Chapter Nine

DISEASES OF POTATOES

POTATO (*Solanum tuberosum*)

BACTERIAL RING ROT

Clavibacter michiganensis pv. *sepedonicum*

Cultural: Clean then disinfect all storages and potato equipment thoroughly at least once annually. To do this, first remove all soil and plant debris then use a recommended disinfectant (see appendix II). When planting, use only certified disease free seed, and disinfect all equipment (please see note 4) between seed lots. Use cup rather than pick type planters to minimize wounding. At harvest, use only new bags for seed since it is impossible to disinfect old ones. If disease is found, dispose of all potatoes as soon as possible then thoroughly disinfect the premises as described previously. Practice crop rotation and do not plant potatoes in an infested field for 2 seasons.

Resistant Cultivars: None.

Chemical: None.

Notes:

1. All grades of Canadian seed potatoes have a zero tolerance for bacterial ring rot.

2. Bacterial ring rot was declared a 'pest' under the Agricultural Pests Act of Alberta in 1939. In 1942 it was also declared a 'pest' in British Columbia. Legislation aims to eradicate the disease on commercial potato farms.

3. Symptomless (latent) infections of ring rot occur (4).

4. *C. michiganensis* can survive for several years on equipment and storage surfaces (3).

References:

1. Letal, J.R. 1977. Efficacy of disinfestants against potato ring rot and black leg bacteria. Am. Potato J. 54: 405-409.

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3. Nelson, G.A. 1980. Long-term survival of *Corynebacterium sepedonicum* on contaminated surfaces and in infected potato stems. Am. Potato J. 57: 595-600.

4. Nelson, G.A. 1982. *Corynebacterium sepedonicum* in potato: Effect of inoculum concentration of ring rot symptoms and latent infection. Can. J. Plant Pathol. 4: 129-133.

5. Bugabee, W.M., and Gudmestad, N.C. 1988. The recovery of *Corynebacterium sepedonicum* from sugar beet seed. Phytopathology 78: 205-208.

6. Westra, A.A.G., and Slack, S.A. 1994. Effect of interaction of inoculum dose, cultivar, and geographic location on the magnitude of bacterial ring rot symptom expression in potato. Phytopathol. 84: 228-235.

BACTERIAL SOFT ROT

Erwinia carotovora pv. *carotovora*

Cultural: Do not over-irrigate fields during the growing season. Harvest only mature tubers when soil temperatures are less than 10EC. Minimize mechanical damage during harvest and handling. Protect tubers from desiccation by sun and wind. Cool tubers of early cultivars to 10EC or lower as soon as possible after harvest then store them at 2 to 5EC. For late potatoes, store tubers for 7-10 days at 10E-15EC to promote wound healing, then lower temperature to 2 - 5°C (7E-10EC for processing tubers). Provide good ventilation to prevent low oxygen concentrations and development of moisture films on tuber surfaces. Do not wash tubers before storage; however, if washing is necessary before marketing, dry the tubers as soon as possible and package them in well-aerated containers. When washing use only clean water and change it frequently to reduce the soft rot inoculum level. Control other diseases that predispose tubers to soft rot. Remove culls and other plant refuse to prevent insect transmission in storage.

Resistant Cultivars: None.

Chemical: None.

Notes: Blackleg symptoms also can be caused by *E. carotovora* pv. *carotovora*

References:

1. Chard, J.M. and Oxley, S.J.P. 1989. Comparison of methods for estimating *Erwinia carotovora* numbers on potato tubers. J. of Appl. Bacteriol. 76:19-23.

2. Cromarty, R.W. and Easton, G.D. 1973. The incidence of decay and factors affecting bacterial soft rot of potatoes. Am. Potato. J. 50: 398-407.

3. Elphinstone, J.G. and Perombelon, C.M. 1986. Contamination of potatoes by *Erwinia carotovora* during grading. Plant Pathol. 35: 25-33.

4. Harrison, M.D. *et al.* 1977. Waste potato dumps as sources of insects contaminated with soft rot coliform bacteria in relation to recontamination of pathogen-free potato stocks. Potato Res. 20:37-52.

5. Lund, B.M. and Kelman, A. 1977. Determination of the potential for development of bacterial soft rot of potatoes. Am. Potato J. 54: 211-225.

6. Nielsen, L.W. 1949. Fusarium seed piece decay of potatoes in Idaho and its relation to blackleg. Idaho Agric. Exp. Sta. Res. Bull. 15. 31 pp.

7. Cappaert, M.R., *et al*. 1988. Irrigation water as a source of inoculum of soft rot erwinias for aerial stem rot of potatoes. Phytopathol. 78: 1668-1672.

8. Kelman, A., *et al*. 1989. Reducing the severity of bacterial soft rot by increasing the concentration of calcium in potato tubers. Pages 102-123. In: Engelhard, A.W. (Ed.). Soilborne Plant Pathogens :

Management of Diseases with Macro and Microelements. American Phytopathological Society Press.

9. Reeves, A.F., *et al.* 1999. Evaluation of potato varieties and selections for resistance to bacterial soft rot. Am. J. Potato Res. 76: 183-189.

