in propagation. Place containers on well drained beds free of standing water. Plant out in well drained locations. Once established in soil, *Phytophthora* species may remain indefinitely. *Phytophthora* may also cause foliar blight and stem dieback on rhododendrons.

Resistant Cultivars: The following is a partial list of root rot-resistant cultivars from the Pacific Northwest Disease Control Handbook:

Resistant Hybrids

‘Caroline’
‘Martha Isaacson’
‘Pink Trumpet’
‘Professor Hugo de Vries’
‘Red Head’
‘Serenade’

Resistant Species

R. davidsonianum ‘Serenade’
R. delavayi
R. glomeratum
R. hyperethrum
R. lapponicum
R. occidentale
R. poukanense
R. pseudochrysanthum
R. quinquefolium
R. sanctum
R. simsii
R. websterianum

Note: *R. poukanense* is a resistant azalea.

Chemical: Apply etridiazole (COM) EC, WP as a soil drench or chlorothalonil (COM) SU, WG for foliar blight. NB: Chlorothalonil may discolour blooms. Overuse will lead to disease resistance.

References:

1. Pscheidt, J. W. and C.M. Ocamb. 2005. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis.

RUST

Chrysomyxa spp.

Cultural: Rake up and dispose of fallen leaves. Early leaf yellowing and drop may occur but is not usually serious except on a few very susceptible varieties. Spores will continue to re-infect rhododendrons throughout the growing season without and alternate host.

Resistant Varieties: Many varieties are resistant or tolerant of infection.

Chemical: No products are registered for control of rust on rhododendron. Chlorothalonil applied for foliar Phytophthora blight may also help to control rust if applied when first symptoms are seen. This product may discolour blooms (see ROOT ROT, above).

ROSE (*Rosa* spp.)**BLACK SPOT, POWDERY MILDEW, RUST**

Diplocarpon rosae, *Sphaerotheca macularis*, *Phragmidium* spp.

Cultural: Remove all remaining foliage during dormant season. Pick off infected leaves as they are seen during the growing season. Avoid planting in damp, shaded locations.

Resistant Cultivars: See listings for cultivar resistance and susceptibility in An Online Guide to Plant Disease Control at http://plant-disease.ippc.orst.edu/articles.cfm?article_id=24. (accessed Dec 18, 2008). See note 2.

Biological: For suppression of powdery mildew apply *Bacillus subtilis* (COM, DOM) LO.

Chemical: Lime sulphur (COM, DOM) SN 1:9 as a dormant spray followed by folpet (COM, DOM) WP, captan (COM, DOM) WP, WG; sulphur (DOM) WP, DU, LI; triforine (COM, DOM) EC; in growing season (see Notes). Chlorothalonil (COM) SU, WG is registered for control of black spot and Botrytis blight when applied starting at budbreak. Thiophanate-methyl (COM) WP or Phyton 27 (elemental copper) (COM) LI may also be used for black spot and powdery mildew control. Myclobutanil (COM) SG, WP, applied at 10-14 day intervals is registered for control of powdery mildew, rust and black spot. Apply in a tank-mix with mancozeb (COM) DG for black spot.

Limitations: As per label.

Notes:

1. Folpet and captan will not control rust; captan, ferbam, and zineb will not control mildew. There are a number of fungicide-insecticide mixtures registered for use on roses. See Chapter 3 for fungicides recommended to control these diseases on greenhouse roses.
2. Cultivars may react differently to disease in locations other than where the reaction tests were conducted due to presence of different strains or races of the disease organism. Changes in the pathogen population can also occur over time resulting in loss of resistance.

