

Chapter Eleven

DISEASES OF VEGETABLE CROPS

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ASPARAGUS (*Asparagus officinalis*)

CROWN ROT, WILT and SEEDLING BLIGHT

Fusarium spp.

Cultural: Plant disease-free crowns if possible. Rotate infested fields with grasses or cereals (1). Avoid planting in fields known to be infested; in fields which have grown asparagus within 5 years; or in fields with undecomposed corn residue.

Resistant cultivars: None.

Intermediate: Jersey Giant, Lucullus 234 and 328.

Chemical: If disease-free soil is not available for growing seedlings, fumigate seedbed with a soil fumigant according to usual procedures (see Chapter 4, under 'General Disease Control Methods for Greenhouse Crops'). Sodium chloride will suppress crown and root rot symptoms (4). Limitations: As per label.

Notes: In Ontario and BC, a sodium hypochlorite seed treatment is recommended.

References:

1. Cohen, S.I. and Heald, F.D. 1941. A wilt and root rot of asparagus caused by *Fusarium oxysporum*. Plant Dis. Rep. 25: 503-509.
2. Damicone, J.P. and Manning, W.J. 1984. Frequency and pathogenicity of *Fusarium* spp. isolated from first year asparagus grown from transplants. Plant Disease 69: 413-416.
3. Elmer, W.H. 1992. Suppression of *Fusarium* crown and root rot of asparagus with sodium chloride. Phytopathology 82: 97-104.
4. Elmer, W.H. *et al.* 1996. Epidemiology and management of the diseases causal to asparagus decline. Plant Dis. 80: 117-125.
5. Stephens, E.T. *et al.* 1989. Evaluation of asparagus species for resistance to *Fusarium oxysporum* f. sp. *asparagi* and *F. moniliforme*. HortScience 24: 365-368.

RUST

Puccinia asparagi

Cultural: Avoid areas having poor air circulation. Cut or destroy all volunteers around fence lines, etc. Grow only resistant cultivars. Irrigate early in the day so that plants do not remain wet overnight.

Resistant Cultivars: None.

Intermediate: Jersey Centennial, Jersey Giant, Viking, UC-157.

Susceptible: Mary Washington, WSU-1.

Chemical: After harvesting has been completed for the year but before disease normally appears, spray fern growth every 10-14 days as required with metiram (COM) WG or zineb (COM) WP (3). Apply propiconazole (COM) EC as soon as fern growth begins at 14 to 21 day intervals, maximum of three applications per season. Apply myclobutanil (COM) WP postharvest to ferns, maximum of 5 applications per season. Apply chlorothalonil (COM) SU postharvest at 14 day intervals, maximum 3 applications per season.

Limitations: As per labels. Do not apply to spears to be cut. Note: zineb is being withdrawn and may not be used after 31 December 2010

Notes: Use of resistant cultivars is usually sufficient.

References:

1. Hepler, P.R. *et al.* 1957. Inheritance of resistance to asparagus rust in Illinois; its causal agent and control. Ill. Agric. Exp. Sta., Bull. 607: 1-47.
2. Johnson, D.A. and Lunden, J.D. 1992. Effect of rust on yield of susceptible and resistant asparagus cultivars. Plant Dis. 76: 84-86.
3. Linn, M.B. and Lubani, K.R. 1958. Zineb as a protective fungicide for the control of asparagus rusts. Plant Dis. Rep. 42: 669-672.

PURPLE SPOT

Stemphylium vesicarium (*Pleospora allii*)

Cultural: Avoid introducing the disease by using treated seed (see fusarium wilt) or crowns from a disease-free field. Incorporate or burn crop refuse at end of season to reduce overwintering (1).

Resistant Cultivars: None.

Intermediate: Jersey Giant

Susceptible: Mary Washington

Chemical: Azoxystrobin (COM) and chlorothalonil (COM) SU are registered for control of purple spot following harvest. Zineb used for control of rust reduces the level of disease on ferns but is not registered for use on spears. Limitations: Azoxystrobin - maximum of 3 applications per season, 180 day PHI; chlorothalonil - maximum of 3 applications per season, 190 day PHI. Note: zineb is being withdrawn and may not be used after 31 December 2010

References:

1. Johnson, D.A. 1990. Effect of crop debris management on severity of stemphylium purple spot of asparagus. Plant Disease 74: 413-415.
2. Johnson, D.A. and Lunden, J.D. 1986. Effects of wounding and wetting duration on infection of asparagus by *Stemphylium vesicarium*. Plant Disease 70: 419-420.
3. Lacy, M.L. 1982. Purple spot: A new disease of young asparagus spears caused by *Stemphylium vesicarium*. Plant Disease 66: 1198-1200.
4. Meyer, M.P., *et al.* 2000. Optimal fungicide management of purple spot of asparagus and impact on yield. Plant Dis. 84:525-530

BEANS (Snap) (*Phaseolus vulgaris*)

ANTHRACNOSE

Colletotrichum lindemuthianum (= *Glomerella lindemuthiana*, perfect state)

Cultural: The use of clean seed; rotation for 2-3 years with nonhost crops (i.e. cereals and corn) to reduce initial inoculum from infested debris.

Resistant Cultivars: Few cultivars are resistant to all the major races (Alpha, gamma, delta, kappa and lambda).

Chemical: Tribasic copper sulphate WP (COM) - as needed to keep plants covered. Seed treatment - carbathiin + thiram (COM) SU. Limitations: As per labels.

References:

1. Goth, R.W. and Zaumeyer, W.J. 1965. Reactions of bean varieties to four races of anthracnose. Plant Dis. Rept. 49: 815-818.
2. Hall, R. Ed. 1994. Compendium of Bean Diseases. APS Press., St. Paul, Mn., USA. 73 pp.
3. Howard, R.J., Garland, J.A. and Seaman, W.L. (Eds.). 1994. Diseases and Pests of Vegetable Crops in Canada. The Canadian Phytopathological Society and Entomological Society of Canada. 554 pp.
4. Ntahimpera, N. *et al.* 1996. Anthracnose development in mixtures of resistant and susceptible dry bean cultivars. Phytopathology 86: 668-673.
5. Tu, J.C. 1994. Occurrence and characterization of the alpha-Brazil race of bean anthracnose (*Colletotrichum lindemuthianum*) in Ontario. Can. J. Plant Pathol. 16: 129-131.

COMMON BACTERIAL BLIGHT, FUSCOUS BLIGHT, HALO BLIGHT

Xanthomonas axonopodis pv. *phaseoli*, *Pseudomonas syringae* pv. *phaseolicola*

Cultural: Use only disease-free seed (3) produced in blight-free areas of the Western United States if possible. Plow under crop refuse promptly after harvest. Follow a 3-year rotation out of beans. Do not work in fields when foliage is wet. Avoid sprinkler irrigation.

Resistant Cultivars: Extensive lists of resistant cvs. are available but are of little use unless the exact identity of the pathogen has been determined (1, 2).

Chemical: Tribasic copper sulfate (COM, DOM) WP; copper hydroxide (COM) WP (see note 1).

Limitations: Preharvest interval - 1 day (tribasic copper sulphate, cupric hydroxide).

Notes: Chemical control is not practical except for small seed plots or other special situations.

References:

1. Burkholder, W.H. and Bullard, E.T. 1946. Varietal susceptibility of beans to *Xanthomonas phaseoli* var. *fuscans*. Plant Dis. Rep. 30: 446-448.
2. Mackie, W.W. *et al.* 1945. Production in California of snap bean seed free from blight and anthracnose. Calif. Agric. Exp. Sta., Bull. 689: 1-23.

3. Wallen, V.R. and Galway, D.A. 1979. Effective management of bacterial blight of field beans in Ontario - a 10 year program. *Can. J. Plant Pathol.* 1: 42-46.
4. Webster, D.M. *et al.* 1983. Bacterial blights of snapbeans and their control. *Plant Dis.* 67: 935-940.

DRY ROOT ROT

Fusarium solani f. sp. *phaseoli*

Cultural: In fields where root rot is known to be a problem, cultivate and fertilize to obtain maximum growth. Plow down crop refuse promptly after harvest. Follow long rotation with wheat, other cereals, or grasses (2, 3).

Resistant Cultivars: Cultivars range from very susceptible to very resistant with most of the common cvs. being intermediate (1).

Chemical: Apply captan (COM) WG as a seed bed treatment, worked into upper 7.5 to 10 cm of soil before planting. Limitations: As per label.

References:

1. Boomstra, A.G. *et al.* 1977. New sources of *Fusarium* root rot resistance in *Phaseolus vulgaris* L. *J. Amer. Soc. Hort. Sci.* 102: 182-185.
2. Maier, C.R. 1968. Influence of nitrogen nutrition on *Fusarium* root rot of pinto beans and on its suppression by barley straw. *Phytopathology* 58: 620-625.
3. Miller, D.E. and Burke, D.W. 1974. Influence of soil bulk density and water potential on *Fusarium solani* f. sp. *phaseoli* root rot of beans. *Phytopathology* 64: 526-529.

GREY MOLD

Botrytis cinerea

Cultural: Maintain air circulation through good weed control and avoid dense, lush growth. Avoid long periods of overhead irrigation particularly during flowering.

Resistant Cultivars: None.

Chemical: Boscalid (COM) WG as per label recommendations when 20 to 50% of blossoms have opened and again 7 to 14 days later if disease persists, iprodione (COM) WG as per label recommendation applied when 30 and 50% of blossoms have opened. Thorough coverage is essential for control. Vinclozolin (COM) WG as per label recommendation at early bloom and full bloom (BC only).

Limitations: Preharvest intervals - boscalid (7 days); iprodione: apply at bloom only; 20 days (vinclozolin). Do not apply more than 3 kg/ha of vinclozolin per season. Note: vinclozolin is being discontinued and may not be used after December 31, 2010

Notes: Alternation of iprodione with other fungicides is recommended to minimize the risk of fungicide resistance. Dicloran (COM) WP is also registered for grey mold, but provides limited control in most areas.

References:

1. Gabrielson, R.L. *et al.* 1971. Field control of white and gray molds of beans in Western Washington. *Plant Dis. Rep.* 55: 234-238.
2. Sweeney, M.E. and Ormrod, D.J. 1983. Fungicide applications for the control of grey and white molds of snapbeans. P. 229 *in* Pesticide Research Report. ECPUA, Ottawa.

MOSAICS

Bean Common Mosaic Virus, Bean Yellow Mosaic Virus

Cultural: If common mosaic is a problem, select resistant cultivars. Avoid bean yellow mosaic by planting beans at least 0.5 km from sweet, crimson or red clover and gladioli, which may carry the virus (3).

Resistant Cultivars: Most cultivars of snap and dry beans now commonly grown are resistant to common mosaic (2).

Chemical: None.

Notes: Aphid control may reduce rate of spread.

References:

1. Hampton, R.O. 1975. The nature of bean yield reduction by bean yellow and bean common mosaic viruses. *Phytopathology* 65: 1342-1346.
2. Zaumeyer, W.J. and Meiners, J.P. 1975. Disease resistance in beans. *Ann. Rev. Phytopathol.* 13: 313-334.
3. Zaumeyer, W.J. and Thomas, H.R. 1957. A monographic study of bean diseases and methods for their control. U.S. Dep. Agric., Bull. 868: 90-107.

PYTHIUM DAMPING-OFF AND PHYTOPHTHORA ROOT ROT

Pythium spp., *Phytophthora* spp.

Cultural: Sow seed as shallowly as possible into a well-drained, warm and moist but not wet soil. Bean crops should be rotated with grains or pasture crops rather than vegetable crops.

Resistant Cultivars: None.

Chemical: Apply metalaxyl (COM) EC at planting to the seed furrow. Treat seed with captan (COM) SU. Apply captan (COM) WG as a seed bed treatment, worked into upper 7.5 to 10 cm of soil before planting

Limitations: As per label. Apply metalaxyl only once per year during seeding. Seed treated by the slurry of captan should not be bagged or stacked until it has dried. A colourant must be added to captan to colour seed.

References:

1. Adegbola, M.O.K. and Hagedorn, D.J. 1970. Host resistance and pathogen virulence in *Pythium* blight of bean. *Phytopathology* 60: 1477-1479.
2. Hall, R. Ed. 1994. *Compendium of bean diseases*. APS Press. St. Paul, MN, USA. 73 pp.
3. Howard, R.J., Garland, J.A. & Seaman, W.L. 1994. *Diseases and Pests of Vegetable Crops in Canada: An Illustrated Compendium*. Can. Phytopath. Soc. and Ent. Soc. Canada. Ottawa, Canada, 554 pp.

RUST

Uromyces appendiculatus (syn. *Uromyces phaseoli*)

Cultural: Plow under crop refuse after harvest. Follow a 3-year rotation with non-legume crops. Disinfest used posts and stakes in commercial formalin 1:30 or lime sulphur 1:10 (2).

Resistant Cultivars: Most bush beans are resistant; most popular pole beans are susceptible although some are resistant to certain races.

Chemical: Where early infections occur, use of sulphur (COM, DOM) WP dusts or sprays at 7-day intervals up to blossoming may be warranted.

Limitations: Preharvest interval - 1 day (sulphur).

References:

1. Stavely, J.R. 1984. Pathogenic specialization in *Uromyces phaseoli* in the United States and rust resistance in beans. *Plant Dis.* 68: 95-99.
2. Zaumeyer, W.J. and Thomas, H.R. 1957. A monographic study of bean diseases and methods for their control. U.S. Dep. Agric., Tech. Bull. 868: 34-42.

STEM ROT (WHITE MOLD)

Sclerotinia sclerotiorum

Cultural: Avoid dense foliage by restricting nitrogen fertility and moisture levels. Rotate with non-susceptible crops such as beets, onions, spinach, corn, cereals, and grasses (1, 2).

Resistant Cultivars: None.

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of white mold.

Limitations: Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: Thiophanate-methyl (COM) WP applied during early stages of bloom prior to rows closing in (white beans only). Iprodione (COM) WG, WP can be used. Vinclozolin (COM) WG is registered for white mold and as used for grey mold in British Columbia will also control white mold (3). Dicloran (COM) WP is registered for control of sclerotinia on beans. Boscalid (COM) WG may be applied at 20 to 50% bloom with a second application 7 to 14 days later if disease persists or weather favours disease.

Limitations: Preharvest interval - 2 days (dicloran); 7 days (boscalid); 20 days (vinclozolin). Do not feed treated crop refuse to livestock. Note: vinclozolin is being withdrawn and may not be used after December 31, 2010

Notes: Chlorothalonil [Bravo] and thiophanate-methyl [Senator] are registered for use only on dry (field) beans (see Field Beans in Chapter 9) (5). Boscalid and dicloran (Botran) are registered for use on snap beans and dry beans. Dicloran is registered for use on pole beans in British Columbia only.

References:

1. Gabrielson, R.L. *et al.* 1971. Field control of white and gray molds of beans in Western Washington. Plant Dis. Rep. 55: 234-238.
2. Natti, J.J. 1979. Epidemiology and control of bean white mold. Phytopathology 61: 669-674.
3. Ormrod, D.J., Sweeney, M.E. and Brookes, V.R. 1993. Efficacy of single applications of fungicides at 10% bloom against gray and white mold of snapbeans. Pesticide Research Report. ECPUA Ottawa.
4. Sweeney, M.E. and Ormrod, D.J. 1983. Fungicide applications for the control of grey and white mold of snapbeans. Pp. 229 *in* Pesticide Research Report. ECPUA, Ottawa
5. Tu, J.C. 1983. Efficacy of iprodione against alternaria black pod and white mold of white beans. Can. J. Plant Pathol. 5: 133-135.

BEET (*Beta vulgaris*)

See SUGAR BEET, in Chapter 9.

BROAD BEAN (*Vicia fabae*)

See FABABEAN, in Chapter 9.

BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER (*Brassica oleracea*)

BLACKLEG

Leptosphaeria maculans (imperfect state *Phoma lingam*)

Cultural: Use clean seed or hot water-treated seed (see BLACK ROT on page 11). Eradicate cruciferous weeds. Use a 4-year crop rotation with non-cruciferous crops. Maintain good soil drainage.

Resistant Cultivars: None.

Chemical: None.