10. Toth, I.K., *et al.* 1999. A one step PCR-based method for the detection of economically important soft rot Erwinia species on micropropagated potato plants. J. Appl. Microbiol. 87: 158-166.

BLACKLEG

Erwinia carotovora pv. *atroseptica*

Cultural: Plant whole seed that is free from blackleg. Plant in well-drained soil, especially when using cut seed. Treat cut seed with approved fungicides then plant immediately or suberize it well before planting to reduce infection by *Fusarium* spp. and other pathogens that predispose it to bacterial invasion (see Note 1). Plant on land with at least two or three years between potato crops. Avoid excessive irrigation to prevent seed-piece decay and subsequent stem invasion. Remove potato culls and other plant refuse to avoid insect transmission. Frequently clean and disinfest seed cutting and handling equipment as well as planters, harvesters and conveyers to eliminate contamination. This should be done at least between different seed lots. Avoid washing seed potatoes unless absolutely necessary, and exercise care during handling operations to minimize damage. Remove infected plants as soon as they appear, if practical.

Resistant Cultivars: None.

Intermediate: Russet Burbank (Netted Gem).

Chemical: None.

Notes:

1. Fungicidal seed piece treatments do not directly control blackleg.

2. Seed potatoes in Canada are inspected in the field for blackleg.

3. Blackleg bacteria may be present on tuber surfaces even in the absence of foliage or tuber symptoms.

References:

1. Cappaert, M.R., and Powelson, M.L. 1990. Canopy density and microclimate effects on the development of aerial stem rot of potatoes. Phytopathol. 80: 350-356.

2. Graham, D.C. and Hardie, J.L. 1971. Prospects for control of potato blackleg disease by the use of stem cuttings. Proc. Br. Insectic. Fungic. Conf. 6: 219-224.

3. Harrison, M.D. *et al.* 1977. Waste potato dumps as sources of insects contaminated with soft rot coliform bacteria in relation to recontamination of pathogen-free potato stocks. Potato Res. 20:37-52.

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6. Perombelon, M.C.M. *et al.* 1988. Effects of contamination by *Erwinia carotovora* subsp. *atroseptica* of potato seed tubers and of cultivar resistance on blanking or non-emergence and blackleg development in Valencia, Spain. Potato Research 31: 591-599.

7. Hyman, L.J., *et al*. 2000. A competitive PCR-based method for the detection and quantification of Erwinia carotovora subsp. atroseptica on potato tubers. Let. Appl. Microbiol 30: 330-335.

8. Perombelon, M.C.M., and Hyman, L.J. 1992. Control of potato blackleg: production on healthy seed. Aspects Appl. Biol. 33: 77-84.

9. Prokkola, S. 1994. Effect of applying nitrogen fertilizer to a potato seed crop on the susceptibility of the daughter plants to Erwinia carotovora subsp. atroseptica. Pot. Res. 37: 103-111.

Also see the references under BACTERIAL SOFT ROT on page 3.

COMMON SCAB

Streptomyces scabies

Cultural: Use a 3-5 year rotation, preferably with legumes. Plant scab-free or treated seed on land free of scab. Use an acidic fertilizer, such as ammonium sulfate, for nitrogen and irrigate adequately especially during tuber initiation. Neutralizing excessively acidic or alkaline soils may help to reduce levels of common scab.

Resistant Cultivars: None.

Intermediate: Chieftain, Russet Burbank, Norchip, Norgold Russet, Norland, Superior, Viking.

Chemical: See Appendix I.

Notes:

1. The addition of sulfur to increase soil acidity is generally not recommended because of high cost and the danger of causing excessive soil acidity.

References:

1. Davis, J.R., *et al*. 1976. Fertilizer effects on common scab of potato and the relation of calcium and phosphate-phosphorus. Phytopathology 66: 1236-1241.

2. Hayashida, S., *et al.* 1988. Production of potato common scab biofertilizer from swine feces with *Streptomyces albidoflavus.* Agric. Biol. Chem. 52:2397-2402.

3. Lapwood, D.H. and Adams, M.J. 1975. Mechanisms of control of common scab by irrigation. Pp. 123-129 *in* Bruehl, G.W. (ed.). Biology and control of soil-borne plant pathogens. Am. Phytopath. Soc., St. Paul, Minn.

4. Conn, K.L., *et al.* 1998. A quantitative method for determining soil populations of Streptomyces and

differentiating potential potato scab-inducing strains. Plant Dis. 82 631-638.

5. Errampalli, D., and Johnston, H.W. 1999. Effect of chlorine disinfection prior to planting on black scurf (*Rhizoctonia solani*) and common scab (*Streptomyces scabies*) of potatoes. Phytopathol. 89: S24.

6. Faucher, E., *et al*. 1995. Characterization of streptomycetes causing deep-pitted scab of potato in Quebec, Canada. Int. J. Syst. Bacteriol. 45: 222-225.

7. Faucher, E., *et al*. 1992. Characterization of actinomycetes isolated from common scab lesions on potato tubers. Can. J. Plant Pathol. 14: 197-202.

8. Keinath, A.P., and Loria, R. 1991. Effects of inoculum density and cultivar resistance on common scab of potato and population dynamics of Streptomyces scabies. Am. Potato J. 68: 515-524.