References:

1. Colbaugh, P.F. *et al.* 2005. Rose variety reaction to blackspot disease under minimal input growing conditions, 2001. Biological and Cultural Tests for Control of Plant Diseases (online). Report 20: O0018. DOI: 10.1094/BC20
2. Cole, T.J. 1979. Growing Roses, Publ. 1675E. Agriculture Canada, Ottawa.
3. Holcomb, G.E and T. Raiford. 2005. Reaction of rose cultivars to blackspot disease, 2004. Biological and Cultural Tests for Control of Plant Diseases (online). Report 20: O005. DOI: 10.1094/BC20
4. Horst, R. Kenneth. 1983. Compendium of Rose Diseases. Am. Phytopathol. Soc. St. Paul, Minn.
5. Svejda, Felicitas. 1984. New winter-hardy roses and other flowering shrubs. publ. 1727. Agriculture Canada, Ottawa.
6. Pscheidt, J.W. and C.W. Ocamb. 2008. Rose Cultivar Resistance *in* Online Guide to Plant Pathology. Oreg. State Univ., Corvallis.

DOWNY MILDEW*Peronospora sparsa*

Cultural: Remove and destroy fallen leaves and prune back infected twigs and stems. Since the disease can infect crowns and roots, pruning may not eliminate the fungus. If the disease appears annually in landscape plants and foliar loss is severe, replace with different cultivars or other plants. Space plants for good air circulation. Avoid overhead watering or water during the day so leaves can dry off before evening dew. Take cuttings only from uninfected plants and avoid overhead misting.

Resistant Cultivars: Most mini-roses, 'Meidiland' and 'Austin' cultivars are highly susceptible. There has been little or no systematic screening for resistance. Wild *Rosa* spp., including *R. californica*, *R. centifolia*, *R. canina*, *R. rubiginosa* and *R. indica*, are also susceptible.

Chemical: Phyton 27 (elemental copper) (COM) applied for black spot and powdery mildew may provide some control.

References:

1. Aegerter, B. J., Nunez, J.J. and Davis, R.M. 2002. Detection and management of downy mildew in rose stock. Plant Dis. 86: 1363-1368.
2. Horst, R. Kenneth *et al.* 2007. Compendium of Rose Diseases and Pests. 2nd Edition. Am. Phytopathol. Soc. St. Paul, Minn.

THUJA (*Thuja* spp.)

NEEDLE BLIGHT (KEITHIA BLIGHT)

Didymascella thujina

Cultural: Avoid prolonged overhead sprinkling of *T. plicata*. Space nursery plants to maximize air circulation. Locate beds well away from native stands that may be infected.

Resistant Cultivars: *T. occidentalis* cultivars. The *T. plicata* cultivar known as 'Emerald Giant' in B.C. and *T. plicata* 'Aurea'.

Susceptible: *T. plicata* cultivars such as 'Excelsa' and 'Atrovirens'.

Chemical: Apply mancozeb (COM) WG 3 times between March and June and twice more prior to fall rains or propiconazole (COM) EC every 4 weeks with a maximum of 6 applications per year.

References:

1. B.C. Min. of Agriculture and Lands. 2003. Keithia blight *in* Landscape Pest Management & Production Guide. P. 134.
2. Kope, H. 1996. The use of propiconazole (Topas) to control keithia blight on container-grown western red cedar seedlings in British Columbia reforestation nurseries. Contact Biologicals, 17 Jedburgh Rd., Victoria, B.C. V9B 1K7.

ROOT ROT

Armillaria spp.

Cultural: Avoid growing Thuja in land that has recently been cleared of forest in which *Armillaria* was established. Remove as much root debris as possible before planting recently cleared land.

Resistant Cultivars: Resistant and susceptible species are listed in reference 3.

Chemical: None.

References:

1. B.C. Min. of Agriculture and Lands. 2002. Armillaria root rot *in* Landscape Pest Management & Production Guide. P. 140.
2. Foster, A.T. and J.A. Baranyay. 1971. *Armillaria* root rot. Pac. For. Res. Cent., Can. For. Serv., Pest Leaflet 35.
3. Morrison, D.J. 1981. *Armillaria* root disease. Pacific Forest Res. Centre, Victoria B.C. BC-X-203.
4. Raabe, R.D. 1979. Plants resistant or susceptible to *Armillaria* root rot. Univ. Calif., Agric. Ext. Serv. Leaflet 2591.
5. Wargo, P.M. and C.G. Shaw. 1985. *Armillaria* root rot: the puzzle is being solved. Plant Dis. 69: 826-832.