References:

1. Gabrielson, R.L. *et al.* 1977. Fungicidal eradication of seed-borne *Phoma lingam* of crucifers. *Plant Dis. Rep.* 61: 118-121.
2. Kharbanda, P.D. 1992. Performance of fungicides to control blackleg of canola. *Can. J. Plant Path.* 14: 169-176.
3. Petrie, A. and Vanterpool, T.C. 1974. Infestation of crucifer seed in Western Canada by the blackleg fungus *Leptosphaeria maculans*. *Can. Plant Dis. Survey* 54: 119-123.

BLACK ROT

Xanthomonas campestris pv. *campestris*

Cultural: Use clean seed or seed soaked in water at 50°C for 25 min. for cabbage and Brussels sprouts and 15 min. for cauliflower or broccoli. This treatment may reduce germination. Use a 2-year rotation out of crucifers in production fields (2). Use a 3-year rotation in the transplant bed. This is important since most spread of the disease occurs in the seed bed.

Resistant Cultivars: King Cole and Roundup cabbage are said to be highly tolerant. See seed catalogue descriptions for additional resistant cultivars.

Chemical: None.

References:

1. Kocks, C.G. and Zadoks, J.C. 1996. Cabbage refuse piles as sources of inoculum for black rot epidemics. *Plant Dis.* 80: 789-792.
2. Lockhart, C.L. *et al.* 1976. Control of *Xanthomonas campestris* in Brussels sprouts with hot water and Aureomycin seed treatment. *Can. Plant Dis. Survey* 56: 63-66.
3. Schaad, N.W. 1989. Detection of *Xanthomonas campestris* pv. *campestris* in crucifers. Pp. 68-75 in Saettler, A.W. *et al.* Detection of Bacteria in Seed and other Planting Material. APS Press, St. Paul, MN. 122 pp.
4. Williams, P.H. 1980. Black rot: a continuing threat to world crucifers. *Plant Dis.* 64: 736-742.

CLUBROOT

Plasmodiophora brassicae

Cultural: Plant seed in soil known to be free of clubroot. Where plants are to be set out rather than seeded direct, be sure the seed bed is free of clubroot or thoroughly fumigated before seeding (see Notes). Plant early in well drained soils. Where clubroot is known to occur, rotate with other than cole crops at least 3 out of every 4 years. In light sandy soils, thoroughly disk-in hydrated lime at 4.5 tonnes/ha at least 6 weeks before planting. Finely ground limestone at 10 tonnes/ha one year prior to planting is preferable (2, 6). The pH of the soil must be raised above 7.0 for this treatment to be effective. This is not practical on muck soils (3). Do not overfertilize. Use a soil test to determine nutritional requirements.

Resistant Cultivars: Cabbage - Badger Shipper, Richelain; broccoli - B 150 MC, Oregon CR1 (See note 3).

Chemical: While it is not a general recommendation because of the high cost and marginal control achieved, quintozone 75% WP (COM) is still registered for use. On the light sandy soils where experience has shown it to be effective, it may be applied as a transplanting drench. For cauliflower only, apply Agral 90 as a drench at planting for control. See label for directions (see Ref. 4).

Limitations: Quintozone is registered as a transplant treatment only.

Notes:

1. Clubroot is normally a problem only in acidic soils.
2. Lime should never be added to seed beds as it will mask symptoms.
3. Cultivar resistance (1) depends on the race(s) of clubroot present in the field. Badger Shipper cabbage and B 150 MC broccoli are resistant to race 6, the predominant race in B.C. Oregon CR1 broccoli is resistant to clubroot races 1, 4, and 6. Richelain cabbage has multi-race resistance.
4. Recent research has included solarization with and without chemicals; pre and post planting applications of calcium cyanamide; and biological control including the use of trap crops to stimulate spore germination.

References:

1. Campbell, R.N. *et al.* 1985. Factors related to control of clubroot of crucifers in the Salinas Valley of California. *Phytopathol.* 75: 665-670.
2. Chiang, M.S. and Crete, R. 1972. Screening crucifers for germplasm resistance to clubroot *Plasmodiophora brassicae*. *Can. Plant Dis. Surv.* 52: 45-50.
3. Dobson, R.L. *et al.* 1983. Effects of lime particle size and distribution and fertilizer formulation on clubroot disease caused by *Plasmodiophora brassicae*. *Plant Dis.* 67: 50-52.
4. Edgington, L.V. *et al.* 1986. Use of surfactants to control clubroot in cauliflower, 1986. Pesticide Research Report, ECPUA, Ottawa.
5. Myers, D.F. and Campbell, R.N. 1985. Lime and the control of clubroot of crucifers: effects of pH, calcium, magnesium and their interactions. *Phytopathology* 75: 670-673.
6. Sweeney, M.E. and Ormrod, D.J. 1986. Evaluation of soil fumigants for the control of clubroot and weeds in cole crop seedbeds. Pesticide Research Report, ECPUA, Ottawa.

DOWNY MILDEW

Peronospora parasitica

Cultural: Rotate to noncruciferous plants. Use good field sanitation including destruction of mustard weeds. Avoid heavy seeding, over-watering, and the application of water after 3 p.m. Plow in crop remains as soon as harvest is complete. Obtain good soil coverage of plowed refuse to ensure early breakdown of crop remains.

Resistant Cultivars: Cabbage - Badger Shipper, Richelain; broccoli - B 150 MC, Oregon CR1 (See note 3).

Chemical: While it is not a general recommendation because of the high cost and marginal control achieved, quintozone 75% WP (COM) is still registered for use. On the light sandy soils where experience has shown it to be effective, it may be applied as a transplanting drench. For cauliflower only, apply Agral 90 as a drench at planting for control. See label for directions (see Ref. 4).

Limitations: Quintozone is registered as a transplant treatment only.

Notes:

1. Clubroot is normally a problem only in acidic soils.
2. Lime should never be added to seed beds as it will mask symptoms.
3. Cultivar resistance (1) depends on the race(s) of clubroot present in the field. Badger Shipper cabbage and B 150 MC broccoli are resistant to race 6, the predominant race in B.C. Oregon CR1 broccoli is resistant to clubroot races 1, 4, and 6. Richelain cabbage has multi-race resistance.
4. Recent research has included solarization with and without chemicals; pre and post planting applications of calcium cyanamide; and biological control including the use of trap crops to stimulate spore germination.

References:

1. Campbell, R.N. *et al.* 1985. Factors related to control of clubroot of crucifers in the Salinas Valley of California. *Phytopathol.* 75: 665-670.
2. Chiang, M.S. and Crete, R. 1972. Screening crucifers for germplasm resistance to clubroot *Plasmodiophora brassicae*. *Can. Plant Dis. Surv.* 52: 45-50.
3. Dobson, R.L. *et al.* 1983. Effects of lime particle size and distribution and fertilizer formulation on clubroot disease caused by *Plasmodiophora brassicae*. *Plant Dis.* 67: 50-52.
4. Edgington, L.V. *et al.* 1986. Use of surfactants to control clubroot in cauliflower, 1986. Pesticide Research Report, ECPUA, Ottawa.
5. Myers, D.F. and Campbell, R.N. 1985. Lime and the control of clubroot of crucifers: effects of pH, calcium, magnesium and their interactions. *Phytopathology* 75: 670-673.
6. Sweeney, M.E. and Ormrod, D.J. 1986. Evaluation of soil fumigants for the control of clubroot and weeds in cole crop seedbeds. Pesticide Research Report, ECPUA, Ottawa.

DOWNY MILDEW

Peronospora parasitica

Cultural: Rotate to noncruciferous plants. Use good field sanitation including destruction of mustard weeds. Avoid heavy seeding, over-watering, and the application of water after 3 p.m. Plow in crop remains as soon as harvest is complete. Obtain good soil coverage of plowed refuse to ensure early breakdown of crop remains.

Resistant Cultivars: A number of broccoli varieties with resistance are now available (e.g. 'Emerald City'). Consult your seed supplier.

Very Susceptible: Waltham 29 broccoli.

Chemical: In the seed bed, spray seedlings at germination and repeat twice a week until transplanted, with zineb (COM) WP or chlorothalonil (COM) SU. In the field, after transplanting or direct seeding, use chlorothalonil (1, 3). Tribasic copper sulphate (COM, DOM) is also registered for use. For broccoli and bok choy only, apply fosetyl-AI (COM) WG up to 5 applications per season.

Limitations: As per label. Preharvest interval - 1 day (tribasic copper sulphate); 7 days (chlorothalonil, fosetyl-AI, zineb). Note: zineb is being withdrawn and may not be used after December 31, 2010

References:

1. Natti, J.J. 1957. Control of downy mildew of broccoli with antibiotics and fungicides. *Plant Dis. Res.* 41: 780-788.
2. Natti, J.J. 1958. Resistance of broccoli and other crucifers to downy mildew. *Plant Dis. Rep.* 42: 656-662.
3. Natti, J.J. 1959. Control of downy mildew of broccoli with fungicide and fungicide-streptomycin combination sprays. *Plant Dis. Rep.* 43: 735-740.

GREY LEAF SPOT

Alternaria brassicae, *A. brassicicola*

Cultural: Rotate with non-cruciferous crops on a 4 or 5 year cycle and use clean seed or hot water-treated seed (see BLACK ROT on page 11). Eradicate cruciferous weeds.

Resistant Cultivars: None.

Chemical: In the seed bed, spray seedlings, at germination and repeat twice a week until transplanted, with zineb (COM) WP or chlorothalonil (COM) SU. In the field, after transplanting or direct seeding use chlorothalonil. Tribasic copper sulphate (COM, DOM) WP is also registered, but some formulations are not registered for use on broccoli. Apply iprodione (COM) WG, WP 1-2 days prior to tying of cauliflower or 7 to 14 days before harvest for cabbage. Cyprodinil + fludioxonil (COM) WG is registered for control of *Alternaria* leaf blight on cabbage.

Limitations: Preharvest interval: 1 day (tribasic copper sulphate); 5 days for cauliflower, 7 days for cabbage (iprodione); 7 days (chlorothalonil, cyprodinil + fludioxonil, zineb). Note: zineb is being withdrawn and may not be used after December 31, 2010

References:

1. Changsri, W. and Weber, G.F. 1963. Three *Alternaria* species pathogenic on certain cultivated crucifers. *Phytopathology* 53: 643-648.

SCLEROTINIA ROT (DROP or WATERY SOFT ROT)*Sclerotinia sclerotiorum*

Cultural: Rotate with more resistant crops such as grasses, cereals, beets, onions, spinach, or corn. Plant in well-drained soil. Use plant spacing that will allow good air circulation among plants. Practice good field sanitation (remove and destroy diseased plants). Disinfest storage bins before harvest using copper sulphate at 1 kg/50 liters of water as a spray. Storage area must be allowed to dry before storing produce.

Resistant Cultivars: Varieties differ in susceptibility. ‘Lunet’ and ‘Vancouver’ have some tolerance.

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of white mold.

Limitations: Preharvest interval -0 days (*Bacillus subtilis*).

Chemical: None.

SOFT ROT*Erwinia* spp., *Pseudomonas* spp.

Cultural: Avoid bruising plants in cultivation and harvesting (1). Use plant and row spacing that will allow good air circulation (5). Prolonged overhead irrigation sets may increase the likelihood of water-soaking the plant tissue, thus favoring bacterial infection. Control root maggots, slugs, and chewing insects. Avoid excess nitrogen (2). Avoid frost injury (6). Disinfest storages with copper sulphate at 1 kg/50 liters of water or other disinfestants. Storage area must be allowed to dry before storing produce. Avoid warm, humid storage conditions.

Resistant Cultivars: Chinese cabbage lines CC-14-1, CC-18-2, C3-26, C3-27, C3-28 and C3-29.

Chemical: None.

Notes:

1. Tribasic copper sulphate (COM, DOM) WP used for fungal diseases will also reduce bacterial infections in the field.
2. Do not use surfactants with sprays applied during weather conducive to bacterial rots. When the cuticular wax is damaged by surfactants, water soaking and bacterial infection of the plant tissue increases.

References:

1. Burton, C.L. 1971. Bacterial soft rot and black spot disease of Bok Choy (Chinese chard). Plant Dis. Rep. 55: 1037-1039.
2. Farmer, L.J. *et al.* 1971. A firm head rot of broccoli. Plant Dis. Rep. 55: 1136.
3. Ren, J.P. *et al.* 2001. CC-14-1 and CC-18-2 progenies of Chinese cabbage derived from somatic hybridization for resistance to bacterial soft rot. HortScience 36: 990-991.

4. Ren, J.P. and Dickson, M.H. 2001. Release of Chinese cabbage lines derived from recurrent selection for resistance to soft rot disease. *HortScience* 36: 992-994.
5. Smith, M.A. and Ramsey, G.B. 1956. Bacterial zonate spot of cabbage. *Phytopathology* 46: 210-213.
6. Sumner, D.R. 1972. Effect of freezing injury on head rot and spot of cabbage. *Phytopathology* 62: 322-325.

SPROUT ROT OF BRUSSELS SPROUTS

Cause unknown (*Rhizoctonia* spp. and *Cladosporium* spp. associated)

Cultural: Use good field sanitation practices. Harvest as soon as sprouts are ready.

Resistant Cultivars: None. Jade Cross is very susceptible.

Chemical: None.

WIRESTEM, DAMPING-OFF

Rhizoctonia solani, *Pythium* spp.

Cultural: Delay planting as long as possible to avoid cold, wet soils that favor disease development. Avoid excessive irrigation. Grow seedlings for transplanting in fumigated seed beds. Reduce seeding rate in seed beds to allow air circulation around plants.

Resistant Cultivars: None.

Chemical: Regardless of whether the seed is hot-water treated, it should be dusted before seeding with thiram (COM) WP. **Limitations:** As per label.

Notes: It has been observed that seedbed drenches with zineb (COM) WP or chlorothalonil (COM) SU for control of downy mildew also reduce wirestem incidence.

YELLOW

Fusarium oxysporum f. sp. *conglutinans*

Cultural: To avoid introducing this disease to new areas, do not purchase transplants from areas where the disease is known to occur. The disease is not known to occur in Western Canada.

Resistant Cultivars: Most modern cabbage cvs. are resistant (see commercial vegetable seed catalogues). No radish cvs. show much resistance.

Chemical: None.

Notes: Resistance in cabbage cvs. is of two types. Type A is uniformly resistant at all temperature ranges. Type B is resistant only at lower temperatures (1, 2).

References:

1. Armstrong, G.M. and Armstrong, J.K. 1952. Physiologic races of the *Fusarium* causing wilts of the Cruciferae. *Phytopathology* 42: 255-257.
2. Armstrong, G.M. and Armstrong, J.K. 1966. Races of *Fusarium oxysporum* f. sp. *conglutinans*, "race 4", new race; and a new host for race 1, *Lychnis chalconica*. *Phytopathology* 56: 525-530.
3. Bosland, P.W. *et al.* 1988. Influence of soil temperature on the expression of yellows and wilt of crucifers by *Fusarium oxysporum*. *Plant Disease* 72: 777-780.

CARROT (*Daucus carota*)**ASTER YELLOWS**

Aster yellows phytoplasma

Cultural: Isolate carrot plantings from forage legume fields and rough weedy areas where leafhoppers abound. Remove affected plants as soon as detected, if practical.

Resistant Cultivars: None known (1).

Tolerant Cultivars: Scarlet Nantes, Royal Chantenay, Gold King (1).

Chemical: None (see Notes).

Notes: Control of the leafhopper vector has reduced disease in some areas. For small scale organic growers, the use of straw mulch may be as effective as an insecticide spray program (2).

References:

1. Gabelman, W.H. 1995. Field evaluation and selection for resistance to aster yellows. *In: Carrot Country*, pp. 10-18, 1995.
2. Wally, O. *et al.* 2004. Incidence and molecular detection of yellows-type disease in carrots, associated with leafhoppers in southern Manitoba, Canada. *Can. J. Plant Path.* 26: 498-505
3. Setiawan, D.P. and Ragsdale, D.W. 1987. Use of aluminum foil and oat-straw mulches for controlling aster leafhopper, *Macrostelus fascifrons* and aster yellows in carrot. *Great Lakes Entomologist* 20: 103-109.

BLACK ROOT ROT

Thielaviopsis basicola (*Chalara elegans*)

Cultural: Rotate carrot fields with beets, cereals or cole crops. Avoid legumes. Seed late in fields with a history of the disease. Wounding during and after harvest is necessary for infection to occur. Carrots harvested during warm weather should be cooled as quickly as possible. Keep carrots cool and not too damp after harvest. The discoloration is most severe when carrots are held in polyethylene bags at or near room temperature.