DRY ROT

Fusarium spp.

Cultural: Harvest during dry, cool weather if possible. Top killing prior to harvest encourages a good skin set which helps to reduce damage at harvest. Avoid bruising the tubers when harvesting. Store tubers for 7-10 days at 12EC to favour wound healing, then lower temperature to 2-5EC (10EC for processing tubers). Maintain humidity at 90% RH with adequate air circulation. Treat seed-pieces with a fungicide for control of seed-piece decay (see Appendix I). Handle seed with noncontaminated equipment and store in clean containers.

Chemical: See Appendix I.

Notes:

1. Cross-resistance to thiabendazole and thiophanate-methyl has been identified for one species of the fusarium dry rot pathogen complex, i.e. *Fusarium sambucinum*.

References:

1. Anon. 1976. Facts and figures about Mertect (Thiabendazole, MSD) for storage potatoes. Merck, Sharp Dohme Can. Ltd., Pointe Claire, Que., Tech. Bull. 76-02 (A)-AH.

2. Boyd, A.E.W. 1952. Dry-rot disease of the potato. Ann. Appl. Biol. 39: 322-357.

3. Kawchuk, L.M., *et al.* 1994. Resistance to thiabendazole and thiophanate-methyl in isolates of *Fusarium sambucinum* and *Helminthosporium solani.* Am. Potato J. 71:185-192.

4. Leach, S.S. and Nielsen, L.W. 1975. Elimination of fusarial contamination of seed potatoes. Am. Potato J. 52: 211-218.

5. Morris, S.C., *et al.* 1989. Determination of optimum conditions for suberization, wound periderm formation, cellular desiccation and pathogen resistance in wounded *Solanum tuberosum* tubers. Physiol. and Molecular Plant Pathol. 35:177-190.

6. Aprasad, K.S., *et al*. 1997. Variation in pathogenicity on potato tubers and sensitivity to thiabendazole of the

dry rot fungus *Fusarium avenaceum*. Potato Res. 40: 357-365.

7. Bang, U. 1992. Influence of seed tuber infestation, chemical seed treatment, and pre-harvest climate on incidence of gangrene and dry rot of potato (Solanum tuberosum L.). Eur. Assoc. Potato Res. 35: 3-15.

8. Carnegie, S.F.,*et al*. 2000. The effect of treating seed potato tubers with benzimidazole, imidazole and phenylpyrrole fungicides on the control of rot and skin blemish diseases. Ann. Appl. Biol. 133: 343-363.

9. Leach, S.S. 1985. Contamination of soil and transmission of seed-borne potato dry rot fungi (*Fusarium* spp.) to progeny tubers. Am. Potato J. 62: 129-136.

10. Ranganna, B., *et al.* 1997. Ultraviolet irradiance to control dry rot and soft rot of potato in storage. Can. J. Plant Pathol. 19: 30-35.

11. Schisler, D.A., *et al.* 2000. Biological control of fusarium dry rot of potato tubers under commercial storage conditions. Am. J. Potato Res. 77: 29-40.

12. Theron, D.J., and Holz, G. 1991. Prediction of potato dry rot based on the presence of Fusarium in soil adhering to tubers at harvest. Plant Dis. 75: 126-130.

EARLY BLIGHT

Alternaria solani

Cultural: Minimize stress by maintaining adequate soil moisture and fertility. Avoid potatoes, tomatoes, or egg plants in the crop rotation for at least 2 consecutive years. Use seed potatoes free of the disease. Permit tubers to mature in the ground before digging. Avoid bruising during digging and handling.

Resistant Cultivars: None.

Chemical: See Appendix I.

References:

1. Douglas, D.R. and Groskopp, N.D. 1974. Control of early blight in eastern and south-central Idaho. Am. Potato J. 51: 361-368.

2. Harrison, M.D. and Venette, J.R. 1970. Chemical control of potato early blight and its effect on potato yield. Am. Potato J. 54: 81-86.

3. Jarvis, W.B. and Slingsby, K. 1976. A comparative evaluation of preplant dip treatments and foliage sprays to control early blight and anthracnose on field tomatoes. Pp. 317-319 *in* Pesticide Research Report. CCPUA, Ottawa.

4. Venette, J.R. and Harrison, M.D. 1973. Factors affecting infection of potato tubers by *Alternaria solani* in Colorado. Am. Potato J. 50: 283-292.

5. Christ, B.J. 1990. Influence of potato cultivars on the effectiveness of fungicide control of early blight. Am. Potato J. 67: 419-425.

6. Guenthner, J.F., *et al*. 1999. Assessment of pesticide use in the U.S. potato industry. Am. J. Pot. Res. 76: 25-29.

7. Holley, J.D., *et al*. 1985. Effect of reducing oxidant injury and early blight on fresh weight and tuber density of potato. Phytopathol. 75: 529-532.

8. Holley, J.D., *et al*. 1985. Effects of cultivar resistance, leaf wetness duration and temperature on rate of development of potato early blight. Can. J. Plant Sci. 65: 179-184.

9. Holley, J.D., *et al*. 1983. Identification of rate-reducing resistance to early blight in potato (*Alternaria solani*). Can. J. Plant Pathol. 5: 111-114.