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1. Anon. 1980-1994. Proceedings of the Northwest bulb growers' conference. Washington State University and Northwest Bulb Growers' Association, Puyallup, WA.
2. B.C. Min. of Agri. and Lands and B.C. Landscape and Nursery Association. 2008. Nursery and Landscape Pest Management and Production Guide. (Ordering information available at <http://www.agf.gov.bc.ca/cropprot/prodguide.htm>)
3. B.C. Min. of Agriculture and Lands. 2004. B.C. Floriculture Production Guide - Best Management Practices. (Ordering information available at <http://www.agf.gov.bc.ca/cropprot/prodguide.htm>).
4. Coyier, Duane L. *et al.* 1986. Compendium of Rhododendron and Azalea Diseases. Am. Phytopathol. Soc., St. Paul, Minn. 65 pp.
5. Dreistadt, S.H. *et al.* 2001. Integrated Pest Management for Floriculture and Nurseries. University of California Statewide Integrated Pest Management Project. Pub. #3402. pp. 422.
6. Gould, C.M. and R.S. Byther. 1979. Diseases of Narcissus. Washington State Univ. Ext. Bull 709.
7. Gould, C.M. and R.S. Byther. 1979. Diseases of Bulbous Iris. Washington State Univ. Ext. Bull. 710
8. Gould, C.M. and R.S. Byther. 1979. Diseases of Tulips. Washington State Univ. Ext. Bull. 711.
9. Horst, R. Kenneth *et al.* 2007. Compendium of Rose Diseases and Pests. 2nd Ed. Am. Phytopathol. Soc., St. Paul, Minn.
10. Horst, R. Kenneth. 2001. Westcott's Plant Disease Handbook. 6th Edition. Kluwer Academic Publishers. 1008 pp.
11. Pscheidt, J.W. and C.M. Ocamb. 2008. Pacific Northwest Plant Disease Control Handbook. Oreg. State Univ., Corvallis. (searchable online info <http://plant-disease.ippc.orst.edu/search.cfm?errors=true>)
12. Moore, W.C., A.A. Brunt, D. Price and A.R. Rees 1979. Diseases of bulbs. Ministry of Agriculture, Fisheries and Food, London.
13. Pirone, P.P. 1978. Diseases and Pests of Ornamental Plants (5th Ed.). John Wiley, N.Y. 566 pp.
14. Sinclair, W.A. *et al.* 2005. Diseases of Trees and Shrubs, 2nd Ed. Cornell University Press. 660 pp.
<http://www.flowerbulbs.co.uk/> click on Professional (accessed Dec 18, 2008).
<http://plant-disease.ippc.orst.edu/index.cfm> An Online Guide to Plant Disease Control. Oregon State Univ.

APPENDIX 1. Fungicides Registered for Use on Ornamentals (See Appendix 2 for bulbs)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
AMELANCHIER (Saskatoon berry):					
myclobutanil	Nova	40% WP	22399	C	rust, powdery mildew
triforine	Funginex DC	190 g/L EC	27686	C	rust, Entomosporium
propiconazole	Topas	250 g/L EC	24030	C	rust, Entomosporium
	Propiconazole	250 g/L EC	24029	C	Entomosporium
ASH:					
chlorothalonil	Daconil Ultrex Fungicide	82.5% WG	28354	C	<i>Cercospora</i> , <i>Cercosporidium</i> , <i>Cylindrosporium</i> leafspots
	Daconil 2787	40.4% SU	15724	C	
mancozeb	Dithane DG Rainshield	75% WG	20553	C	anthracnose
	Manzate 200 DF	75% WG	21057	C	
myclobutanil	Nova	40% WP	22399	C	rust
AZALEA: see RHODODENDRON, page 33					
CLEMATIS:					
<i>Agrobacterium radiobacter</i>	Dygal		21106	C	crown gall
sulphur	Safer's Sulphur Dust	92% WP	19703	D	powdery mildew
	Green Earth Sulphur		21890		
	Later's Garden Sulphur	90% WP	5293	D	powdery mildew
	Safer's Defender Garden Fungicide	12% LC	19691	D	powdery mildew
	Wilson Green Earth Sulphur	0.9% L	21880	D	powdery mildew
	Safer's Defender Garden Fung.	0.4% L	20812, 19061	D	powdery mildew
thiophanate methyl	Senator 70 WP	70% WP	12279, 25343	C	leaf spot
	Senator 70WP WSB		27297	C	
COTONEASTER:					
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	fire blight
	Clean Crop Copper Spray		19146		
	Later's Copper	50% WP	16140	D	fire blight
sulphur	Safer's Sulphur Dust	92% WP	19703	D	rust
	Green Earth Sulphur		21890		
	Later's Garden Sulphur	90% WP	5293	D	rust
	Safer's Defender Garden Fungicide	12% LC	19691	D	rust
	Wilson Green Earth Sulphur	0.9% L	21880	D	rust
	Safer's Defender Garden Fung.	0.4% L	20812, 19061	D	rust
	Safer's Liquid Sulphur		19451		