- Resistant Cultivars:** None.
- Intermediate:** Six Pence, Sprinter, Paramount
- Susceptible:** Golden State, Cimmaron, A-Plus

Chemical: None.

Notes: Chlorination in the range of 100 ppm NaOCl buffered to pH 7 in the hydro-cooling and final rinse water reduces infection. Cleaning and disinfesting conveyer belts in the sorting and packaging lines reduces inoculum levels. Anything that reduces post-harvest injury will reduce infection.

References:

1. Punja, Z.K. and Gaye, M.M. 1993. Influence of postharvest handling practices and dip treatments on development of black root rot on fresh market carrots. *Plant Disease* 77: 989-995.

CAVITY SPOT

Pythium spp.

Cultural: Select fields with good drainage or improve drainage where possible. Avoid heavy irrigations which might cause temporary waterlogging of the soil. If carrots are to be left in the field late in the fall, select only the best drained fields for cropping. Carrots grown on high narrow ridges have less cavity spot than when grown on wide beds. Avoid fields with a past history of cavity spot. For early plantings, use cultivars with some resistance.

- Resistant Cultivars:** None.
- Intermediate:** Panther, Six Pak, Six Pak II, Caroprider, Fannia, Navajo, Carochoice (ranked high to low).
- Variable:** Eagle, Nathlie, Paramount.

Chemical: Metalaxyl (COM) GR or metalaxyl-M (COM) GR applied in the seed furrow. **Limitations:** As per label. Only recommended where there is a high likelihood of cavity spot.

References:

1. Benard, D. and Punja, Z.K. 1995. Role of *Pythium* species in cavity spot development on carrots in British Columbia. *Can. J. Plant Pathol.* 17: 31-45.
2. Vivoda, E. *et al.* 1991. Factors affecting the development of cavity spot of carrot. *Plant Dis.* 75: 519-522.

LEAF SPOT, LEAF BLIGHT

Alternaria dauci, Cercospora carotae

Cultural: Rotate to an unrelated crop for several years. Practice good field sanitation (3).

Resistant Cultivars: None.

Chemical: In areas where leaf spots are a problem, apply about five sprays, starting in late July, using chlorothalonil (COM) SU, metiram (COM) WG, tribasic copper sulphate (COM, DOM) WP, mancozeb (COM), zineb (COM) WP or maneb (COM) WP (1, 4); or for *Alternaria*, at 7 to 14 day intervals apply boscalid (COM) WG or boscalid + pyraclostrobin (COM) WG. Pyraclostrobin (COM) WG may be applied at 7 to 14 day intervals for a maximum of 3 applications. Cyprodinil + fludioxonil (COM) WG may be used at 7-10 day intervals for a maximum of 3 applications. Use iprodione (COM) WP seed treatment for *Alternaria* leaf spot.

Limitations: Preharvest interval - 0 days (boscalid, boscalid + pyraclostrobin); 1 day (chlorothalonil, tribasic copper sulphate); 3 days (pyraclostrobin); 5 days (maneb); 7 days (zineb, metiram, mancozeb, cyprodinil + fludioxonil). Note: zineb is being withdrawn and may not be used after December 31, 2010

Notes: Neither of these fungi will sporulate below 15°C. *Alternaria* is seed-borne so the use of disease-free seed is an important preventive measure.

References:

1. Carisse, O. and Kushalappa, A. 1990. Development of an infection model for *Cercospora carotae* on carrot based on temperature and leaf wetness duration. *Phytopathology* 80: 1233-1238.
2. Farrar, J.J., Pryor, B.A. & Davis, R.M. 2004. *Alternaria* Diseases of Carrot. *Plant Dis.* 88:776-784
3. Kushalappa, A.C. 1989. Forecasting incidence thresholds of cercospora blight in carrots to initiate fungicide applications. *Plant Dis.* 73: 979-983.
4. Rogers, P.M and W.R. Stevenson. 2006. Integration of host resistance, disease monitoring, and reduced fungicide practices for the management of two foliar diseases of carrot. *Can. J. Plant Pathol.* 28: 401-410.
5. Slingsby, K. and McKeen, C.D. 1970. Leaf spot *Alternaria dauci* (Kuhn) Groves and Skolko. P. 237 in *Pesticide Research Report*. CCPUA, Ottawa.
6. Weber, P.V.V. *et al.* 1954. Fungicidal control of alternaria blight of carrots. *Phytopathology* 44: 112.

RUBBERY ROOT

Phytophthora cactorum, *P. porri*

Cultural: This disease occurs primarily on growing carrot roots and its appearance in storage depends upon infection in the field (see Notes). Excessive soil moisture is necessary for infection to take place. Providing adequate drainage or harvesting the carrots as soon as they mature reduces the incidence of the disease (2). Storages should be well ventilated.

Resistant Cultivars: None.

Chemical: None.

Notes: *P. porri* can infect carrots in the field and in 0°C storage. *P. cactorum* infects only in the field.

References:

1. Ito, H.H. 1983. *Phytophthora porri* from stored carrots in Alberta. *Mycologia* 75: 747-751.
2. Rader, W.E. 1952. Diseases of stored carrots in New York State. Cornell Univ. Agric. Exp. Sta., Bull. 889: 35-38.
3. Stelfox, D. and Henry, A.W. 1978. Occurrence of rubbery brown rot of stored carrots in Alberta. *Can. Plant Dis. Survey* 58: 87-91.

RUSTY ROOT (LATERAL ROOT DIEBACK)

Pythium spp.

Cultural: Lateral root dieback does not normally occur in fields where carrots have not been grown previously. Avoid seeding carrots repeatedly in the same field; rotate with onions or other suitable crops. Avoid heavy seeding rates; precision seeding at a spacing of 3 cm is ideal. In fields with a high risk based on disease history, seed on raised beds particularly for the early crops when periods of prolonged wet weather can be expected.

Resistant Cultivars: Spartan Premium, Spartan Delight, Spartan Fancy, Six-Pak, Six-Pak II.

Intermediate: Chancellor, Grenadier, Spartan, Spartan Classic, Spartan Winner.

Susceptible: Gold Pak.

Highly Susceptible: Hicolor.

Chemical: None.

References:

1. Davis, R.M. and Nunez, J.J. 1993. Influence of soil temperature and microflora on the incidence of *Pythium* induced root rot and dieback of carrot. *Phytopathol.* 83: 1345.
2. Fushtey, S.G. and Filman, C.C. 1968. An early wilt and rusty root problem in carrots at the Bradford Marsh. *Can. Plant Dis. Surv.* 48: 150.
3. Liddell, C.M., Davis, R.M. and Nunez, J.J. 1989. Association of *Pythium* spp. with carrot root dieback in the San Joaquin Valley of California. *Plant Dis.* 73: 246-249.
4. McElroy, F.D. *et al.* 1971. Dieback of carrot roots caused by *Pythium debaryanum*. *Phytopathology* 61: 586-587.
5. Mildenhall, J.P. *et al.* 1971. *Pythium* brown root and forking of muck-grown carrots. *Plant Dis. Rep.* 55: 536-540.
6. Pratt, R.G. and Mitchell, J.E. 1973. A new species of *Pythium* from Wisconsin and Florida isolated from carrots. *Can. J. Bot.* 51: 333-339.

SCLEROTINIA ROT

Sclerotinia sclerotiorum

Cultural: Rotate with resistant crops (i.e., beets, onions, spinach, cereals, corn, or grasses) for 2 years before planting susceptible crops (i.e. beans, lettuce, parsnips, cole crops, cucumbers, and celery). Harvest before excessively wet conditions in fall (1). If feasible, flood land with water for a minimum of 30 days to kill the overwintering fungus. Copper sulphate at 1 kg/50 liters of water may be used as a spray to disinfest storages. Storage areas must be allowed to dry before storing produce. Avoid the use of floating row covers on crops grown in fields known to have a high *Sclerotinia* potential. Harvested roots should be cooled as quickly as possible. Storage at 0°C will help to reduce disease development in storage.

Resistant Cultivars: None.

Chemical: None.

References:

1. Finlayson, J.E., *et al.* 1989. Infection of carrots by *Sclerotinia sclerotiorum*. *Can. J. Plant Pathol.* 11: 242-246.
2. Finlayson, J.E., *et al.* 1989. Electrolyte leakage and storage decay of five carrot cultivars in response to infection by *Sclerotinia sclerotiorum*. *Can. J. Plant Pathol.* 11: 313-316.
3. C. Kora, *et al.* 2005. Epidemiology of sclerotinia rot of carrot caused by *Sclerotinia sclerotiorum*. *Can. J. Plant Pathol.* 27: 245-258.

SOFT ROT

Botrytis cinerea, Erwinia carotovora, Alternaria dauci

Cultural: Handle the crop carefully to avoid wounds. Cull during harvest if rots are present. Allow crop to dry before storing. Store at 0-1°C and 90-95% relative humidity (2). Copper sulphate at 1 kg/50 L of water may be used as a spray to disinfest storages. Storage areas must be allowed to dry before storing produce (1).

Resistant Cultivars: None.

Chemical: None.

References:

1. Dye, D. W. 1953. Control of soft rot in carrots during transit and in storage. *N.Z. J. Sci. Tech. A.* 34: 465-467.
2. Rader, W.E. 1952. Diseases of stored carrots in New York State. *Cornell Univ. Agric. Exp. Sta., Bull.* 889: 7-10.

CELERY (*Apium graveolens* var. *dulce*)

ASTER YELLOWS

Aster yellows phytoplasma

Cultural: Avoid growing susceptible crops such as celery near forage legumes or other areas where leafhopper populations are high. Control weeds around perimeter of field.

Resistant Cultivars: None.

Chemical: None.

Notes: Rough, weedy headlands may be sprayed for leafhopper control. Before spraying any forage crop with an insecticide, check to be sure that the product is registered for use on the crop.

BACTERIAL BLIGHT

Pseudomonas syringae pv. *apii*

Cultural: Use disease-free transplants. Keep irrigation to a minimum and apply water early in the morning so leaves can dry during the day. Work in crops only when foliage is dry and always work uninfected fields first. Turn under infested crop residues immediately after harvest.

Chemical: None. See notes.

Notes: Copper oxychloride (COM, DOM) WP applied for late blight control during mild, humid weather should help to deter the spread of bacterial blight.

BLACK HEART

Physiological

Cultural: In the greenhouse, keep humidity and night temperature low. In the field avoid heavy applications of fertilizers with a high salt index and maintain uniform soil moisture. Apply calcium nitrate at 1.0-2.0 kg or calcium chloride at 0.5-1.0 kg/100 L water every 7-10 days to the foliage during periods when disease threatens, especially during cloudy yet warm weather.

Resistant Cultivars: None.

Chemical: None.

EARLY BLIGHT, LATE BLIGHT

Cercospora apii, *Septoria apii*

Cultural: Clean and disinfest greenhouse flats and cold frames between crops. Turn under crop refuse promptly after harvest. Follow a 2-year rotation. Use disease-free seed or seed that is more than 2 years old or has been immersed in water at 48°C for 30 min.

Resistant Cultivars: None.

Chemical: Begin fungicide spray or dust schedule in the greenhouse or seed bed and continue in the field using chlorothalonil (COM) SU; copper oxychloride or tribasic copper sulphate (COM, DOM); folpet (DOM); thiram (COM) WP; or one of maneb, mancozeb, zineb or metiram (COM).

Limitations: Preharvest interval - 1 day (copper oxychloride, tribasic copper sulphate); 7 days (chlorothalonil, folpet, thiram); 14 days (maneb, mancozeb, zineb, metiram). Note: zineb is being withdrawn and may not be used after December 31, 2010

References:

1. Berger, R.D. 1975. Disease incidence and infection rates of *Cercospora apii* in plant spacing plots. *Phytopathology* 65: 485-487.
2. Lacy, M.L. 1974. Efficacy of two spray adjuvants in fungicidal protection of celery against septoria leaf spot. *Plant Dis. Rep.* 58: 232-234.
3. Paulus, A.O. *et al.* 1974. Control of septoria leaf spot of celery. *Calif. Agric.* 28(9): 14.
4. Sheridan, J.E. 1968. Conditions for infection of celery by *Septoria apiicola*. *Plant Dis. Rep.* 52: 142-145.

FUSARIUM YELLOWS

Fusarium oxysporum f. sp. *apii*

Cultural: Avoid the movement of plants or soil from other farms or areas where the disease occurs. Start seedlings in soilless media or fumigated soil and plant in fields where the disease has not occurred previously. Avoid moving soil from infested to clean fields.

Resistant Cultivars: Bishop, Deacon, Matador, Picador, Starlet, Tendercrisp, Utah 52-70HK, Ventura, Vicar.

Very Susceptible: Utah 52-70R, Florida 683, Summit.

Chemical: None.

References:

1. Cerkauskas, R.F. and Chiba, M. 1991. Soil densities of *Fusarium oxysporum* f. sp. *apii* race 2 in Ontario, and the association between celery cultivar resistance and photocarcinogenic furocoumarins. *Can. J. Plant Pathol.* 13: 305-314.
2. Elmer, W.H. *et al.* 1986. Evaluation of celery germ plasm for resistance to *Fusarium oxysporum* f. sp. *apii* race 2 in Michigan. *Plant Disease* 70: 416-419.

3. Gaye, M.M. *et al.* 1991. Occurrence of *Fusarium* yellows of celery in southwestern British Columbia and evaluation of cultivars for disease tolerance. *Can. J. Plant Pathol.* 13: 88-92.
4. Opgenorth, D.C. and Endo, R.M. 1985. Additional sources of resistance to race 2 of *Fusarium oxysporum* f. sp. *apii*. *Plant Dis.* 69: 882-884.

SOFT ROT

Erwinia carotovora

Cultural: Soft rot follows bruising, freezing, insect injury and black heart, a physiological disease. Control in the field is almost impossible but post-harvest losses may be greatly reduced by harvesting celery quickly and putting it into cold storage promptly.

Resistant Cultivars: None.

Chemical: None.

Notes: Celery plants contain phototoxic furocoumarins which reach high levels in decaying tissue. Farm workers harvesting celery should always wear protective clothing to prevent skin contact with plant sap, especially in sunny weather.

References:

1. Cerkauskas, R.F. and Chiba, M. 1990. Association of phoma canker with phototoxic furocoumarins in parsnip cultivars. *Can. J. Plant Pathol.* 12: 349-357.
2. Wimalajeewa, D.L.S. 1976. Studies on bacterial soft rot of celery in Victoria. *Australian J. Exp. Agric. and Animal Husb.* 16: 915-920.

CORN (*Zea mays*)

See Corn, in Chapter 9, Special Field Crops.

CUCUMBER, MELON, PUMPKIN, SQUASH (*Cucumis* spp. & *Cucurbita* spp.)

ANGULAR LEAF SPOT

Pseudomonas lachrymans

Cultural: Use disease-free seed grown in a dry area if possible. Turn under crop refuse promptly after harvest. Follow a 3-year crop rotation. Do not work in crop when foliage is wet.

Resistant Cultivars: Gemini, Pioneer cucumbers. Other disease-resistant cultivars are listed in commercial seed catalogues.

Chemical: At first sign of disease, apply tribasic copper sulfate (COM, DOM) WP, copper oxychloride (COM, DOM) WP and for cucumbers only, copper hydroxide (COM) WP. Repeat at weekly intervals or as required.

Limitations: Preharvest interval - 1 day (tribasic copper sulfate, copper hydroxide, copper oxychloride).

References:

1. Hopkins, D.L. and Schenck, N.C. 1972. Bacterial leaf spot of watermelon caused by *Pseudomonas lachrymans*. *Phytopathology* 62: 542-545.

BACTERIAL WILT

Erwinia tracheiphila

Cultural: Control cucumber beetles in and around fields especially for the first 3 to 5 weeks after emergence or transplanting. Destroy vines after harvest.

Resistant Cultivars: Country Fair, Calypso (pickling), H19 Little Leaf (1).

Chemical: Copper oxychloride (COM). Spray at 7 day intervals.

Limitations: Preharvest interval -1 day (copper oxychloride).

References:

1. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin Extension. #A3110., 26 pp.

DAMPING-OFF

Fusarium spp., *Pythium* spp., *Rhizoctonia* spp.