10. Johanson, A., and Thurston, H.D. 1990. The effect of cultivar maturity on the resistance of potatoes to early blight caused by *Alternaria solani*. Am. Potato J. 67: 615-623.

11. Johnson, K.B., and Teng, P.S. 1990. Coupling a disease progress model for early blight to a model of potato growth. Phytopathol. 80: 416-425.

12. Shtienberg, D., *et al.* 1999. Integrated management of early and late blight in potatoes. In: Modern fungicides and antifungal compounds II. pp. 247-255.

13. Shtienberg, D., *et al.* 1995. Integration of genotype and age-related resistances to reduce fungicide use in management of Alternaria diseases of cotton and potato. Phytopathol. 85: 995-1002.

14. Stevenson, W.R. 1994. The potential impact of field resistance to early blight on fungicide inputs. Am. Potato J. 71: 317-324.

FUSARIUM WILT

Fusarium spp.

Cultural: Grow potatoes on land free from wilt fungi. Use disease-free potatoes for seed. Do not add inoculum from infested soil, diseased tubers or plant refuse to clean fields. Practice crop rotation. Follow good soil management, including the use of proper irrigation practices.

Resistant Cultivars: None.

Chemical: See Appendix I.

References:

1. Emmond, G.S. and Ledingham, R.J. 1972. Effects of crop rotation on some soil-borne pathogens of potato. Can. J. Plant Sci. 52: 605-611.

LATE BLIGHT

Phytophthora infestans

Cultural: Destroy cull piles by burying or spraying them with a herbicide. Plant healthy seed potatoes. Kill infected potato tops 2 weeks before harvest to reduce tuber infection during harvest (see appendix IV for desiccants and topkillers). Remove diseased tubers before storage and maintain adequate air circulation in the pile. Maintain good air circulation to dry out decaying tubers. Infected tubers should be held at a temperature that is as low as practical. Cool temperatures needed for suppression of tuber rot tend to have a negative impact on frying color.

Resistant Cultivars: None.

Chemical: Follow label instructions when applying registered fungicides listed in Appendix I. Time spray applications according to late blight forecasts for your region. Apply sprays every 10-14 days in hot dry weather when the risk of infection is low. Apply fungicides every 5 to 7 days in late blight favourable weather particularly when late blight warnings are high.

References:

1. Anonymous. 1996. Integrated management of late blight on potatoes. Sustainable Pest Management Series - S96-01. 17 pp. Pest Management Regulatory Agency, Ottawa, ON.

2. Fry, W.E. *et al.* 1983. Evaluation of potato late blight forecasts modified to incorporate host resistance and fungicide weathering. Phytopathology 73:1054-1059.

3. Tartier, L. 1974. Control of late blight by different fungicides. Pp. 307-308 in Pesticide Research Report. CCPUA, Ottawa.

4. Wallin, J.R. 1962. Summary of recent progress in predicting late blight epidemics in the United States and Canada. Am. Potato J. 39: 306-312.

5. Anderson, B., *et al*. 1998. Indications of soil borne inoculum of *Phytophthora infestans*. Potato Res. 41: 305-310.

6. Cohen, Y., *et al*. 1997. Oospore production of *Phytophthora infestans* in potato and tomato leaves. Phytopathol. 87: 191-196.

7. Collier, R.A. 1993. Use of sticker/surfactant products in a high risk potato blight spray program. Pestic. Sci. 37: 223-225.

8. Daayf, F., and Platt, H.W. 1999. Assessment of mating types and resistance to metalaxyl of Canadian populations of *Phytophthora infestans* in 1997. Am. J. Potato Res. 76: 287-295.

9. Dowley, L.J., and O'Sullivan, E. 1991. Sporulation of *Phytophthora infestans* (Mont.) de Bary on the surface of diseased potatoes and tuber to tuber spread of infection during handling. Potato Res. 34: 295-296.

10. Fay, J.C., and Fry, W.E. 1997. Effects of hot and cold temperatures on the survival of oospores produced by United States strains of *Phytophthora infestans*. Am. Potato J. 74: 315-323.

11. Fry, W.E., and Shtienberg, D. 1990. Integration of host resistance and fungicide to manage potato diseases. Can. J. Plant Pathol. 12: 111-116.

12. Gill, T.S., *et al.* 1999. A simple method for isolation of *Phytophthora infestans*, cause of late blight of potato. Plant Dis. Res. 14: 82-84.

13. Hamm, P.B., and Clough, G.H. 1999. Comparison of application methods on deposition and redistribution of chlorothalonil in a potato canopy and potential for control of late blight. Plant Dis. 83: 441-444.

14. Hide, G.A., and Cayley, G.R. 1991. Control of late blight (*Phytophthora infestans* (Mont.) de Bary) with fungicide applied by hydraulic and electrostatic sprayers. Pot. Res. 34: 183-186.

15. Inglis, D.A., *et al.* 1999. Effect of registered potato seed piece fungicides on tuber-borne *Phytophthora infestans*. Plant Dis. 83: 229-234.

16. Lambert, D.H., *et al.* 1998. Transmission of *Phytophthora infestans* in cut potato seed. Am. J. Potato Res. 75: 257-263.