* C/D = commercial or domestic registration

APPENDIX 1 (continued)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
CRABAPPLE:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	scab, powdery mildew, sooty blotch
	Daconil Ultrex Fungicide	82.5% WG	28354	C	scab, rust, Sphaeropsis leafspot
copper oxychloride	Guardman copper oxychloride	50% WP	13245	C	fire blight
	Clean Crop Copper Spray	50% WP	19146	C	
	Later's Copper	50% WP	16140	D	fire blight
folpet	Folpan	50% WP	15654	C	scab, alternaria leaf spot, sooty blotch, black rot, Brooks fruit spot, fly speck
	Folpan	50% WG	27733	C	
myclobutanil	Nova	40% WP	22399	C	rust, powdery mildew, scab
sulphur	Safer's Sulphur Dust	92% WP	19703	D	scab, powdery mildew, rust
	Green Earth Sulphur		21890	D	
	Later's Garden Sulphur	90% WP	5293	D	scab, powdery mildew, rust
	Safer's Defender Garden Fungicide	12% LC	19691	D	scab, powdery mildew, rust powdery mildew
	Wilson Green Earth Sulphur	0.9% L	21880	D	scab, powdery mildew, rust
	Safer's Defender Garden Fung.	0.4% L	20812, 19061	D	scab, powdery mildew, rust
	Safer's Liquid Sulphur		19451	D	
trifloxystrobin	Compass 50WG	50% WG	27527	C	scab, powdery mildew
DOGWOOD:					
captan + carbaryl + malathion	King Fruit Tree & Garden Spray	10% WP 10% 5%	9986	D	leaf spot
chlorothalonil	Daconil 2787	40.4% SU	15724	C	septoria leaf spot
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
myclobutanil	Nova	40% WP	22399	C	powdery mildew, anthracnose, Septoria leaf spot
propiconazole	Banner	130 g/L EC	23693	C	anthracnose