Cultural: Use steamed or fumigated soil (see chapter 4, under General Disease Control Methods for Greenhouse Crops) or synthetic mix for starting seedlings for transplanting. Avoid seeding in cold, wet soil.

Resistant Cultivars: None.

Chemical: Treat seed with fludioxonil (COM) SU or thiram (COM) WP.

Limitations: As per label.

LEAF SPOT

Alternaria spp., *Ulocladium* spp.

Cultural: Maintain optimum growing conditions. Turn under crop refuse after harvest. Follow a rotation of at least 2 years.

Resistant Cultivars: Gurney's Burpless, Wisconsin SMR 18, Wisconsin SMR 58 (5).

Chemical: If leaf spot appears early in season on muskmelon or cucumber apply fungicide every 7-10 days (1, 2). Use copper oxychloride (COM) WP, mancozeb (COM) WG, or zineb (COM) WP. For *Alternaria* apply pyraclostrobin (COM) WG at 7 day intervals or boscalid (COM) WG at 7-14 day intervals.

Limitations: Preharvest interval -0 days (boscalid); 1 day (copper oxychloride); 3 days (pyraclostrobin); 5 days (mancozeb, zineb). Note: zineb is being withdrawn and may not be used after December 31, 2010.

References:

1. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin- Extension. #A3110., 26 pp.
2. Vakalounakis, D.J. 1990. *Alternaria alternata* f. sp. *cucurbitae*, the cause of a new leaf spot disease of melon (*Cucumis melo*). Ann. Appl. Biol. 117: 507-513.
3. Zitter, T.A. and L.W. Hsu. 1990. A leaf spot of cucumber caused by *Ulocladium cucurbitae* in New York. Plant Dis. 74: 824-827.

SCAB, ANTHRACNOSE

Cladosporium cucumerinum, *Colletotrichum orbiculare*

Cultural: Use disease-free seed. Turn under crop refuse promptly after harvest. Follow a 3-year rotation.

Resistant Cultivars: Gemini, Pioneer, and SMR cucumber cvs. are resistant to scab. Consult commercial seed catalogues for additional resistant cvs.

Chemical: Follow the alternaria leaf spot spray program or use: captan (cucumbers only) (COM) WG; chlorothalonil (COM) SU; folpet (anthracnose only) (COM, DOM) WP; pyraclostrobin (anthracnose only) (COM) WG; tribasic copper sulphate (COM, DOM) WP; zineb (COM) WP.

Limitations: Preharvest interval - 1 day (chlorothalonil, folpet, tribasic copper sulphate); 2 days (captan); 3 days (pyraclostrobin); 5 days (zineb). Note: zineb is being withdrawn and may not be used after December 31, 2010.

References:

1. Emmatty, D.A. *et al.* 1975. Yield response of resistant and susceptible cucumber cultivars to scab infection. Hortscience 10: 619.

WHITE MOLD, SCLEROTINIA ROT*Sclerotinia sclerotiorum*

Cultural: Rotate cucurbits with resistant crops, e.g. beets, onions, spinach, cereals, corn or grasses, for at least 2 years and preferably 4 years before planting susceptible crops such as beans, peas, lettuce, parsnips, cole crops, cucumbers and celery. Control weeds and eliminate cull piles. Orient rows parallel to prevailing winds to encourage good air movement within plant canopies to reduce humidity and promote rapid drying after rain or irrigation. Reduce irrigation if disease outbreaks occur.

Resistant Cultivars: None. Select varieties with an erect, open growth habit to promote drying in the canopy.

Chemical: None.

References:

1. Purdy, L.H. 1979. *Sclerotinia sclerotiorum*: History, diseases and symptomatology, host range, geographic distribution, and impact. *Phytopathology* 69: 875-880.
2. Young, P.A. 1936. Sclerotinia rot of squash and pumpkin. *Phytopathology* 26: 184-190.

WILT*Fusarium* spp.

Cultural: Use disease-free seed. Start plants in steamed or fumigated soil mix. Avoid fields where the disease is known to occur (1).

Resistant Cultivars: Baby Bear (pumpkin) (2). Numerous resistant cultivars are listed in commercial vegetable seed catalogues.

Chemical: None.

References:

1. Maloy, O.C. *et al.* 1974. Fusarium wilt of muskmelon in Washington. *Plant Dis. Rep.* 58: 10-12.
2. Wessel-Beaver, L. 1999. Pumpkin: pp. 938-984. *In*: Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999*. *HortScience* 34(6): 957-1012.

LETTUCE (*Lactuca sativa*)

BACTERIAL DISEASES

Erwinia carotovora, *Pseudomonas* spp., *Xanthomonas* spp.

Cultural: Avoid overcrowding and overwatering. Do not sprinkler irrigate close to harvest. Harvest promptly when mature and cool to 1°C immediately.

Resistant Cultivars: Ithaca is the most tolerant of the popular iceberg type cultivars grown in B.C.

Chemical: None.

References:

1. Patterson, C.L. *et al.* 1986. Economically important diseases of lettuce. *Plant Dis.* 70: 982-987.

DOWNY MILDEW

Bremia lactucae

Cultural: Seed late plantings in fields with good drainage and air circulation. Maintain good weed control. Deep plough diseased crop residues.

Resistant Cultivars: For late seedings where downy mildew may be a problem, use Patriot, Calgary, El Dorado, Valverde, Calmar, Target or Alpha (4). Other resistant cvs are Esmeralda, Nevada, Nancy, Ruby Tuffles, Salad Bibb, Sierra, Sunfire and Tania (3).

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of downy mildew.

Limitations: Preharvest interval -0 days (*Bacillus subtilis*).

Chemical: Spray every 7-10 days with fosetyl-Al (COM) WG, WP or zineb (COM) WP, or apply metalaxyl + mancozeb (COM) WP every 14 days after thinning in enough water to wet all foliage thoroughly. Apply metalaxyl before mildew appears.

Limitations: Preharvest interval - 7 days (fosetyl-Al); 10 days (zineb); 14 days (metalaxyl + mancozeb). Do not apply metalaxyl more than three times per crop. Note: zineb is being withdrawn and may not be used after December 31, 2010.

References:

1. Carisse, O. and V. Pilon. 2002. Meteorological factors affecting periodicity and concentration of airborne spores of *Bremia lactucae*. *Can. J. Plant Pathol.* 24: 184-193.
2. Fletcher, J.T. 1976. *Bremia lactucae*, oospores, sporangia dissemination and control. *Ann. Appl. Biol.* 84: 294-298.
3. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin-Extension. #A3110., 26 pp.

4. Scherm, H. *et al.* 1995. Field evaluation of fungicide spray advisories against lettuce downy mildew (*Bremia lactucae*) based on measured or forecast morning leaf wetness. *Plant Dis.* 79: 511-516.
5. Wu, B.M. *et al.* 2001. Comparison of three fungicide spray advisories for lettuce downy mildew. *Plant Dis.* 85:895-900.

FUNGAL ROTS

Botrytis cinerea, *Rhizoctonia solani*, *Sclerotinia sclerotiorum*

Cultural: Turn under crop residues promptly after harvest. Avoid poorly drained fields and overcrowded planting. Rogue sclerotinia-infected plants to reduce for future crops. Discard heads with any trace of infection at harvest. Cool to 1°C promptly after harvest. Rotate with corn, cereals, forages, onions or potatoes.

Resistant Cultivars: None.

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of sclerotinia.
Limitations: Preharvest interval – 0 days (*Bacillus subtilis*).

Chemical: For gray mould (*Botrytis*) control, apply iprodione (COM) WG, WP. Maximum 4 applications per year at 7 day intervals between sprays. For sclerotinia drop control, apply dicloran (COM) WP two times per year. Make a second application as a foliar spray at the rosette stage. For grey mold (*Botrytis*) or lettuce drop, apply vinclozolin (COM) WG at early to mid bloom (30-50%) with a second application 7-14 days later at full bloom if the disease persists.

Limitations: Preharvest interval –3 days (vinclozolin); 4 days (iprodione); 14 days (boscalid, dicloran). Apply boscalid up to maximum of 2 times per year. Apply vinclozolin up to a maximum of three times per year. Note: vinclozolin is being withdrawn and may not be used after December 31, 2010.

References:

1. Hao, J.J.& K.V. Subbarao. 2006. Dynamics of lettuce drop incidence and *Sclerotinia minor* inoculum under varied crop rotations. *Plant Dis.*90: 269-278.
2. Matheron, M.E. & M. Porchas. 2004. Activity of boscalid, fenhexamid, fluazinam, fludioxonil, and vinclozolin on growth of *Sclerotinia minor* and *S. sclerotiorum* and development of lettuce drop. *Plant Dis.* 88: 665-668.
3. Paterson, C.L. and Grogan, R.G. 1985. Differences in epidemiology and control of lettuce drop caused by *Sclerotinia minor* and *S. sclerotiorum*. *Plant Dis.* 69: 766-770.
4. Subbarao, K.V. *et al.* 1996. Effects of deep plowing on the distribution and density of *Sclerotinia minor* sclerotia and lettuce drop incidence. *Plant Dis.* 80: 28-33.

PYTHIUM STUNT AND DAMPING-OFF

Pythium spp.

Cultural: None.

Resistant Cultivars: None.

Chemical: Apply metalaxyl (COM) GR at time of planting. Ensure product is applied evenly with the seed in the seed furrow.

Limitations: Do not use on transplanted lettuce. Only one application per year.

ONION (*Allium cepa*)**BASAL ROT**

Fusarium oxysporum f. sp. *cepae*

Cultural: Avoid planting sets and transplants in new land that is to be used for onion production as several diseases including basal rot may be introduced in this way. Follow a long rotation. Control onion maggots. Avoid injury to bulbs during cultivation, harvesting, and storage. Keep storage temperature below 4°C.

Resistant Cultivars: Cultivars differ in susceptibility, but the disease is not serious enough in most areas to warrant the use of resistant cultivars.

Tolerant Cultivars: Bullet, Criterion, Duration, Endurance, Frontier, Gibraltar, Legacy, North Star, Number 6404, Number 8911, Vaquero (1).

Chemical: None.

References:

1. Havey, M.J. 1999. Onion: pp. 961-968. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.

DOWNY MILDEW

Peronospora destructor

Cultural: Avoid planting spring-seeded onions in the vicinity of overwintered onions or onions grown from sets. Prevent growth of onions on cull piles. Follow a rotation of at least 2 years. Avoid poorly drained fields with poor air circulation.

Resistant Cultivars: There are no suitable resistant storage onions, although there are marked differences in susceptibility of green bunching onions. Resistant cultivars include Southport White Globe (1), Feast and Red Cross (2).

Tolerant Cultivars: Dragon Eye, Eskimo, Express Yellow, Hi-Ball, Hi-Keeper, Keep Well, Kodiak (1022), Norstar, Red Cross, Top Keeper, Tough Ball. (1)

Biological: *Bacillus subtilis* (COM) WP provides suppression of downy mildew.

Limitations: Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: Begin fungicide applications 1 June for crops grown from sets or transplants and 1 July for spring-seeded crops (3) or when advised by IPM scout. Use copper oxychloride (COM, DOM) WP; fosetyl-Al (COM) WG; mancozeb (COM) WG (for dry bulb onions only); pyraclostrobin (COM) WG; or zineb (COM) WP. For fosetyl-Al apply a maximum of 5 applications per season. Apply metalaxyl + mancozeb (COM) WP before disease appears, and every 7 to 14 days up to three times per season. Boscalid + pyraclostrobin (COM) WG and fenamidone (COM) SC provide suppression of downy mildew.

Limitations: Preharvest interval - 1 day (copper oxychloride); 7 days (fosetyl-Al, metalaxyl + mancozeb, boscalid + pyraclostrobin, pyraclostrobin, zineb); 10 days (mancozeb); 14 days (fenamidone). Note: zineb is being withdrawn and may not be used after December 31, 2010.

References:

1. Havey, M.J. 1999. Onion: pp. 961-968. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin-Extension. #A3110., 26 pp.
3. Jespersen, G.D. and Sutton, J.C. 1987. Evaluation of a forecaster for downy mildew of onion (*Allium cepa* L.). Crop Protection 6: 95-103.
4. Sigurdson, L.S. and Ormrod, D.J. 1984. Fungicide applications for the control of downy mildew in green bunching onions. P. 290 *in* Pesticide Research Report, ECPUA, Ottawa.

LEAF BLIGHT (BLAST)

Botrytis squamosa

Cultural: Avoid high rates of seeding. Avoid high rates of nitrogen fertilizer.

Resistant Cultivars: Frontier, Norstar, Red Cross, Tokyo Long White, Wolf (2).

Tolerant Cultivars: Dragon Eye, Eskimo, Express Yellow, Hi-Ball, Hi-Keeper, Keep Well, Norstar, Red Cross, Top Keeper, Tough Ball (1).

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of Botrytis on bulb vegetables (crop group 3). **Limitations:** Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: Begin boscalid (COM) WG, boscalid + pyraclostrobin (COM) WG, chlorothalonil (COM) SU, cyprodinil + fludioxonil (COM) WG, iprodione (COM) WG, WP, mancozeb (COM) WG, or zineb (COM) WP sprays when advised by IPM scout or in mid-June. Alternate with downy mildew sprays. For green bunching onions, only boscalid, boscalid + pyraclostrobin, chlorothalonil, or zineb may be used.

Limitations: Preharvest interval - 7 days (boscalid, boscalid + pyraclostrobin, cyprodinil + fludioxonil, zineb, chlorothalonil for dry bulb onion); 10 days (mancozeb); 14 days (chlorothalonil for green bunching onion); 15 days (iprodione for dry bulb onions only). Chlorothalonil should not be used more than 3 times on bulb onions or 5 times on green bunching onions. Note :zineb is being withdrawn and may not be used after December 31, 2010.

Notes: Use of a spray program to control downy mildew will help to control leaf blight. Several blight prediction programs have been developed (2, 4).

References:

1. Havey, M.J. 1999. Onion: pp. 961-968. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Sutton, J.C. 1990. Epidemiology and management of botrytis leaf blight of onion and grey mold of strawberry: a comparative analysis. Can. J. Plant Path. 12: 100-110.
3. Trembley, D.M. *et al.* 2003. Sensitivity of *Botrytis squamosa* to different classes of fungicides. Plant Dis. 87: 573-578.
4. Vincelli, P.C. and Lorbeer, J.W. 1989. Blight-Alert: A weather based predictive system for timing fungicide applications on onion before infection periods of *Botrytis squamosa*. Phytopathology 79: 493-498.

NECK ROT

Botrytis aclada, other *Botrytis* spp.

Cultural: Grow early maturing, tight-necked cultivars. Seed as early as possible. Avoid late growth by restricting nitrogen and water after early August. Do not lift bulbs until two-thirds of the tops are down. Dry in the field for 8-18 days followed by additional drying in storage (1). Supplemental heat may be required for the first 10-14 days to facilitate curing (3). If heat is to be used for curing, it should be applied immediately after the onions are put into storage. Do not exceed 35°C or prolong the curing period for more than 14 days. Reduce storage temperature to 0-4°C and less than 70% RH after the initial curing period.

Resistant Cultivars: None.

Tolerant Cultivars: Dragon Eye, Eskimo, Express Yellow, Frontier (T-400), Hi-Ball, Hi-Keeper, Keep Well, Norstar, Red Cross, Top Keeper, Tough Ball. (1)

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of *Botrytis* on bulb vegetables (crop group 3). **Limitations:** Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: None.

Notes:

1. Downy mildew sprays may reduce neck rot by encouraging proper maturity of bulbs.
2. Seed-borne *B. allii* may be an important source of neck rot in Europe (3). Onion seed grown in desert areas of North America is not usually affected.

References:

1. Havey, M.J. 1999. Onion: pp. 961-968. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Gunkel, W.E. *et al.* 1973. Recent developments on artificial heating - a method of control of botrytis neck rot in bulk stored onions. Dep. Agric. Eng. Plant Pathol., Cornell Univ., Unpublished.
3. Maude, R.B. and Presley, A.H. 1977. Neck rot (*Botrytis allii*). Seed-borne infection and its relationship to the disease in the onion crop. Ann. Appl. Biol. 86: 163-180.
4. Vaughan, E.K. *et al.* 1964. Effects of field curing practices, artificial drying, and other factors in the control of neck rot in stored onions. Oreg. State Univ., Tech. Bull. 77.

PINK ROOT

Phoma terrestris (*Pyrenochaeta terrestris*), *Fusarium* spp.