17. Leonard, R., *et al*. 2000. The effect of air assistance on spray deposition and biological effect in the control of *Phytophthora infestans* in potatoes. Aspects Appl. Biol. 57: 243-249.

18. Medina, M.V., and Platt, H.W. 1999. Viability of oospores of *Phytophthora infestans* under field conditions in northeastern North America. Can. J. Plant Pathol. 21: 137-143.

19. Medina, M.V., and Platt, H.W. 1999. Comparison of different culture media on the mycelial growth, sporangia and oospore production of *Phytophthora infestans*. Am. J. Potato Res. 76: 121-125.

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21. Misener, G.C., *et al*. 1990. Effect of mechanical top pulling and chemical top desiccation on the incidence of late blight tuber rot. Am. Potato J. 67: 859-863.

22. Peters, R.D., *et al*. 1999. Variation in aggressiveness of Canadian isolates of *Phytophthora infestans* as indicated by their relative abilities to cause potato tuber rot. Plant Dis. 83: 652-661.

23. Peters, R.D., *et al.* 1999. Hypotheses for the inter-regional movement of new genotypes of *Phytophthora infestans* in Canada. Can. J. Plant Pathol. 21: 132-136.

24. Peters, R.D., *et al.* 1998. Changes in race structure of Canadian populations of *Phytophthora infestans* based on specific virulence to selected potato clones. Potato Res. 41: 355-370.

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26. Powelson, M.L., and Inglis, D.A. 1999. Foliar fungicides as protective seed piece treatments for management of late blight of potatoes. Plant Dis. 83: 265-268.

27. Robinson, T.H., *et al*. 2000. The effect of nozzle angle and nozzle types on the deposition and biological performance of potato blight fungicides. Aspects Appl. Biol. 57: 267-272.

28. Scott, D.L., *et al.* 1999. The differentiation of *Phytophthora* species that are pathogenic on potatoes by an asymmetric PCR combined with single-strand conformation polymorphism analysis. Lett. Appl. Microbiol. 27: 39-44.

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30. Stromberg, A., *et al.* 1999. Infection of potatoes by oospores of *Phytophthora infestans* in soil. Plant Dis. 83: 876.

31. Tooley, P.W., *et al*. 1998. Application of a PCR-based test for detection of potato late blight and pink rot in tubers. Am. J. Potato Res. 75: 187-194.

32. Trout, C.L., *et al.* 1997. Rapid detection of *Phytophthora infestans* in late blight-infected potato and tomato using PCR. Plant Dis. 81: 1042-1048.

33. Zarzycka, H., and Sobkowiak, S. 1997. Formation and survival of *Phytophthora infestans* oospores and their role as a primary infection source of the pathogen. Plant Breeding Seed Sci. 41: 27-38.

34. Zwankhuizen, M.J., *et al*. 1998. Development of potato late blight epidemics: disease foci, disease gradients, and infection sources. Phytopathol. 88: 754-763.

LEAF ROLL

Potato leaf roll virus

Cultural: Plant leaf roll-free seed. Rogue out infected plants if practical. Control aphids to limit virus spread. Top-kill seed potatoes as early as possible after aphid vectors appear.

Resistant Cultivars: None.

Chemical: None. (See note 1).

Note:

1. Limit virus spread by reducing aphid vector populations with registered insecticides.

References:

1. Bacon, D.B. *et al.* 1976. Control of the green peach aphid and its effect on the incidence of potato leaf roll virus. J. Econ. Entomol. 69: 410-414.

2. Committee. 1983. Report of Western Committee on Crop Pests. Pp. 33, 37-38.

3. Barker, H., *et al.* 1994. Resistance to potato leaf roll virus multiplication in potato is under major gene control. Theor. Appl. Genet. 88: 754-758.

4. Presting, G.G., *et al*. 1995. Resistance to potato leafroll in potato plants transformed with the coat protein gene

or with vector control constructs. Phytopathol. 85: 436-442.

5. Schoen, C.D., *et al*. 1996. Detection of potato leafroll virus in dormant potato tubers by immunocapture and a fluorogenic 5' nuclease RT-PCR assay. Phytopathol. 86: 993-999.

LEAK

Pythium ultimum

Cultural: Grow potatoes on well-drained soils. Do not irrigate hot soils heavily. Harvest tubers when they are mature in cool weather. Avoid bruising and injuring potatoes. Store the potatoes at the proper temperature and humidity (refer to section on dry rot above for more details). Tubers harvested in hot, sunny weather are likely to develop leak and should be cooled below 10EC and marketed as soon as possible.

Resistant Cultivars: None.

Chemical: See Appendix I.

References:

1. Stasz, T.E. and Martin, S.P. 1988. Insensitivity of thick walled oospores of *Pythium ultimum* to fungicides, methyl bromide and heat. Phytopathology 78: 1409-1472.

2. Charron, C.S., and Sams, C.E. 1999. Inhibition of *Pythium ultimum* and *Rhizoctonia solani* by shredded leaves of Brassica species. J. Am. Soc. Hortic. Sci. 124: 462-467.