* C/D = commercial or domestic registration

APPENDIX 1 (continued)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
ELDER:					
sulphur	Safer's Sulphur Dust Green Earth Sulphur	92% WP	19703 21890	D	powdery mildew, rust
	Later's Garden Sulphur	90% WP	5293	D	powdery mildew, rust
	Safer's Defender Garden Fungicide	12% LC	19691	D	powdery mildew, rust
	Wilson Green Earth Sulphur	0.9% L	21880	D	powdery mildew, rust
	Safer's Defender Garden Fung. Safer's Liquid Sulphur	0.4% L	20812, 19061 19451	D	powdery mildew, rust
FIRETHORN:					
chlorothalonil	Daconil 2787	40.4% SU	157242	C	scab
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
propiconazole	Banner	130 g/L EC	23693	C	scab
FORSYTHIA:					
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	bacterial blight
	Clean Crop Copper Spray	50% WP	19146	C	
HAWTHORN:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	<i>Fabraea</i> , rust
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	fire blight
	Clean Crop Copper Spray	50% WP	19146	C	
mancozeb	Later's Copper	50% WP	16140	D	fireblight
	Dithane DG Rainshield	75% WG	20553	C	leaf blight
Manzate 200 DF	75% WG	21057	C		
myclobutanil	Nova	40% WP	22399	C	rust
tribasic copper sulphate	Green Earth Bordo	53% WP	17482	D	leaf spot
trifloxystrobin	Compass 50WG	50% WG	27527	C	scab
HOLLY:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	rhizoctonia web blight
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
mancozeb	Dithane DG Rainshield	75% WG	20553	C	leaf & twig blight, algae (Dithane)
	Manzate 200 DF	75% WG	21057	C	
HOLLYHOCK:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	rust
	Daconil Ultrex Fungicide	82.50% WG	28354	C	
myclobutanil	Nova	40% WP	22399	C	rust, powdery mildew
sulphur	Safer's Sulphur Dust	92% WP	19703	D	powdery mildew, rust
	Green Earth Sulphur	92% WP	21890	D	
	Later's Garden Sulphur	90% WP	5293	D	
	Wilson Green Earth Sulphur	0.9% L	21880	D	
	Safer's Defender Garden Fung. Safer's Liquid Sulphur	0.4% L	20812, 19061 19451	D	

* C/D = commercial or domestic registration

APPENDIX 1 (continued)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
IRIS GERMANICA:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	leaf spot, <i>Botrytis</i>
	Daconil Ultrex Fungicide	82.50% WG	28354	C	blossom blight
myclobutanil	Nova	40% WP	22399	C	rust
JUNIPER:					
captan + thiophanate methyl + carbaryl + malathion	Green Cross Gardal Rose & Evergreen Dust	5% DU 3% 5% 4%	14851	D	foliar blight
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	needlecast, twig
	Copper Spray Fungicide	50% WP	19146	C	blight
	Later's Copper	50% WP	16140	D	needlecast, twig blight
mancozeb	Dithane DG Rainshield	75% WG	20553	C	coryneum blight, dieback, keithia blight, pear trellis rust
	Manzate 200 DF	75% WG	21057	C	coryneum blight, dieback, keithia blight
myclobutanil	Eagle WSP	40% SG	26585	C	rust
KALMIA:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	cercospora leaf spot
tribasic copper sulphate	Green Earth Bordo	53% WP	17482	D	leaf spot
LILAC:					
captan	Clean Crop Supra Captan	80% WG	24613	C	botrytis blight
	Maestro	80% WG	26408		
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	bacterial blight
	Copper Spray	50% WP	19146	C	
	Later's Copper	50% WP	16140	D	bacterial blight
fenhexamid	Decree	50% WG	26132	C	botrytis blight
myclobutanil	Nova	40% WP	22399	C	powdery mildew
sulphur	Safer's Sulphur Dust	92% WP	19703	D	powdery mildew
	Green Earth Sulphur	92% WP	21890	D	
	Later's Garden Sulphur	90% WP	5293	D	
	Wilson Green Earth Sulphur	0.9% SU	21880	D	
	Safer's Defender Garden Fung.	0.4% SN	20812, 19061 19451	D	
	Safer's Liquid Sulphur				
LILY:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	gray mold
	Daconil Ultrex Fungicide	82.5% WG	28354	C	