Cultural: In fields where the disease is not known to occur, do not introduce transplants or sets from fields where it does occur. Follow long rotations in heavily infested fields. Lettuce, celery, beets, potatoes, and rutabagas are suitable rotation crops. The fungus can survive on the roots of cereal crops. Encourage rapid growth in infested fields through generous use of fertilizer and irrigation.

Resistant Cultivars: 157 cultivars are listed by Havey (4). Among them the best resistant cultivars are: Majestic (AX 1507), NuMex Bolo, NuMex Centric, NuMex Crispy, NuMex Dulce, NuMex Jose, Jose Fernandez, NuMex Mesa, Numex Starlite, NuMex Sundial, NuMex Sunlite, NuMex Suntop, NuMex Sweetpak, Rio Verde PRR (RCSX 948) (4), NuMex Chaco and NuMex Snowball (2, 3).

Chemical: None.

Notes: Preplant fumigation is effective on mineral soils.

References:

1. Awuah, R.T. and Lorbeer J.W. 1989. A procedure for isolating *Pyrenochaeta terrestris* from onion roots. Ann. Appl. Biol. 114: 205-208.
2. Cramer, C.S. and Corgan, J.N. 2001. "NuMex Chaco" onion. HortScience 36: 1337-1338.
3. Cramer, C.S. and Corgan, J.N. 2001. "NuMex Snowball" onion. HortScience 36: 1339-1340.
4. Havey, M.J. 1999. Onion: pp. 961-968. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
5. Thornton, M.K. and Mohan, S.K. 1996. Response of sweet spanish onion cultivars and numbered hybrids to basal rot and pink root. Plant Dis. 80: 660-663.

SMUT

Urocystis magica

Cultural: In areas where smut does not occur, avoid introduction of transplants or sets from areas where the disease does occur. Clean equipment when moving from smut-infested fields to new fields. In heavily infested fields, transplants can be set out safely as only the seedling stage is susceptible to infection.

Resistant Cultivars: Bulb-type - none; green bunching type (*A. fistulosium*) cv. Beltsville Bunching (2).

Chemical: In fields having more than 1% infection the last year that onions were grown, control measures are required. Use carbathiin + thiram (COM) DU seed treatment applied with a sticker to raw seed before any other coating; thiram (COM) WP.

Limitations: As per label.

Notes: Efficacy of carbathiin seed treatment is improved significantly by the use of methylcellulose sticker (1). To prepare, sprinkle Methocel A15 powder into hot (80-90°C) water and mix until particles are thoroughly dispersed and wetted. Add cold water to give a final concentration of 2% methylcellulose, and refrigerate overnight to dissolve the particles. Add methylcellulose solution to seed at a rate of 65 mL/kg of seed and shake in a suitable container until seed is uniformly wetted. Then add the fungicide in small amounts with shaking to obtain uniform distribution on the seed.

References:

1. Littley, E. and Rahe, J.E. 1982. Comparison of two seed treatments and two methylcellulose stickers for smut control. P. 244 in Pesticide Research Report. ECPUA, Ottawa.
2. Utkhede, R.S. and Rahe, J.E. 1980. Screening world onion germplasm collection and commercial cultivars for resistance to smut. Can. J. Plant Sci. 60: 157-161.

WHITE ROT

Sclerotium cepivorum

Cultural: In areas where the disease does not occur, do not introduce transplants or sets from areas where it does occur. To prevent field-to-field and farm-to-farm spread, clean equipment after leaving an infested field before entering a clean field. Dispose of infected culls in such a way that they will not be returned to fields where onions are to be grown. Avoid seeding onions in fields where white rot occurred the last time onions were grown.

Flooding fields reduces survival of sclerotia, but take steps to prevent movement of flood waters from infested to clean fields (1, 2).

Resistant Cultivars: There are no resistant cultivars yet available although resistance related to inability to stimulate sclerotial germination is known within the genus *Allium* (2). Hudelson *et al.* listed cv. Norstar as resistant (3).

Chemical: If onions must be grown in infested soil, the following treatments may reduce losses: for seeded onions on mineral soils, broadcast dicloran (COM) WP and rotovate to a depth of 4 cm, 1-2 weeks before seeding (see Note 2); for transplants, apply dicloran in the furrow at planting (3).

Limitations: As per label.

Notes:

1. The broadcast treatment is not considered to be very effective as white rot infection can occur throughout the growing season.
2. Before seeding dicloran-treated areas to a sensitive crop such as spinach or lettuce, plow to a depth of 20 cm and cross disc.

References:

1. Banks, E. and Edgington, L.V. 1989. Effects of integrated control of the onion white rot pathogen in organic soils. *Can. J. Plant Path.* 11: 268-272.
2. Brix, H.D. and Zinkernagel, V. 1992. Screening for resistance of *Allium* species to *Sclerotium cepivorum* with special reference to non-stimulatory resistance. *Plant Pathology* 41: 308-316.
3. Hovius, M.H.Y. & McDonald, M.R. 2002. Management of *Allium* white rot (*Sclerotium cepivorum*) in onions on organic soil with soil-applied diallyl disulfide and di-N-propyl disulfide. *Can. J. Plant Pathol.* 24:281-286.
4. Maloy, O.C. and Machtmes, R. 1974. Control of onion white rot by furrow and root dip application of fungicides. *Plant Dis. Rep.* 58: 6-9.
5. Utkhede, R.S. and Rahe, J.E. 1982. Interactions of antagonist and pathogen in biological control of onion white rot. *Phytopathology* 73: 890-893.

PARSNIP (*Pastinaca sativa*)

CANKER

Itersonilia pastinacae, *Phoma complanata*

Cultural: This disease is common in wet seasons. Grow in well-drained soils. Rotate fields. Grow varieties with rounded rather than broad shouldered crowns.

Resistant Cultivars: Gladiator is resistant to *Itersonilia*. All American and Hollow Crown Improved were resistant to *Phoma* (1). In Ontario, Andover is said to be resistant to both *Itersonilia* and *Phoma* canker.

Chemical: Apply chlorothalonil (COM) SU in mid-August and carry through the wet fall weather in BC.
Limitations: Pre-harvest interval - 7 days (chlorothalonil). Do not apply more than 7 times per season.

Notes:

1. Control of carrot rust fly reduces canker as root infection usually begins at the crown or at points where carrot rust fly larvae have penetrated.
2. Where the leaf spot phase appears to be an important source of inoculum for root infection, a fungicide spray program such as that for foliar blights of carrots may be justified.

References:

1. Cerkauskas, R.F. 1986. Susceptibility of parsnip cultivars to canker caused by *Phoma camplanata*. Can. J. Plant Pathol. 8: 455-458.
2. Cerkauskas, R.F. and McGarvey, B.D. 1988. Fungicidal control of phoma canker of parsnip. Can. J. Plant Pathol. 10: 252-258.
3. Channon, A.G. 1963. Studies on parsnip canker. I. The causes of the disease. Ann. Appl. Biol. 51: 1-15.
4. Channon, A.G. 1963. Studies on parsnip canker. II. Observations on the occurrence of *Itersonilia pastinacae* and related fungi on the leaves of parsnips and in the air within parsnip crops. Ann. Appl. Biol. 51: 223-230.
5. Channon, A.G. 1964. Studies on parsnip canker. III. The effect of sowing date and spacing on canker development. Ann. Appl. Biol. 54: 63-70.
6. Channon, A.G. 1969. Infection of the flowers and seeds of parsnip by *Itersonilia pastinacae*. Ann. Appl. Biol. 64: 281-288.
7. Smith, P.R. 1966. Seed transmission of *Itersonilia pastinacae* in parsnip and its elimination by a steam-air treatment. Aust. J. Exp. Agric. Ani. Husb. 6: 441-444.
8. Smith, P.R. 1967. The survival in soil of *Itersonilia pastinacae* Channon, the cause of parsnip canker. Aust. J. Biol. Sci. 20: 647-660.

PEA (*Pisum sativum*)**DOWNY MILDEW**

Peronospora viciae

Cultural: Rotate crops to non-legumes for 2-3 years. Plant disease-free seed on well-drained land with good air circulation (1).

Resistant Cultivars: Green Arrow, Lincoln (3).

Chemical: Metalaxyl (COM) SU applied as a seed treatment for damping off and root rot will also reduce seed-borne downy mildew.

Notes: Downy mildew of peas is of minor importance.

References:

1. Campbell, L. 1935. Downy mildew of peas caused by *Peronospora pisi*. Wash. Agr. Exp. Sta., Bull. 318. 42 pp.
2. Dixon, G.R. 1981. Downy mildews of peas and beans. Pp. 487-514 in Spencer, D.M. ed., The Downy Mildews. Academic Press. N.Y. 636 pp.
3. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin- Extension. #A3110., 26 pp.

LEAF and POD SPOT, FOOT ROT, MYCOSPHAERELLA BLIGHT

Ascochyta pisi, *A. pinodella*, *Mycosphaerella pinodes*, *Phoma medicaginis* var. *pinodella*

Cultural: Rotate with crops other than peas for a minimum of 4 years. Do not include vetch in rotation. Use disease-free seed if possible. Remove diseased pea vines after harvest.

Resistant Cultivars: Fristo (*Ascochyta* race C) (2).

Chemical: Apply boscalid (COM)WG prior to disease development or at beginning of flowering and repeat on a 5 to 14 days interval.

Limitations: Pre-harvest -7 days (boscalid). Maximum 2 applications per season.

References:

1. Ali, S.M. *et al.* 1978. Selection of pea lines for resistance to pathotypes of *Ascochyta pinodes*, *A. pisi* and *Phoma medicaginis* var. *pinodella*. *Aust. J. Agric. Res.* 29: 841-849.
2. Gritton, E.T. 1999. Green Pea. Pp. 968-971 *in*: Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999*. *HortScience* 34(6): 957-1012.
3. Wark, D.C. 1950. The inheritance of resistance to *Ascochyta pisi* in *Pisum sativum*. *Aust. J. Agric. Res.* 1: 382-390.
4. Xue, A. G. 2000. Effect of seed-borne *Mycosphaerella pinodes* and seed treatments on emergence, foot rot severity, and yield of field pea. *Can. J. Plant Pathol.* 22: 248-253.

POWDERY MILDEW

Erysiphe pisi

Cultural: Destroy or plow under diseased crop debris. Rotate crops for several years. Seed early to avoid infection.

Resistant Cultivars: Aspen, Neptune (3); Dewdrop, Encore, Horison, Kalamo, Karisma, Laser, Mariner, Mendota, Opal, Oregon 605, Oregon Giant, Oregon Trail, Quantum, Scepter, Shield, Snowflake, Spartan, Super Sugar Snap, Tacoma, Tasman, Taxi, Turbo (2).

Chemical: Sulfur (DOM, COM) WP, WG. Repeat at 7 to 10 day intervals as necessary.

Limitations: Preharvest interval - 1 day.

Notes: Chemical control is not normally required.

References:

1. Dixon, G.R. 1978. Powdery mildews of vegetables and allied crops. III. Papilionaceae. A. Pea. Pp.502-506 *in* Spencer, D.M. ed., *The Powdery Mildews*. Academic Press. N.Y. 565 pp.
2. Gritton, E.T. 1999. Green Pea: pp. 968-971. *In*: Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999*. *HortScience* 34(6): 957-1012.
3. Tiwari, K.R. *et al.* 1999. Studies on winter survival strategies of *Erysiphe pisi* in Manitoba. *Can. J. Plant Pathol.* 21:159-164.

ROOT ROT

Fusarium solani, *Pythium* spp., *Rhizoctonia solani*

Cultural: Peas should not be planted in the same soil more frequently than every fourth year. Plant in a well drained soil. Do not pack soil. Avoid over-irrigation. Destroy infested crop residues by deep plowing. Do not crowd plants. Drill in high-percentage phosphate fertilizer. Disc in up to 22.5 kg nitrogen/ha in fields where root rot has occurred and the weather is cold and wet.

Resistant Cultivars: Paint, Scepter (2), Bolero (4).

Chemical: None (see Note 2).

Notes:

1. Land where severe root rot has occurred should not be replanted to peas or broadbean (fababean) for 8-10 years (3).
2. Seed treatment fungicides used to control seed rot and damping-off will not control root rot in post-seedling plants.

References:

1. Basu, P.K. *et al.* 1973. Prevalence and severity of diseases of processing peas in Canada, 1970-71. *Can. Plant Dis. Surv.* 53: 49-57.
2. Gritton, E.T. 1999. Green Pea. Pp. 968-971 *in:* Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999.* *HortScience* 34(6): 957-1012.
3. Harper, F.R. 1983. Personal communication. *Agric. Can. Res. Sta., Lethbridge.*
4. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin-Extension. #A3110., 26 pp.
5. Tu, J.C. 1991. Response of cultivars and breeding lines to the disease complex of fusarium wilt and root rot of green peas in southwestern Ontario. *Can Plant Dis. Surv.* 71: 9-12.

SEED ROT, DAMPING-OFF

Pythium spp., *Rhizoctonia solani*

Cultural: Avoid planting in cool, moist soil. Avoid excessive irrigation. Improve the texture of heavy soil.

Resistant Cultivars: None.

Chemical: Treat seed with captan (COM) SU, WP, DU, carbathiin + thiram (COM) SU, metalaxyl-M (COM) SU or thiram (COM) WP. Use inoculants after the chemical disinfectant and no earlier than 2 hours before planting (1).

Limitations: As per labels.

Notes: Processing pea seed is usually sold pretreated with a fungicide or fungicide-insecticide.

References:

1. McKeen, C.D. and Slingsby, K. 1974. Evaluation of chemical treatments to control seed rot of peas. Pp. 323-324 in Pesticide Research Report. CCPUA, Ottawa.
2. Xi, K., J.H.G. & S.F. Hwang. 1995. Dynamics of pea seed infection by *Pythium ultimum* and *Rhizoctonia solani*: Effects of inoculum density and temperature on seed rot and pre-emergence damping-off. Can. J. Plant Pathol. 17:19-24.

WILT

Fusarium oxysporum f. sp. *pisi*

Cultural: Plant resistant cultivars (1, 2). Avoid infested fields. Plant disease-free seed in well drained soil. Rotate to other crops where fields are severely infested. Avoid planting peas in known infested areas within fields. Leave a generous border around the area. In newly developed infested spots, burn plants with a weed burner as soon as noticed, and definitely before harvest. Clean mobile viners before leaving the harvested field. Do not dump vines from one field in another field.

Resistant Cultivars: **Race 2** - Array, Award, Bemol, Bravo, Citadel, Elegance, Epic, Hailey, Menuet, Opal, Podella, Princess, Renown, Talon, Targhee, Trump.
Races 5 & 6 - Aristagreen, Barok, Captain, Goal, Podella, Tasman, Valgreen (2).

Chemical: None.

Notes: **Race 1** - most processing pea cvs. are resistant.
Race 2 - a few resistant processing pea cvs. are available.
Races 5 & 6 - are important only in western Washington and southwest British Columbia.

References:

1. Armstrong, G.M. and Armstrong, J.K. 1974. Races of *Fusarium oxysporum* f. sp. *pisi*, causal agent of wilt of pea. Phytopathology 64: 849-857.
2. Gritton, E.T. 1999. Green Pea. Pp. 968-971 in: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
3. Haglund, W.A. and Kraft, J.M. 1970. *Fusarium oxysporum* f.sp. *pisi*, Race 5. Phytopath. 60: 1861-1862.

VIRUSES

Pea enation virus, pea streak virus, pea seed-borne mosaic virus

Cultural: If possible, separate pea fields by at least 100 m from other leguminous crops and control aphids, the vectors for these viruses.

Resistant Cultivars: See seed catalogue descriptions for cultivar reactions to the different viruses.

Chemical: None.

References:

1. McKeen, C.D. and Slingsby, K. 1974. Evaluation of chemical treatments to control seed rot of peas. Pp. 323-324 in Pesticide Research Report. CCPUA, Ottawa.
2. Xi, K., J.H.G. & S.F. Hwang. 1995. Dynamics of pea seed infection by *Pythium ultimum* and *Rhizoctonia solani*: Effects of inoculum density and temperature on seed rot and pre-emergence damping-off. Can. J. Plant Pathol. 17:19-24.