MOSAIC

Potato virus X, potato virus S, potato virus A, potato virus Y

Cultural: Use seed that is free of viruses. Avoid rubbing foliage with clothing, machinery, etc. Disinfest cutting knives and equipment as often as possible. Rogue diseased plants from seed fields. Reduce aphid populations to limit spread of viruses A and Y as described for leaf roll.

Resistant Cultivars: None.

Chemical: None (see note 2).

Notes:

1. Disinfest equipment (see Appendix II).
2. Insecticides recommended for leaf roll limit spread of viruses A and Y.

References:

1. de Bokx, J.A. (ed.). 1972. Viruses of potatoes and seed-potato production. Pudoc, Wageningen. 233 pp.

2. Peterson, L.C., *et al.* 1961. Viricidal disinfectants for the potato-cutting knife. Am. Potato J. 38: 382-387.

PINK ROT

Phytophthora erythroseptica

Cultural: Plant potatoes in well-drained soil. Do not over irrigate potatoes during the growing season. Allow tubers to mature underground for 2-3 weeks after top-killing. Do not harvest potatoes when soil temperatures rise above 17-18EC. Minimize bruising and cutting at harvest. Remove field heat from healthy potatoes gradually in a humid environment (90-95% relative humidity) to thicken skin and increase tuber resistance to infection in storage. Remove field heat as rapidly as possible from potatoes harvested from warm damp soil if symptoms of pink rot appear in storage after harvest. Store pink rot infected potatoes at or below 8EC in a continuously ventilated dry storage facility (80-85% relative humidity) until all affected tubers have dried up. Process potatoes as rapidly as possible if continuous ventilation fails to stop the spread of pink rot decay. If possible, harvest wet areas of fields last and store separately from healthy tubers.

Resistant Cultivars: None.

Chemical: See Appendix I.

Notes:

1. Symptoms of leak and pink rot are so similar that it can be difficult to correctly identify the causal agent.

2. Tuber flesh adjacent to darkened areas colonized by the *P. erythroseptica* pathogen turn pink 30-45 minutes after an infected tuber is cut open.

References:

1. Secor, G.A., and Gudmestad, N.C. 1999. Managing fungal diseases of potato. Can. J. Plant Pathol. 21: 213-221.

2. Torres, H., *et al.* 1985. Chemical control of pink rot of potato (*Phytophthora erythroseptica Pethyb.*). Am. Potato J. 62: 355-361.

3. Goodwin, S.B., and McGrath, M.T. 1995. Insensitivity to metalaxyl among isolates of *Phytophthora erythroseptica* causing pink rot of potato in New York. Plant Dis. 79: 967.

4. Ho, H.H., and Jong, S.C. 1989. *Phytophthora erythroseptica.* Mycotaxon 36: 73-90.

5. Tooley, P.W., *et al.* 1998. Application of a PCR-based test for detection of potato late blight and pink rot in tubers. Am. J. Potato Res. 75: 187-194.

6. Torres, H., *et al.* 1985. Chemical control of pink rot of potato (*Phytophthora erythroseptica* Pethyb.). Am. Potato J. 62: 355-361.

RHIZOCTONIA (BLACK SCURF)

Rhizoctonia solani

Cultural: Use disease-free seed. Avoid planting in cold, wet soil and cover seed pieces with not more than 5 cm (2 inches) of soil when planting early in cool soil. Harvest the tubers as soon as they are mature. Avoid growing potatoes in fields or portions of fields where the disease has been severe.

Resistant Cultivars: None.

Chemical: See Appendix I.

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SEED PIECE DECAY

Fusarium spp., *Pythium* spp., *Erwinia carotovora*

Cultural: Cut, treat, and plant the seed the same day. If cut seed cannot be planted the same day, then store it at 10-15EC with high humidity to facilitate suberization. Never allow cut seed to stand in the hot sun or in a drying wind. Plant in soils sufficiently warm and moist to promote good sprout growth and wound healing. Whole seed is quite resistant to decay. Stressing seed by putting it in direct contact with systemic insecticides or bands of liquid fertilizer apparently increase levels of seed piece decay.

Resistant Cultivars: None.
Chemical: See Appendix I.

Notes: Thiophanate-methyl may be phytotoxic under some conditions (1).

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SILVER SCURF

Helminthosporium solani

Cultural: Plant disease-free seed tubers and practice crop rotation. Harvest tubers as soon as they are mature. Cull out noticeably infected ones at digging and grading. Rid the field of all tubers left after harvest. Maintain stable levels of relative humidity and temperature in storage after harvest.

Resistant Cultivars: None.

Chemical: See Appendix I.

Notes: Resistance of *H. solani* to thiabendazole may limit this product's effectiveness.

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SPINDLE TUBER

Potato spindle tuber viroid (PSTV)

Cultural: Use seed tubers known to be free from PSTV. Avoid mechanical transmission by planting whole, rather than cut seed, and avoid leaf contact by equipment in field operations. Decontaminate knives and other equipment as frequently as possible (see Note 1). Rogue diseased plants in seed fields.

Resistant Cultivars: None.

Chemical: None.

Notes:

1. For disinfestation use sodium hypochlorite 6% (household bleach, dil. 1:10 not a.i.); ammonium based disinfectants (Roccal; 4-X; Liquid Quarternary Sanitizer (COM) SN) or soapy water.