* C/D = commercial or domestic registration

APPENDIX 1 (continued)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
MAHONIA:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	rust
MOUNTAIN ASH:					
captan + carbaryl + malathion	Green Cross Fruit Tree & Garden Spray	10% WP 10% 5%	9986	D	scab
copper oxychloride	Guardsman copper oxychloride Copper Spray	50% WP 50% WP	13245 19146	C C	fire blight
	Later's Copper	50% WP	16140	D	bacterial blight
PEONY:					
fenhexamid	Decree	50% WG	26132	C	<i>Botrytis</i>
iprodione	Rovral	50% WP	15213	C	<i>Botrytis</i>
	Rovral WDG	50% WG	24709	C	
PHOTINIA:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	<i>Fabraea</i> leaf spot
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
RHODODENDRON & AZALEA:					
captan	Maestro	80% WG	26408	C	damping off, rot of cuttings
chlorothalonil	Daconil 2787	40.4% SU	15724	C	ovulinia flower blight,
	Daconil Ultrex Fungicide	82.5% WG	28354	C	phytophthora foliar blight
etridiazole	Truban	30% WP	11460	C	phytophthora root rot
		25% EC	12222	C	
myclobutanil	Nova	40% WP	22399	C	powdery mildew
sulphur	Safer's Sulphur Dust	92% WP	19703	D	powdery mildew, rust
	Green Earth Sulphur	92% WP	21890	D	
	Later's Garden Sulphur	90% WP	5293	D	powdery mildew, rust
	Safer's Defender Garden Fungicide	12% LC	19691	D	powdery mildew, rust
	Wilson Green Earth Sulphur	0.9% L	21880	D	powdery mildew, rust
	Safer's Defender Garden Fung.	0.4% L	20812, 19061	D	powdery mildew, rust
	Safer's Liquid Sulphur		19451		
ROSE:					
<i>Agrobacterium radiobacter</i>	Dygal	-	21106	C	crown gall
<i>Bacillus subtilis</i> strain QST 713	Rhapsody ASO	1.34% LO	28627	C	powdery mildew
	Serenade Garden	1.34% LO	28628	D	
	Serenade Garden RTU	0.074% LO	28629	D	
captan	Captan 50W	50% WP	14823	C	black spot, <i>Botrytis</i>
	Clean Crop Captan	80% WG	23691	C	black spot, <i>Botrytis</i>
	Clean Crop Supra Captan	80% WG	24613		
	Maestro	80% WG	26408		
captan + thiophanate methyl + carbaryl + malathion	Green Cross Gardal Rose & Evergreen Dust	5% DU 3% 5% 4%	14851	D	black spot
chlorothalonil	Daconil 2787	40.4% SU	15724	C	black spot, <i>Botrytis</i>
	Daconil Ultrex Fungicide	82.5% WG	28354	C	
copper oxychloride	Copper Spray	50% WP	19146	C	bacterial blight
	Later's Copper Spray	50% WP	16140	D	bacterial blight

* C/D = commercial or domestic registration

APPENDIX 1 (continued)

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
ROSE: (continued)					
copper (picric cupric ammonium formate and tannate complex)	Phyton 27	5.5% LI	21699	C	<i>Botrytis</i> , black spot, powdery mildew
copper (tribasic copper sulphate)	Basicop	53% WP	19003	C	black spot, powdery mildew
	Copper	53% WP	9934	C	
	Green Earth Bordo	53% WP	17482	D	
dicloran	Botran	75% WP	8772	C	<i>Botrytis</i>
dodemorph-acetate	Meltatox	400 g/L LI	11798	C	powdery mildew
fenhexamid	Decree	50% WG	26132	C	<i>Botrytis</i> gray mold
folpet	Folpan	50% WP	15654	C	black spot, powdery mildew
	Later's Folpet	50% WP	15798	D	
folpet + carbaryl + pirimicarb	Wilson Floritect	10% EC 10% 2.5%	24876	D	black spot, powdery mildew
folpet + malathion + carbaryl	C-I-L Rose Dust	5% DU 4% 5%	10565	D	black spot, powdery mildew
lime sulphur (calcium poly sulphide or sulphide sulphur)	C-I-L Liquid Lime Sulphur	23% LI	7386	D	black spot, canker, powdery mildew
	Wilson Lime Sulphur	23%	23782	D	
	Lime sulphur	23% LI	27978	C	black spot, canker
myclobutanil	Nova	40% WP	22399	C	powdery mildew, rust, black spot
	Eagle WSP	40% SG	26585	C	
sulphur	Safer's Sulphur Dust	92% WP	19703	D	black spot, powdery mildew, rust
	Green Earth Sulphur	92% WP	21890	D	
	Later's Garden Sulphur	90% WP	5293	D	
	Safer's Defender Garden Fungicide	12% LC	19691	D	
	Wilson Green Earth Sulphur	0.9% L	21880	D	black spot, powdery mildew
	Safer's Defender Garden Fung. Safer's Liquid Sulphur	0.4% L	20812, 19061 19451	D	
thiophanate-methyl	Senator 70WP	70% WP	12279	C	black spot, powdery mildew
	Senator 70WP WSB	70% WP	27297	C	
triforine	Funginex DC	190 g/L DC	27686	C	black spot, powdery mildew
	Rosepride Funginex	6.5% LI	15727	D	
THUJA:					
copper oxychloride	Guardsman copper oxychloride	50% WP	13245	C	tipblight, leaf blight
	Copper Spray	50% WP	19146	C	
	Later's Copper Spray	50% WP	16140	D	
mancozeb	Dithane DG Rainshield	75% WG	20553	C	keithia blight, coryneum blight
propiconazole	Topas	250 g/L EC	24030	C	keithia blight
	Propiconazole	250 g/L EC	24029	C	