WILT

Fusarium oxysporum f. sp. *pisi*

Cultural: Plant resistant cultivars (1, 2). Avoid infested fields. Plant disease-free seed in well drained soil. Rotate to other crops where fields are severely infested. Avoid planting peas in known infested areas within fields. Leave a generous border around the area. In newly developed infested spots, burn plants with a weed burner as soon as noticed, and definitely before harvest. Clean mobile viners before leaving the harvested field. Do not dump vines from one field in another field.

Resistant Cultivars: **Race 2** - Array, Award, Bemol, Bravo, Citadel, Elegance, Epic, Hailey, Menuet, Opal, Podella, Princess, Renown, Talon, Targhee, Trump.
Races 5 & 6 - Aristagreen, Barok, Captain, Goal, Podella, Tasman, Valgreen (2).

Chemical: None.

Notes: **Race 1** - most processing pea cvs. are resistant.
Race 2 - a few resistant processing pea cvs. are available.
Races 5 & 6 - are important only in western Washington and southwest British Columbia.

References:

1. Armstrong, G.M. and Armstrong, J.K. 1974. Races of *Fusarium oxysporum* f. sp. *pisi*, causal agent of wilt of pea. Phytopathology 64: 849-857.
2. Gritton, E.T. 1999. Green Pea. Pp. 968-971 in: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
3. Haglund, W.A. and Kraft, J.M. 1970. *Fusarium oxysporum* f.sp. *pisi*, Race 5. Phytopath. 60: 1861-1862.

VIRUSES

Pea enation virus, pea streak virus, pea seed-borne mosaic virus

Cultural: If possible, separate pea fields by at least 100 m from other leguminous crops and control aphids, the vectors for these viruses.

Resistant Cultivars: See seed catalogue descriptions for cultivar reactions to the different viruses.

Chemical: None.

PEPPER (*Capsicum annum*)

BLOSSOM-END ROT

See tomato, BLOSSOM-END ROT on page 48.

SUNSCALD

Physiological

Cultural: Fruits not well protected from the sun by leaves are especially susceptible to sunscald. Any treatment that promotes luxuriant foliage reduces damage. Avoid varieties with upright fruits.

Resistant Cultivars: None.

Chemical: None.

Notes:

1. Diseases causing loss of leaves, such as verticillium wilt, increase the severity of sunscald.
2. Varieties with light-coloured fruits are less susceptible to damage than those with purple, black or brown fruits.

References:

1. Pernezny, K.L., P.D. Roberts, J.F. Murphy and N.P. Goldberg. 2003. Compendium of Pepper Diseases. APS Press, St. Paul, MN. U.S.A. 63 pp.

VERTICILLIUM WILT

Verticillium albo-atrum and *V. dahliae*.

Cultural: Seedlings should be grown in virgin or sterilized soil. Follow a 4-year rotation with crops other than potato, tomato or eggplant. Old crop remains should not be left on the field. The fungus may also be maintained from year to year by symptomless hosts (2).

Resistant Cultivars: Giant Szegedi.

Chemical: Treat seed with thiram (COM) WP. Limitations: As per label.

Notes: Flats used for growing seedlings should be disinfested.

References:

1. Bhat, R.G. *et al.* 2003. Characterization of *Verticillium dahliae* isolates and wilt epidemics of pepper. *Plant Disease* 87:789-797.
2. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin- Extension. #A3110., 26 pp.
3. Krikun, J. and C.C. Bernier. 1987. Infection of several crop species by two isolates of *Verticillium dahliae*. *Can. J. Plant Pathol.* 9: 241-245

4. Pernezny, K.L., P.D. Roberts, J.F. Murphy and N.P. Goldberg. 2003. Compendium of Pepper Diseases. APS Press, St. Paul, MN. U.S.A. 63 pp.

VIRUS DISEASES

Cucumber mosaic virus (CMV), tobacco mosaic virus (TMV), tomato spotted wilt virus (TSWV - lettuce strain), impatiens necrotic spot virus (INSV formerly known as TSWV - impatiens strain), pepper mild mottle virus.

Cultural: Maintain rigid weed control near plantings. Rogue infected plants early. Wash hands after handling TMV-infected plants. Controlling aphid and thrips vectors with insecticides may help reduce spread. Do not start transplants in greenhouses containing ornamentals which may be infected with TSWV or INSV.

Resistant Cultivars: CMV - Consul, Summer Sweet 5000.
TMV - Yolo Wonder, Early California Wonder, Liberty Bell.

Chemical: None.

Notes: Cucumber mosaic virus is particularly prevalent in the B.C. Okanagan. Tobacco mosaic virus is uncommon but may appear if peppers are grown near tomatoes or if those handling young plants are smokers. Pepper mild mottle virus is mainly a disease of greenhouse peppers.

References:

1. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin-Extension. #A3110., 26 pp.
2. Pernezny, K.L., P.D. Roberts, J.F. Murphy and N.P. Goldberg. 2003. Compendium of Pepper Diseases. APS Press, St. Paul, MN. U.S.A. 63 pp.

RADISH (*Raphanus sativus*)

BLACK ROOT

Aphanomyces raphani

Cultural: Grow only small globe-type cultivars as they are not seriously damaged. In new land, where the disease has not occurred, use hot-water-treated seed to avoid introducing the fungus. Diseased crop residues should be plowed under. Provide good soil drainage and follow a 4-year rotation.

Resistant Cultivars: Small globe-type cultivars show some field tolerance (2); Vintage (1).

Chemical: None

Notes: This disease has not been reported from the Prairie Provinces.

References:

1. Behling, J. 1999. Radish: p. 984. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Humaydan, H.S. *et al.* 1976. Resistance in radish to *Aphanomyces raphani* and *Rhizoctonia solani*. Plant Dis. Rep. 60: 156-160.
3. Sherf, A.F. 1959. Radish black root disease yields to chemical control. Union Carbide Chem. Co., New York, Sta. to Sta. Res. News 5(1).

DOWNY MILDEW

Peronospora parasitica

Cultural: Avoid planting radishes after radishes in the same year. Incorporate crop remains or remove from field after harvest to prevent carryover in diseased refuse, volunteers, and cruciferous weeds. Reduce density of plantings in the late summer to improve air circulation. Increase the phosphorus to potassium ratio of the fertilizer applied before late seedings.

Resistant Cultivars: Altabelle, Altaglobe, Tae-Baek.

Chemical: None.

References:

1. Channon, A.G. 1981. Downy mildew of brassicas. Pp. 321-339 *in* Spencer, D.M. ed., The Downy Mildews. Academic Press, London. 636 pp.
2. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin- Extension. #A3110, 26 pp.
3. Natti, J.J. 1958. Resistance of broccoli and other crucifers to downy mildew. Plant Dis. Rep. 42: 656-662.
4. Sherriff, C. and Lucas, J.A. 1990. The host range of isolates of downy mildew, *Peronospora parasitica* from *Brassica* crop species. Plant Pathol. 39: 77-91.

YELLOWWS

Fusarium oxysporum f. sp. *conglutinans*

Resistant Cultivars: Fuego (1), Vintage (2).

References:

1. Behling, J. 1999. Radish: p. 984. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin Extension. #A3110., 26 pp.

RHUBARB (*Rheum rhabarbarum*)

LEAF SPOT, GREY MOLD

Ramularia rhei, *Botrytis cinerea*

Cultural: Clean up crop refuse at the end of harvest by rotovating to encourage rapid breakdown.

Resistant Cultivars: None.

Chemical: Spray with captan (COM) WG at weekly intervals.

Limitations: Pre-harvest interval - 1 day (captan).

Notes: Captan is registered for grey mold control only but the same spray schedule will control leaf spot.

References:

1. Ormrod, D.J. *et al.* 1985. Effect of fungicides on *Ramularia* leaf and stalk spot of rhubarb in coastal British Columbia. *Can. Pl. Dis. Surv.* 65: 29-30.

VIRUS DISEASES

Turnip mosaic virus and others

Cultural: Obtain crowns for planting out from a source that is apparently free of virus and other diseases. Rogue out plants with obvious symptoms of dwarfing, mottling, or leaf reddening (1). Do not allow populations of black bean aphid or other aphids to build up in rhubarb plantings.

Resistant Cultivars: None.

Chemical: None.

References:

1. Stace-Smith, R. and Jacoli, G.G. 1967. A virus disease of rhubarb in British Columbia. *Can. J. Bot.* 45: 1059-1061.

RUTABAGA (SWEDE TURNIP) (*Brassica napobrassica*)

BLACKLEG, BLACK ROT

Leptosphaeria maculans (imperfect state *Phoma lingam*), *Xanthomonas campestris*, pv. *campestris*

Cultural: Use hot-water-treated seed (20 min. at 50°C). Follow a 2-year rotation with non-cruciferous crops for black rot or a 4- to 5-year rotation for black leg. Do not apply manure containing rutabaga refuse or diseased rutabagas to land intended for crucifer production. Avoid storing diseased roots. Clean and disinfest storages each spring (2).

Resistant Cultivars: None.

Chemical: None

References:

1. Bonman, J.M. *et al.* 1980. *Leptosphaeria maculans* on cabbage in Wisconsin. Plant Dis. 64: 326.
2. Walker, J.C. 1948. Diseases of cabbage and related plants. U.S. Dep. Agric., Farmers' Bull. 1439.
3. Williams, P.H. 1980. Black rot: a continuing threat to world crucifers. Plant Dis. 64: 736-742.

CRATER ROT

Rhizoctonia solani

Cultural: Avoid injury to roots in the field and during harvest. Harvest under dry conditions if possible. Store close to 0°C and 90-95% RH. Disinfest storage bins before harvest (1).

Resistant Cultivars: None.

Chemical: Azoxystrobin (COM) SU is registered for control of *Rhizoctonia* root rot, crown rot and stem canker of turnip/rutabaga either in-furrow at seeding or as a banded application over the row soon after emergence or within 30 days of emergence.

Limitations: Preharvest interval – 40 days (azoxystrobin)

Notes: If it is necessary to grow on heavy, poorly drained soils, try to delay seeding until danger of cool, wet weather is past. This will reduce the amount of damping-off, wirestem and crater rot.

References:

1. Ramsey, G.B. and Smith, M.A. 1961. Market diseases of cabbage, cauliflower, turnips, cucumbers, melons, and related crops. U.S. Dep. Agric., Agric. Handb. 184: 9-10.

SOFT ROT

Erwinia carotovora

Cultural: Avoid bruising roots in cultivation and harvesting. Harvest under dry conditions if possible. Store roots close to 0°C and 90-95% RH. Disinfest storage bins with a 2% copper sulphate solution or other disinfestant before harvest if storage rots have been a problem.

Resistant Cultivars: None.

Chemical: None.

Notes: *Erwinia* can infect cut surfaces and growth cracks. It is important to dry the roots promptly after trimming and washing. If that is not possible, the final rinse water should contain 100 ppm NaOCl buffered to pH 7.

WATER CORE, BROWN HEART

Boron deficiency

Cultural: In light, sandy soils or where boron deficiency has occurred in the past, broadcast and disc in agricultural borax (11.4%) at 40 kg/ha or Tronabor (14.0%) at 30 kg/ha before planting. If deficiency occurs after planting, immediately apply Solubor (20.5%) or Borospray (20.5%) at 0.55 to 1.1 kg/ha as a 0.1% spray, using at least 1120 L of water/ha. In fields with a history of boron deficient crops, one or two foliar applications should be routinely applied.

Resistant Cultivars: None.

Chemical: None.

Notes: Fields to which boron has been applied should not be planted to beans or cucumbers the following year as both crops are extremely sensitive to boron.

OTHER DISEASES

The following disease of rutabaga is currently of minor importance (MI).

Surface Pitting: This is a form of bacterial soft rot which is controlled by prompt drying after washing. (MI)

SPINACH (*Spinacia oleracea*)**DOWNY MILDEW**

Peronospora spinacea

Cultural: If downy mildew is a recurring problem, consider using resistant cvs. Follow a 3-year or longer rotation. Use disease-free seed or treat seed with hot water (50°C for 25 min.). When growing successive crops, turn under refuse promptly after harvest. Avoid fields with poor air or soil drainage.

Resistant Cultivars:

Race 1 - Ambassador, Bolero, Bossanova, Carpo, Cello-Pak, Correnta, Eslivato, Fallgreen, Gladiator, Laron, Lina, Manta, Mazurka, Meridian, Murena, Nordic 4, Pacifica, Polka, Regency, Rhythm, Rico, Sassy, Sitra, Unipack 12, Unipack 151 (1).

Race 2 - Ambassador, Bolero, Bossanova, Carpo, Cello-Pak, Correnta, Eslivato, Fallgreen, Gladiator, Laron, Lina, Mazurka, Meridian, Murena, Nordic 4, Pacifica, Polka, Regency, Rhythm, Rico, Sassy, Sitra, Unipack 12, Unipack 151 (1).

Race 3 - Bolero, Bossanova, Carpo, Cello-Pak, Correnta, Gladiator, Laron, Lina, Manta, Mazurka, Meridian, Nordic 4, Pacifica, Polka, Regency, Rhythm, Rico, Sitra, Unipack 12, Unipack 151 (1).

Race 4 - Bolero, Bossanova, Cello-Pak, Nordic 4, Pacifica, Unipack 12, Unipack 151 (1).

Chemical: Use azoxystrobin (COM) or tribasic copper sulfate (DOM, COM) DU, WP (see Notes).

Limitations: Preharvest interval - 7 days (azoxystrobin); 1 day (copper sulfate). Maximum 2 azoxystrobin applications per season.

Notes: If a spray program becomes necessary, avoid applications of copper close to harvest. These may result in a visible residue.

References:

1. Morelock, T.E. 1999. Radish: pp. 987-988. *In:* Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
2. Brandenberger, L.P., Correll, J.C., Morelock, T.E. and McNew, R.W. 1991. Identification of and cultivar reactions to a new race (race 4) of *Peronospora farinose* f. sp. *spinaciae* on spinach in the United States. Plant Dis. 75: 630-6334.
3. Koike, S.T., Smith, R.F. and Schulbach, K.F. 1992. Resistant cultivars, fungicides combat downy mildew of spinach. Calif. Agric. 46: 29-31.
4. Irish, B.M., Correll, J.C., Koike, S.T., Schafer, J. and Morelock, T.E. 2003. Identification and cultivar reaction to three new races of the spinach downy mildew pathogen from the United States and Europe. Plant Dis. 87: 567-572.

TOMATO (*Lycopersicon esculentum*)

ANTHRACNOSE

Colletotrichum spp.

Cultural: Turn under crop refuse after harvest. Follow a rotation of at least 3 years, that includes cereals and legumes.

Resistant Cultivars: There are a few commercial cvs. with useful resistance to anthracnose. Consult vegetable seed catalogues.

Chemical: A regular spray program may be a necessity in commercial tomato fields. About 1 June and every 7 to 14 days thereafter apply azoxystrobin (COM), captan (DOM, COM) DU, WG; chlorothalonil (COM) SU; copper oxychloride (DOM); folpet (COM, DOM) WP; mancozeb (COM) WG; metiram (COM)WP; pyraclostrobin (COM) WG; tribasic copper sulphate (DOM, COM) WP; or zineb (COM) WP.

Limitations: Preharvest interval - 0 days (pyraclostrobin); 1 day (azoxystrobin, chlorothalonil, tribasic copper sulphate, folpet); 2 days (captan); 5 days (zineb); 7 days (mancozeb, metiram, copper oxychloride). Note:zineb is being withdrawn and may not be used after December 31, 2010.

References:

1. Batson, W.E. and Roy, K.W. 1982. Species of *Colletotrichum* and *Glomerella* pathogenic to tomato fruit. Plant Dis. 66: 1153-1155.
2. Dillard, H.R. 1989. Effect of temperature, wetness duration and inoculum density on infection and lesion development of *Colletotrichum coccodes* on tomato fruits. Phytopathology 79: 1063-1066.
3. Fulling, B.A. *et al.* 1995. Integration of host resistance and weather-based fungicide scheduling for control of anthracnose of tomato fruit. Plant Dis. 79: 228-233.
4. Raid, R.N. and Pennypacker, S.P. 1987. Weeds as hosts for *Colletotrichum coccodes*. Plant Dis. 71: 643-646.