2. Amendments to the Canada Seeds Act call for a zero tolerance for spindle tuber in all classes of seed potatoes.

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VERTICILLIUM WILT

Verticillium albo-atrum, *Verticillium dahliae*

Cultural: Treat seed pieces to prevent soil- and seed-borne infection. Use a 3-or 4-year rotation with cereals or grasses to reduce soil-borne inoculum. Control susceptible weeds.

Resistant Cultivars: None.

Chemical: See Appendix I.

Notes: Plant parasitic nematodes may increase the incidence and severity of verticillium wilt. Nematicides or soil fumigants (please see appendix III) applied for the control of these nematodes may also suppress verticillium wilt. (Preharvest interval - 90 days).

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OTHER DISEASES

The following diseases of potato are currently of minor importance and/or are diseases for which no practical control measures are currently recommended:

Black Dot (*Colletotrichum* spp.)

Calico (Alfalfa mosaic virus)

Corky Ring Spot (Spraing) (Tobacco rattle virus)

Phoma Rot (*Phoma* sp.)

Potato Mop Top Virus

Powdery Scab (*Spongospora subterranea*)

Purple-top Wilt (aster yellows phytoplasma)

Witches'-broom (potato witches'-broom phytoplasma)

QUARANTINE DISEASES

The following diseases do not occur at present or are of limited distribution in Canada and are under quarantine regulations:

Columbia Root-knot Nematode (*Meloidogyne chitwoodi*)

Golden Nematode (*Globodera rostochiensis*) - Confined to areas of Vancouver Island, B.C. and Newfoundland.

Wart (*Synchytrium endobioticum*) - Confined to areas of Newfoundland.

PVY-n (Potato virus Y - necrotic strain)

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APPENDIX I. Fungicides Registered for Controlling Plant Diseases on Potato

Disease	Active Ingredient	Trade Name	Formulation	PCP No.
Blackleg	thiophanate-methyl	Senator PSPT Seed Piece Treatment	10% D	14599
Common Scab	captan	Wilbur Ellis Potato seed Piece Treatment	7.5% D	15590
	captan+diazinon	Co-op Potato Seed piece Treatment	7.5%+0.1%D	*15755*
	metiram	Polyram 16D Fungicide Dust	16% D	22029
Dry Rot	fludioxonil	Maxim PSP	0.5% DP	26647
	mancozeb	Dithane F-45	37% F	20552
	thiabendazole	Mertect SC Fungicide	45% F	13975
	thiophanate-methyl	Senator PSPT Seed Piece Treatment	10% D	14599
Early Blight	anilazine	Dyrene Solupak 50% WP	50% WP	22090
	chlorothalanil	Bravo 500	40.2% SN	15723
	chlorothalanil+ carbaryl	C-I-L Deecop Insecticide-Fungicide for Vegetables	18% + 18SN	*13723*
	chlorothalanil+ metalaxyl	Bravo/ Ridomil Fungicide Twin Pack	36%F + 24%EC	24125
	copper oxychloride	Clean Crop Copper Spray Green leaf Copper Spray WP Fungicide Guardsman Copper Oxychloride	50% WP	19146 *16637* *13245*
	copper oxychloride + carbaryl	Green Leaf Potato and Tomato Dust Insecticide Fungicide Later's Potato and Tomato Dust Insecticide Fungicide	7% + 5% D	*15391* 16106
	dimethomorph+ mancozeb	Acrobat MZ	9%+60% WP	24546
	mancozeb	Dithane M-45 80%WP Dithane DG Rainshield NT Manzate 200 DF Dithane F-45 Fungicide Penncozeb 75DF	80% WP 75% DG 75% DF 37% F 75% DF	*8556* 20553 21057 20552 25397
	mancozeb + zoxamide	Gavel 75 DF	66.7% + 8.3% DF	26842

	maneb	Dithane M-22 80% WP		*4918*
	metiram	Polyram DF Polyram 16D	80% WG 16% D	20087 22029
	tribasic copper sulfate	Clean Crop Copper Wettable Powder Grifin Basicop (TM) Fungicide Wilson's Bordo Fungicide Spray		9934 19003 17482
	tribasic copper sulfate+ carbaryl	C-I-L Deecop Insecticide-Fungicide Dust for Vegetables Co-op Potato & Tomato Dust Insecticide-Fungicide Wilson Tomato & Vegetable Dust	7% + 5%D	14160 17423 17424
	zineb	Clean Crop Zineb 80W WP	80% WP	*14562*
	zineb + carbaryl	Co-op Bug & Blight Control Insecticide Fungicide Dust King PTV Potato Dust Insecticide Fungicide Manchester 2 in 1 Bug Killer Dust	4% + 5% D	*10644* *10711* *11515*
Late Blight	anilazine	Dyrene Solupak 50% WP	50% WP	22090
	chlorothalanil	Bravo 500	40.2% SN	15723
	chlorothalanil+ carbaryl	C-I-L Deecop Insecticide-Fungicide for Vegetables	18% + 18SN	*13723*
	chlorothalanil+ metalaxyl	Bravo/ Ridomil Fungicide Twin Pack	36%F + 24%EC	24125
	copper oxychloride	Clean Crop Copper Spray Green Leaf Copper Spray WP Fungicide Guardsman Copper Oxychloride Later's Potato & Tomato Dust Insecticide-Fungicide	50% WP	19146 *16637* *13245*
	copper oxychloride + carbaryl	Green Leaf Potato and Tomato Dust Insecticide Fungicide Later's Potato and Tomato Dust Insecticide Fungicide	7% + 5% D	*15391* *16106*
	cymoxanil	Curzate 60DF	60% DF	26284
	dimethomorph+ mancozeb	Acrobat MZ	9%+60% WP	24546