* C/D = commercial or domestic registration

APPENDIX 2. Fungicides Registered for Use on Bulbs in Canada

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
GLADIOLUS, IRIS, NARCISSUS, TULIP: (See below for individual registrations)					
captan	Captan 50W	50% WP	14823	C	bulb rot, damping off
	Clean Crop Captan	80% WG	23691	C	
	Clean Crop Supra Captan	80% WG	24613		
	Maestro	80% WG	26408		
captan + carbaryl	Later's Bulb Dust	5% DU	12146	D	bulb rot, root rot, damping off
	Wilson's Bulb & Soil Dust	5% DU	14852		
formaldehyde	Clean Crop Formalin	37% LI	6998	C	nematodes in stored bulbs
GLADIOLUS:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	flower & leaf spot <i>Botrytis, Curvularia</i>
IRIS:					
chlorothalonil	Daconil 2787	40.4% SU	15724	C	flower & leaf spot <i>Botrytis, Curvularia</i>
folpet	Folpan	50% WP	15654	C	leaf spot
	Later's Folpet	50% WP	15798	D	
myclobutanil	Nova	40% WP	22399	C	rust
quintozene	Quintozene (Terraclor)	75% WP	11425, 7251	C	bulb rot
NARCISSUS:					
quintozene	Quintozene (Terraclor)	75% WP	11425	C	bulb rot
TULIP:					
captan	Captan 50W	50% WP	14823	C	flower blight, <i>Botrytis</i>
	Maestro	80% WG	26408	C	
quintozene	Quintozene (Terraclor)	75% WP	11425, 7251	C	bulb rot

* C/D = commercial or domestic registration

APPENDIX 3. General Ornamental Registrations in Canada

Active Ingredient	Trade Name	Formulation	PCP#	C/D*	Diseases Controlled
<i>Agrobacterium radiobacter</i>	Dygal	-	21106	C	crown gall
dazomet	Basamid	98% GR	15032	C	nematodes
etr Diazole	Truban	30% WP	11460	C	stem rot, root rot, damping off
fenhexamid	Decree	50% WG	26132	C	<i>Botrytis</i>
iprodione	Rovral	50% WP	15213	C	<i>Rhizoctonia</i> , damping off
metalxyl-m + S isomer	Subdue Maxx	240 g/L EC	27055	C	damping off, root and stem rot caused by <i>Pythium</i> spp., <i>Phytophthora</i> spp. (nurseries & greenhouse only)
metam sodium	Vapam	380 g/L LI	6453	C	soil fungi, weeds, nematodes
oxine benzoate	No-Damp	2.5% LI	3794 11880	C D	damping off
thiophanate-methyl	Senator	70% WP	12279, 25343	C	powdery mildew, <i>Botrytis</i> , leaf spots
triforine	Rosepride Funginex Funginex	6.5% EC 190 g/L EC	15727 27686	D C	powdery mildew

* C/D = commercial or domestic registration