BACTERIAL CANKER, BACTERIAL SPOT, BACTERIAL SPECK

Clavibacter michiganensis subsp. *michiganensis*, *Xanthomonas campestris* pv. *vesicatoria*, *Pseudomonas syringae* pv. *tomato*

Cultural: Use only hot water-treated (50°C for 25 min.), acid-treated or calcium hypochlorite treated seed (1), or disease-free transplants (see Notes). Grow seedlings in steamed or fumigated media in disinfected flats or pots. If any of the diseases appear in a crop, carefully remove the first infected plants, avoid methods of pruning, etc. that may spread disease from plant to plant, avoid sprinkler irrigation. Do not replant tomatoes or related plants for at least 2 years in a field where disease appeared.

Resistant Cultivars: Andino, Aztec, BOS 8033, BOS 8066, Condor, Grandstand 98, H2710, H8893, H9175, H9280, Hy 882, Hypeel 562, Isola, Maya, Nema 1201, Prairie Pastemaker, Prairie Schooner, Puebla, Red Century 32, Salvador, Santa Fe, Spectrum 385, Spectrum 579, Stella, Super Marzano, Viva Italia (4).

Chemical: When bacterial spot threatens, apply copper hydroxide (COM) WP + mancozeb (COM) WP or maneb (COM) WP at 7 to 10 day intervals. For bacterial canker, copper oxychloride (COM) WP or apply copper hydroxide (COM) WP in tank mix with mancozeb (COM) WP or maneb (COM) WP.

Limitations: Pre-harvest interval: 1 day. Not registered for bacterial speck. Chemical control of these diseases in the field may not be practical or effective.

Notes: Buy disease-free transplants (bacterial canker is very severe in Georgia, a major supplier of transplants).

References:

1. Dhanvantari, B.N. 1989. Effect of seed extraction methods and seed treatments on control of tomato bacterial canker. *Can. J. Plant Pathol.* 11: 400-408.
2. Farley, J.D., and Miller, T.D. 1973. Spread and control of *Corynebacterium michiganense* in tomato transplants during clipping. *Plant Dis. Rep.* 57: 767-769.
3. Jones, J.B. *et al.* 1991. Diseases caused by bacteria. p. 25-30 in *Compendium of Tomato Diseases*. APS Press.
4. Scott, J. W. 1999. Tomato, pp. 999-1009. *In: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999.* HortScience 34(6): 957-1012.

BLOSSOM-END ROT

Physiological

Cultural: In acid soils, ensure adequate levels of calcium by adding lime or ground limestone well before planting. Maintain uniform soil moisture throughout the growing season (3). Avoid close cultivation. Apply 2.2 to 5.6 kg per ha of calcium chloride as a spray during fruit development (see Notes).

Resistant Cultivars: Earlibright (2).

Chemical: None.

Notes: Use the lower rate of calcium chloride where frequent applications are possible (1). Higher rates may cause injury to the leaves. Calcium nitrate may also be used. It is less damaging to the leaves but the extra nitrogen may not be desirable. While there are some differences in varietal susceptibility, they are not great enough to warrant selecting the varieties to grow on that basis.

References:

1. Halterlein, A.J. and Lambeth, V.N. 1975. Effect of controlled release fertilizers on blossom-end rot incidence in *Lycopersicon esculentum* cv. Patio Hybrid. HortScience 10: 17-18.
2. Scott, J. W. 1999. Tomato, pp. 999-1009. In: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.
3. Shaykewich, C.F. *et al.* 1971. Nutrition and blossom-end rot of tomatoes as influenced by soil water regime. Can. J. Plant Sci. 51: 505-511.
4. Tan, C.S. and B.N. Dhanvantari. 1985. Effect of irrigation and plant population on yield, fruit speck and blossom end rot of processing tomatoes. Can. J. Plant Sci. 65: 1011-1018.

EARLY BLIGHT*Alternaria solani*

Cultural: Plow under crop debris immediately after harvest. Follow a rotation that includes cereals and legumes. For staking tomatoes, disinfect stakes between crops. Control volunteer tomatoes and potatoes and solanaceous weeds such as nightshade.

Resistant Cultivars: All Star, Atlantic City, Big Beef, Butte, Cannery Row, Capitan, Carnival, Cisco, Colonial, Colusa, Condor, Corona, Duven, Eagle, Early Cascade, Early Goliath, EF 49, EF 50, EF 51, EF 52, Empire, Endura, Falcon, Fame, Famous Wisconsin 55, Floramerica, Florasette, Gardeners Choice, Goliath, Gilbraltor, H2710, H3044, H3302, H8773, H8892, H8893, H9175, H9280, H9382, Hawk, Heatwave, Heritage, Hunter, Husky Pink, Husky Red, Hy 337, Hy 882, Hybrid 922, Hypeel 219, Hypeel 287, Hypeel 696, Jack, Joker, Jubilee, Juliet, Keno, Leading Lady, Lemon Boy, Loteria, Lucky Draw, Lucky Lady, Majesty, Maxim PS, MH VF 789, Milagro, Mountain Fresh, Mountain Supreme, Nema 1201, Nema 1401, Pik Ripe 747 LSL, Pik Ripe 748 LSL, Pink Girl, Reno, PlumDaddy, Royal Red Cherry, Santiago, Shady Lady, Short Red Cherry, Silverado, Solimar, Sonar, Springfield, Stella, Sugar Daddy, Sunbeam, Sunbolt, Sunbrite, Sunglobe, Sunjay, Sunpride, Sweepstakes, Tango, Temprano, Tres Rios, Trojan, Vegas, Viva Italia. (1, 5)

Biological: *Bacillus subtilis* (COM) WP provides suppression of early blight.

Limitation: Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: A regular spray program at 7 to 14-day intervals may be required in commercial tomato fields from early June for control of early blight. Apply azoxystrobin (COM) SU, boscalid (COM) WG, captan (COM, DOM) DU, WG, chlorothalonil (COM) SU, copper oxychloride (COM, DOM) DU, WP famoxadan + cymoxanil (COM) WG, mancozeb (COM) WP, maneb (COM) WP, metiram (COM) WG, pyraclostrobin (COM) WG, tribasic copper sulphate (COM, DOM) DU, WP, zineb (COM) WP, or ziram (COM) WP.

Limitations: Preharvest intervals - 0 days (boscalid, pyraclostrobin); 1 day (azoxystrobin, chlorothalonil, copper oxychloride, tribasic copper sulphate, ziram); 2 days (captan); 3 days (famoxadan + cymoxanil); 5 days (zineb); 7 days (maneb, metiram, mancozeb). Note: zineb is being withdrawn and may not be used after December 31, 2010.

Notes: Chlorothalonil and mancozeb also control anthracnose, late blight and other diseases. Differences in susceptibility of cultivars and breeding lines are known (2).

References:

1. Hudelson, B.D. *et al.* 2000. Disease-resistant vegetables for the home garden. University of Wisconsin-Extension. #A3110., 26 pp.
2. Maiero, M. *et al.* 1990. Genetic resistance to early blight in tomato breeding lines. *HortScience* 25: 344-346.
3. Mills, D.J., *et al.* 2002. Foliar disease in fresh-market tomato grown in differing bed strategies and fungicide spray programs. *Plant Dis.* 86:955-959.
4. Pitblado, R.E. 1988. Development of a weather-timed fungicide spray program for field tomatoes. *Can J. Plant Pathol.* 10: 371 (abstr.).
5. Scott, J. W. 1999. Tomato, pp. 999-1009. *In:* Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999.* *HortScience* 34(6): 957-1012.

FUSARIUM WILT, VERTICILLIUM WILT, SOUTHERN BACTERIAL WILT, FUSARIUM CROWN & ROOT ROT

Fusarium oxysporum f. sp. *lycopersici*, *Verticillium dahliae*, *Pseudomonas solanacearum*, *Fusarium oxysporum* f. sp. *radicis-lycopersici*.

Cultural: In areas where any of these diseases do not occur, avoid introducing field grown seedlings for transplanting. Greenhouse grown seedlings using steamed or fumigated media and disinfected flats and pots are less likely to be infested. Follow a rotation in which members of the tomato-potato-pepper-eggplant group are not grown for at least 2 or 3 years (1, 2).

Resistant Cultivars: Most commercial cvs. have resistance to *Fusarium* (F) and or *Verticillium* (V) wilts. Scott lists 259 cvs resistant to Fol race 1, 167 to Fol race 2, and 242 to Vd race 2. The cultivars Hawk, Heatmaster, and Nahomi are resistant to bacterial wilt (4).

Chemical: Soil fumigation is effective in reducing inoculum levels in mineral soils.

Notes: *Fusarium* crown and root rot caused by *F. oxysporum* f. sp. *radicis-lycopersici* may be a problem in greenhouse grown transplants if the disease is present in the greenhouse.

References:

1. Brammall, R.A. and McKeown, A.W. 1989. An occurrence in Ontario of fusarium crown and root rot disease in field-grown processing tomatoes originating from multicelled tray transplants. *Can. J. Plant Pathol.* 11: 75-77.
2. Denby, L.G. 1963. Culture of field tomatoes in the southern interior of British Columbia. *Agric. Can. Res. Sta., Summerland.* Unnumbered Mimeo Publ.
3. Menzies, J.G., *et al.* 1990. Additions to the host range of *Fusarium oxysporum* f. sp. *radicis-lycopersici*. *Plant Dis.* 74: 569-572.
4. Scott, J. W. 1999. Tomato, pp. 999-1009. *In:* Wehner, T.C. (ed.), *Vegetable Cultivar Descriptions for North America List 25, 1999.* *HortScience* 34(6): 957-1012.
5. Walker, J.C. 1971. *Fusarium* wilt of tomato. *Am. Phytopath. Soc. Monog.* 6.

GREY MOLD ROT

Botrytis cinerea

Cultural: Avoid situations resulting in high humidity. Do not use overhead sprinklers after 3 pm.

Resistant Cultivars: Florida MH-1. (1)

Biological: *Bacillus subtilis* (COM) WP is registered for suppression of grey mold.

Limitations: Preharvest interval - 0 days (*Bacillus subtilis*).

Chemical: At the first appearance of the disease, spray chlorothalonil (COM) SU. If wet weather prevails repeat every 14 days. Fenhexamid (COM) WG is registered for control of *Botrytis cinerea* on field tomato transplants grown in the greenhouse.

Limitations: Preharvest intervals: 1 day (chlorothalonil).

References:

1. Scott, J. W. 1999. Tomato, pp. 999-1009. *In*: Wehner, T.C. (ed.), Vegetable Cultivar Descriptions for North America List 25, 1999. HortScience 34(6): 957-1012.

LATE BLIGHT

Phytophthora infestans

Cultural: Isolate tomato fields from potato fields and potato cull piles. Do not plant tomatoes after potatoes. Avoid excessive foliage. Do not sprinkler irrigate. Control volunteers and solanaceous weeds. With the presence of both the A2 and A1 mating types in Canada, sanitation and rotation will become necessary to reduce overwintering inoculum. Because oospores may be formed in foliage and vines, the prompt removal of diseased vines at the end of the season by whatever means are available may be useful if it is intended to use the same field for tomatoes or potatoes within the next few years. Areas which have not yet identified A2 should avoid importation of tomato transplants from the southern states where it is known to occur.

Resistant Cultivars: None.

Chemical: A regular spray program may be necessary in commercial tomato fields in areas where late blight occurs regularly. About 1 June and every 7-14 days thereafter apply chlorothalonil (COM) SU, copper oxychloride (DOM, COM) WP, mancozeb (COM) WG, SU, metiram (COM) WG, pyraclostrobin (COM) WG, tribasic copper sulphate (DOM, COM) DU, WP, or zineb (COM) WP.

Limitations: Preharvest interval - 0 days (pyraclostrobin); 1 day (chlorothalonil, copper oxychloride, tribasic copper sulphate); 5 days (zineb); 7 days (mancozeb, metiram). Note: zineb is being withdrawn and may not be used after December 31, 2010.

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APPENDIX I. Fungicides and Bactericides Registered for Vegetable Crops in Canada.

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
ASPARAGUS					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	botrytis blight (suppression)
azoxystrobin	Quadris Flowable	250 g/L SU	C	26153	purple spot
chlorothalonil	Bravo 500	500 g/L SU	C	15723	purple spot
metiram	Polyram DF	80% WG	C	20087	rust
myclobutanil	Nova 40W	40% WP	C	22399	rust
propiconazole	Topas 250E Mission 418 EC	250 g/L EC 418 g/L EC	C C	24030 28016	rust
zineb	Zineb 80W	80% WP	C	19318	rust
BEAN					
azoxystrobin + propiconazole	Quilt Fungicide	75 g/L 125 g/L	C	28328	Asian Soybean Rust
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	sclerotinia white mold (suppression)
boscalid	Lance WDG	70% WG	C	27495	grey mold, white mold
captan	Captan Flowable	30% SU	C	12028, 24684	seed treatment: seed decay, root rot, damping-off, seedling blights
	Supra Captan 80 WDG Maestro 80 DF	80% WG 80% WG	C C	24613 26408	seedbed treatment: damping-off, root rot
captan + diazinon	Agrox CD	15% DU + 15%	C	26957	supplemental seed treatment: seedling blight, seed rot
captan + diazinon	Agrox B-2	33.5% DU + 11%	C	26956	seed treatment: seed rots, seedling blights and damping off
carbathiin + thiram	VitaFlo-280	14.9% SU + 13.2%	C	11423	seed treatment: anthracnose, seed rot and seedling blight
copper hydroxide	Kocide 101	50% WP	C	14417	bacterial blight
	Parasol	50% WP	C	24671	
dicloran	Botran 75W	75% WP	C	8772	white mold, grey mold
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
iprodione	Rovral	50% WP	C	15213	white mold, grey mold
	Rovral WDG	50% WG	C	24709	
metalaxyl	Apron FL	317 g/L SU	C	24262	seed treatment: seed rot, seedling blight (<i>Pythium</i>)
	Allegiance FL	317 g/L SU	C	26674	