	mancozeb	Dithane M-45 80%WP Dithane DG Manzate 200 DF Dithane F-45 Fungicide Penncozeb 75DF	80% WP 75% DG 75% DF 37% F 75% DF	*8556* 20553 21057 20552 25397
	mancozeb + zoxamide	Gavel 75 DF	66.7% + 8.3% DF	26842
	maneb	Dithane M-22 80% WP		*4918*
	metiram	Polyram DF Polyram 16D	80% WG 16% D	20087 22029
	propamocarb + chlorothalanil	Tattoo C	37.5% + 37.5% SU	*24544*
	tribasic copper sulfate	Clean Crop Copper Wettable Powder Griffin Basicop (TM) Fungicide Wilson's Bordo Fungicide Spray		9934 19003 17482
	tribasic copper sulfate+ carbaryl	C-I-L Deecop Insecticide-Fungicide Dust for Vegetables Co-op Potato & Tomato Dust Insecticide-Fungicide Wilson Tomato & Vegetable Dust	7% + 5%D	14160 17423 17424
	zineb	Clean Crop Zineb 80W WP	80% WP	*14562*
	zineb + carbaryl	King PTV Potato Dust Insecticide Fungicide Manchester 2 in 1 Bug Killer Dust	4% + 5% D	*10711* *11515*
Pink Rot and Pythium Leak	chlorothalanil + metalaxyl	Bravo/ Ridomil Twin Pack	36%F + 24% EC	24125
	metalaxyl-M + mancozeb	Ridomil Gold MZ 68WP	4% WP + 64%	25379 25419
Rhizoctonia Canker and Black Scurf	captan	Wibur Ellis Potato Seed Piece Treatment Dust	7.5%	15590
	fludioxonil	Maxim PSP	0.5%DP	26647
	thiabendazole	Mertect SC Fungicide	45% F	13975
Seed Piece Decay	captan	Wibur Ellis Potato Seed Piece Treatment Dust	7.5%	15590

	mancozeb	Tuberseal Potato Seed Piece Dust Clean Crop Potato Seed Treatment	16% D 8% D	17042 11051
	metiram	Polyram 16D Fungicide Dust	16% D	22029
	thiophanate-methyl	Senator PSPT Seed Piece Treatment	10% D	14599
Silver Scurf	fludioxonil	Maxim PSP	0.5%DP	26647
	thiophanate-methyl	Senator PSPT Seed Piece Treatment	10% D	14599
Wilt	thiophanate-methyl	Senator PSPT Seed Piece Treatment	10% D	14599

APPENDIX II. Products Registered for Disinfecting Farm Machinery and Storage Areas

Disease	**Active Ingredient**	**Trade Name**	**Formulation**	**PCP No.**
Bacterial Ring Rot	QAC	Ag-Services Incorporated General Storage Disinfectant	10% S	*14957*
	QAK	Bardak 2210 Disinfectant Sanitizer DMR-23 Disinfectant	7.5% S	*17466* 22688

APPENDIX III. Soil Sterilants and Nematicides Registered for Controlling Soil Borne Diseases

Active Ingredient	Trade Name	Formulation	PCP No.
metam	Vapam Liquid Solution	33% S	*6453*
methyl bromide*	Methyl Bromide Fumigant	100% S	*16495*
1,3-dichloropropene	Telone II	94% S	15893
1,3-dichloropropene + chloropicrin	Telone C17	78.3 + 16.5% S	16324
1,3-dichloropropene+ methyl-isothiocyanate	Vorlex Plus Liquid Soil Fumigant	40% + 20% S	18353
1,3-dichloropropene+ methyl-isothiocyanate+ chloropicrin	Vorlex Plus C.P. Liquid Soil Fumigant	34% + 17% + 15% S	*18354*

*Registration for methyl bromide will not be renewed the next time the label is reviewed. Consequently methyl bromide will only be available for the next two to three years. Registration for this chemical is being withdrawn because of the potential damage this product may do to human health and the environment.

APPENDIX IV. Registered Topkillers and Desiccants

Active Ingredient	Trade Name	Formulation	Next Registration	PCP No.
diquat	Reglone Liquid Herbicide and Dessicant		2003	7639
glufosinate ammonium	Ignite 15 SN Herbicide and Dessicant (British Columbia)	15% S	2003	23180
	Liberty (Prairie Provinces)	EC		24081

*****Dessicants are applied so that foliage infected with late blight dies and dries out completely before harvest. This control measure decreases levels of tuber infection at harvest and in so doing reduces levels of storage decay.