*C or D = commercial or domestic registration

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
BEAN continued					
metalaxyl-M	Ridomil Gold 480EC	480 g/L EC	C	25384	pythium damping off, phytophthora root rot
	Apron XL LS	33% EC	C	25585	seed treatment: Pythium damping-off and Phytophthora root rot
pyraclostrobin	Headline EC	250 g/L	C	27322	angular leaf spot (<i>Phaeoisariopsis griseola</i>), mycosphaerella blight, rust, ascochyta blight
sulphur	Later's Garden Sulfur	90% WP	D	5293	powdery mildew
	Sulfur Dust	92% DU	D	19703	powdery mildew, rust
	Garden Sulphur	92% DU	D	21890	
	Defender	12% SU	D	19691	
	Defender	0.40% SU	D	19061, 20812	
	Liquid Sulfur Fungicide	40% SU	D	19451	
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W	53% WP	C	9934	anthracnose, downy mildew, bacterial leafspot
	Basicop	53% WP	C	19003	
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	anthracnose, downy mildew, leafspot
vinclozolin	Ronilan EG	50% WG	C	24894	grey mold, white mold
BEET					
azoxystrobin	Quadris	250 g/L	C	26153	rhizoctonia root rot, crown rot & stem canker
metalaxyl-M	Apron XL LS	33% EC	C	25585	seed treatment: Pythium damping-off and Phytophthora root rot (export only)
pyraclostrobin	Cabrio EG	20% WG	C	27323	alternaria, cercospora, powdery mildew
thiram	Thiram 75WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
BEET continued					
tribasic copper sulphate	Copper 53W	53% WP	C	9934	cerospora leafspot
	Basicop	53% WP	C	19003	
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	cerospora leafspot
BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	sclerotinia rot (suppression)
captan	Supra Captan 80 WDG	80% WG	C	24613	seedbed treatment: dampingoff, root rot
	Maestro 80 DF	80% WG	C	26408	
chlorothalonil	Bravo 500	500 g/L SU	C	15723	alternaria leaf spot, downy mildew
cyprodinil + fludioxonil	Switch	37.5% + 25% WG	C	28189	alternaria leaf blight on cabbage
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
fosetyl-Al	Aliette WDG	80% WG	C	24458	downy mildew (broccoli and bok choy only)
	Alliette WP	80% WP	C	24564	
iprodione	Rovral	50% WP	C	15213	alternaria leaf spots (cabbage and cauliflower only)
	Rovral WDG	50% WG	C	24709	
quintozene	Crusoe 75 WP	75% WP	C	28238	club root
	Terraclor 75W	75% WP	C	7251	
	Quintozene 75	75% WP	C	11425	
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W	53% WP	C	9934	downy mildew, black leafspot, grey leafspot
	Basicop	53% WP	C	19003	
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5% DU	D	17424, 26445	downy mildew, black leafspot, grey leafspot
zineb	Zineb 80W	80% WP	C	9318	downy mildew, black leafspot, gray leafspot
CARROT					
azoxystrobin	Quadris	250 g/L	C	26153	rhizoctonia root rot, crown rot & stem canker
boscalid	Lance WDG	70% WG	C	27495	alternaria leaf blight
boscalid + pyraclostrobin	Pristine	25.2% + 12.8% WG	C	27985	alternaria leaf blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
CARROT continued					
chlorothalonil	Bravo 500	500 g/L SU	C	15723	early blight, late blight
cyprodinil + fludioxonil	Switch	37.5% + 25% WG	C	28189	alternaria leaf blight
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
mancozeb	Dithane DG Penncozeb 75DF	75% WG 75% WG	C C	20553 25397	leaf spots
	Manzate 200DF	75% WG	C	21057	alternaria blight, cercospora leaf spot
maneb	Maneb 80WP	80% WP	C	25176	alternaria leaf spot, cercospora leaf spot
metalaxyl	Ridomil 2G	2% GR	C	24037	cavity spot
metalaxyl-M	Ridomil Gold 1G	1% GR	C	26612	cavity spot
	Apron XL LS	33% EC	C	25585	seed treatment: Pythium damping-off (export use only)
metiram	Polyram DF	80% WG	C	20087	alternaria blight, cercospora blight
pyraclostrobin	Cabrio EG	20% WG	C	27323	alternaria, cercospora, powdery mildew
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W Basicop	53% WP 53% WP	C C	9934 19003	cercospora leaf spot
	Bordo	53% WP	D	17482	cercospora leaf spot
zineb	Zineb 80W	80% WP	C	9318	alternaria blight, cercospora blight
CELERY					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	sclerotinia pink rot (suppression)
captan	Supra Captan 80 WDG	80% WG	C	24613	seedbed treatment: damping-off, root rot
	Maestro 80 DF	80% WG	C	26408	
chlorothalonil	Bravo 500	500 g/L SU	C	15723	early blight, late blight
copper oxychloride	Copper Oxychloride 50 Copper Spray	50% WP 50% WP	C C	13245 19146	early blight, late blight
	Copper Spray	50% WP	D	16140	early blight, late blight
folpet	Latens Phaltan Rose and Garden Fungicide	50% WP	D	15798	early blight, late blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
CELERY continued					
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
mancozeb	Dithane DG	75% WG	C	20553	early blight, late blight
	Manzate 200DF	75% WG	C	21057	
	Penncozeb 75DF	75% WG	C	25397	
maneb	Maneb 80WP	80% WP	C	25176	early blight, late blight
metiram	Polyram DF	80% WG	C	20087	early blight, late blight
thiram	Thiram 75WP	75% WP	C	27556	early blight, late blight, rhizoctonia; seed treatment for seed decay, damping-off, seedling blight
	Taminco Thiram 75 WP	75% WP	C	28220	
tribasic copper sulphate	Copper 53W	53% WP	C	9934	anthracnose, early blight, late blight, septoria leaf spot
	Basicop	53% WP	C	19003	early blight, late blight
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	early blight, late blight
zineb	Zineb 80W	80% WP	C	9318	early blight, late blight
CUCUMBER See also Cucumber, Melon, Pumpkin, Squash					
captan	Maestro 80DF	80% WG	C	26408	anthracnose, scab
	Supra Captan 80WDG	80% WG	C	24613	
captan + carbaryl + malathion	Fruit Tree & Garden Spray	10% WP + 10% + 5%	D	9986	most fungal diseases
copper hydroxide	Parasol	50% WP	C	24671	angular leaf spot
metalaxyl-M	Ridomil Gold 480EC	480 g/L EC	C	25384	Pythium damping-off
CUCUMBER, MELON, PUMPKIN, SQUASH					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	powdery mildew (suppression)
boscalid	Lance WDG	70% WG	C	27495	alternaria blight, gummy stem blight
chlorothalonil	Bravo 500	500 g/L SU	C	15723	anthracnose, powdery mildew, scab
copper oxychloride	Copper Oxychloride 50 Copper Spray	50% WP 50% WP	C C	13245 19146	angular leaf spot, anthracnose, bacterial wilt, alternaria leaf spot, downy mildew, Septoria leaf spot
	Copper Spray	50% WP	D	16140	

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
CUCUMBER, MELON, PUMPKIN, SQUASH (continued)					
cyazofamid	Ranman 400 SC	34.5% SU	C	27984	downy mildew
fenamidone	Reason 500 SC	500 g/L SU	C	27462	downy mildew
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
folpet	Folpan	50% WP	C	15654	anthracnose, downy & powdery mildew
	Laters Phaltan Rose and Garden Fungicide	50% WP	D	15798	anthracnose, powdery mildew
mancozeb	Dithane DG	75% WG	C	20553	anthracnose, alternaria leaf spot, gummy stem blight, scab, downy mildew
	Manzate 200DF	75% WG	C	21057	
	Penncozeb 75DF	75% WG	C	25397	
potassium bicarbonate	Milstop	85% DU	C	28095	powdery mildew (suppression)
pyraclostrobin	Cabrio EG	20% WG	C	27323	alternaria blight, cercospora, anthracnose, downy mildew, gummy stem blight
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W	53% WP	C	9934	angular leaf spot, anthracnose, downy mildew, scab
	Basicop	53% WP	C	19003	
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	anthracnose, leaf spot, scab
zineb	Zineb 80W	80% WP	C	9318	alternaria leaf blight, anthracnose, downy mildew, septoria leaf spot, black rot
ziram	Ziram 85W	85% WP	C	14773	alternaria and septoria leaf spots, anthracnose
ENDIVE					
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
LETTUCE					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	downy mildew, powdery mildew, sclerotinia (suppression)
boscalid	Lance WDG	70% WG	C	27495	sclerotinia lettuce drop, grey mold rot
dicloran	Botran 75W	75% WP	C	8772	sclerotinia drop
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
fosetyl-Al	Aliette WDG	80% WG	C	24458	downy mildew
iprodione	Rovral Rovral WDG	50% WP 50% WG	C	15213 24709	grey mold
metalaxyl	Ridomil 2G	2% GR	C	24037	<i>Pythium</i> damping-off, <i>Pythium</i> stunt
metalaxyl-M	Ridomil Gold 1G	1% GR	C	26612	<i>Pythium</i> damping-off, <i>Pythium</i> stunt
metalaxyl-M + mancozeb	Ridomil Gold MZ 68WP	4% WP + 64%	C	25379, 25419	downy mildew
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
vinclozolin	Ronilan EG	50% WG	C	24894	lettuce drop (white mold), grey mold
zineb	Zineb 80W	80% WP	C	9318	downy mildew
ONION					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	botrytis neck rot and leaf blight, downy mildew (suppression)
boscalid	Lance WDG	70% WG	C	27495	purple blotch, botrytis leaf blight
boscalid + pyraclostrobin	Pristine	25.2% + 12.8% WG	C	27985	alternaria purple blotch, botrytis leaf blight, suppression of downy mildew
carbathiin + thiram	Pro-Gro	30% DU 50%	C	10959	seed treatment: smut
chlorothalonil	Bravo 500	500 g/L SU	C	15723	botrytis leaf blight
copper oxychloride	Copper Oxychloride 50	50% WP	C	13245	downy mildew
	Copper Spray	50% WP	C	19146	
	Copper Spray	50% WP	D	16140	

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
ONION continued					
cyprodinil + fludioxonil	Switch	37.5% + 25% WG	C	28189	botrytis leaf blight, suppression of purple spot
dicloran	Botran 75W	75% WP	C	8772	white rot
fenamidone	Reason 500 SC	500 g/L SU	C	27462	downy mildew (suppression)
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
fosetyl-Al	Aliette WDG	80% WG	C	24458	downy mildew, purple blotch
iprodione	Rovral	50% WP	C	15213	downy mildew (in tank mix with mancozeb), botrytis leaf blight
	Rovral WDG	50% WG	C	24709	
mancozeb	Dithane DG	75% WG	C	20553	botrytis leaf blight
	Penncozeb 75DF	75% WG	C	25397	
	Manzate 200 DF	75% WG	C	21057	botrytis leaf blight, downy mildew, purple blotch
metalaxyl-M	Apron XL LS	33% EC	C	25585	seed treatment: Pythium damping-off
metalaxyl-M + mancozeb	Ridomil Gold MZ 68WP	4% WP + 64%	C	25379, 25419	downy mildew
pyraclostrobin	Cabrio EG	20% WG	C	27323	Alternaria purple blotch, downy mildew
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight, smut
zineb	Zineb 80W	80% WP	C	9318	botrytis leaf blight, downy mildew, purple blotch
PARSNIP					
chlorothalonil	Bravo 500	500 g/L SU	C	15723	root canker
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
PEA					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	botrytis pod rot (suppression)
boscalid	Lance WDG	70% WG	C	27495	Ascochyta blight, mycosphaerella blight, white mold
captan	Captan Flowable	30% SU	C	12028, 24684	seed treatment: seed decay, root rot, damping-off, and seedling blights
	Supra Captan 80 WDG Maestro 80DF	80% WG 80% WG	C C	24613 26408	seedbed treatment: damping-off, root rot
captan + diazinon	Agrox CD	15% DU + 15%	C	26957	supplemental seed treatment: seedling blight, seed rot
captan + diazinon	Agrox B-2	33.5% DU + 11%	C	26956	seed treatment: seed rots, seedling blights and damping off
carbathiin + thiram	Vitaflo-280	14.9 % SU + 13.2%	C	11423	seed treatment: seed rot, seedling blight
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
metalaxyl	Apron FL	317 g/L SU	C	24262	seed treatment: seed rot, seedling blight (<i>Pythium</i>)
	Allegiance FL	317 g/L SU	C	26674	
metalaxyl-M	Apron XL LS	33% EC	C	2558	seed treatment: <i>Pythium</i> damping-off and <i>Phytophthora</i> root rot
pyraclostrobin	Headline EC	250 g/L EC	C	27322	angular leaf spot (<i>Phaeoisariopsis</i>), <i>Mycosphaerella</i> blight, rust, <i>Ascochyta</i> blight
sulfur	Kumulus DF see BEAN for domestic products	80% WG	C	1883	powdery mildew
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
PEPPER					
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	early blight, botrytis grey mold, powdery mildew (suppression)
boscalid	Lance WDG	70% WG	C	27495	early blight, botrytis gray mold
captan	Supra Captan 80 WDG Maestro 80DF	80% WG 80% WG	C C	24613 26408	seedbed treatment: damping-off, root rot
captan + carbaryl + malathion	Fruit Tree & Garden Spray	10% WP + 10% + 5%	D	09986	most diseases
copper hydroxide	Kocide 101 Kocide DF Parasol	50% WP 40% SG 50% WP	C C C	14417 24538 24671	bacterial spot
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
potassium bicarbonate	Milstop	85% DU	C	28095	powdery mildew
pyraclostrobin	Cabrio EG	20% WG	C	27323	anthracnose, early blight, late blight
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W	53% WP	C	09934	anthracnose, early blight, late blight, leaf mold, septoria leaf spot
	Basicop	53% WP	C	19003	early blight, late blight
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	early blight, late blight
zineb	Zineb 80W	80% WP	C	9318	anthracnose, early blight, late blight
RADISH					
azoxystrobin	Quadris	250 g/L	C	26153	rhizoctonia root rot, crown rot & stem canker
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
pyraclostrobin	Cabrio EG	20% WG	C	27323	alternaria, cercospora, powdery mildew
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
RHUBARB					
captan	Supra Captan 80 WDG	80% WG	C	24613	gray mold leaf rot (in forcing sheds)
	Maestro 80DF	80% WG	C	26408	
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
RUTABAGA					
azoxystrobin	Quadris	250 g/L	C	26153	rhizoctonia root rot, crown rot & stem canker
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
propiconazole	Topas	250 g/L EC	C	24030	powdery mildew
	Mission 418 EC	418 g/L EC	C	28016	
pyraclostrobin	Cabrio EG	20% WG	C	27323	alternaria, cercospora, powdery mildew
sulphur	Microscopic Sulphur	92%	C	14653	powdery mildew
SPINACH					
azoxystrobin	Quadris Flowable	250 g/L SU	C	26153	downy mildew
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
metalaxyl-M	Apron XL LS	33% EC	C	25585	seed treatment: Pythium damping-off
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W	53% WP	C	09934	downy mildew, white rust
	Basicop	53% WP	C	19003	
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU + 5%	D	17424, 26445	downy mildew, white rust
TOMATO					
azoxystrobin	Quadris	250 g/L	C	26153	anthracnose, early blight
<i>Bacillus subtilis</i>	Serenade Max	14.6% WP	C	28549	early blight, botrytis grey mold, powdery mildew (suppression)
boscalid	Lance WDG	70% WG	C	27495	early blight, botrytis grey mold
captan	Maestro 80DF	80% WG	C	26408	anthracnose, septoria leaf spot. Seed bed treatment: damping-off, root rot
	Supra Captan 80 WDG	80% WG	C	24613	

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
TOMATO continued					
captan + carbaryl + malathion	Fruit Tree & Garden Spray	10% DU + 10% + 5%	D	9986	most diseases
chlorothalonil	Bravo 500	500 g/L SU	C	15723	anthracnose, Botrytis grey mold, early blight, late blight, Septoria leaf spot
copper hydroxide	Kocide 101 Parasol	50% WP 50% WP	C	14417 24671	bacterial spot
	Kocide DF	61.4% SG	C	24538	bacterial canker, septoria leaf spot, early blight, late blight
	Kocide 2000	35% SG	C	27348	early blight, septoria leaf spot
copper oxychloride	Copper Oxychloride 50 Copper Spray	50% WP 50% WP	C C	13245 19146	bacterial canker, early blight, late blight, septoria leaf spot
	Copper Spray	50% WP	D	16140	
copper oxychloride + carbaryl	Tomato & Potato Dust	7% DU + 5%	D	16106	anthracnose, early blight, late blight, grey leaf spot
famoxadan + cymoxanil	Tanos 50DF	25% WG + 25%	C	27435	early blight, late blight
fenhexamid	Decree 50WDG	50% WG	C	26132	<i>Botrytis cinerea</i> on field tomatoes grown in the greenhouse
fludioxonil	Maxim 480 FS	40.3% SU	C	27001	seed treatment: seed decay, damping-off, seedling blight
folpet	Folpan	50% WP	C	15654	anthracnose
	Latera Phaltan Rose and Garden Fungicide	50% WP	D	15798	anthracnose
mancozeb	Dithane F-45	37% SU	C	20552	anthracnose, early blight, grey leaf spot, late blight
	Dithane DG	75% WG	C	20553	
	Manzate 200DF	75% WG	C	21057	
	Penncozeb 75DF	75% WG	C	25397	
maneb	Maneb 80WP	80% WP	C	25176	anthracnose, cladosporium leaf mold, septoria leaf spot, early blight, late blight
metiram	Polyram DF	80% WG	C	20087	early blight, late blight, anthracnose, grey leaf spot, septoria leaf spot

APPENDIX I. continued

Active Ingredient	Trade Name	Formulation	C or D*	PCP#	Diseases Controlled
TOMATO continued					
pyraclostrobin	Cabrio EG	20% WG	C	27323	anthracnose, early blight, late blight, septoria leaf spot
thiram	Thiram 75 WP	75% WP	C	27556	seed treatment: seed decay, damping-off, seedling blight
tribasic copper sulphate	Copper 53W Basicop	53% WP 53% WP	C C	09934 19003	anthracnose, early blight, late blight, leaf mold, Septoria leaf spot
	Bordo	53% WP	D	17482	
tribasic copper sulphate + carbaryl	Garden Doctor Insecticide-Fungicide	7% DU +5%	D	17424, 26445	anthracnose, early blight, late blight, Septoria leaf spot
tribasic copper sulphate + carbaryl	Tomato & Potato Dust	7% DU + 5%	D	16106	early blight, late blight, anthracnose, grey mold, leaf spot
zineb	Zineb 80W	80% WP	C	09318	anthracnose, early blight, grey leaf spot, grey mold, late blight, leaf mold, septoria leaf spot
ziram	Ziram 85W	85% WP	C	14773	anthracnose, early blight, late blight