Chapter Four

DISEASES OF OILSEED CROPS

FLAX (*Linum usitatissimum*)

BROWNING AND STEM BREAK

Polyspora lini

Cultural: Practice crop rotation, plant flax in fields distant from those of the previous year and use disease-free seed from dry areas, or from crops not showing browning or stem break. Early seeding may reduce injury since the crop could ripen before the disease becomes severe.

Resistant Cultivars: None (see Notes).

Chemical: None.

Notes: Cvs. differ in resistance but variation for pathogenicity also occurs in the fungus.

References:

1. Henry, A.W. 1934. Observations on the variability of *Polyspora lini* Lafferty. Can. J. Res. 10: 409-413.

2. Henry, A.W. and Ellis, C. 1971. Seed infestation of flax in Alberta with the fungus causing browning or stem-break. Can. Plant Dis. Surv. 51: 76-79.

HEAT CANKER AND FROST INJURY

Nonparasitic

Cultural: Heat canker due to scorching by excessively heated soil and frost canker due to freezing temperatures at soil level produce similar symptoms of blight and girdling in flax seedlings. Preventive measures are a firm seedbed to promote even and vigorous stands, dense seeding in a north-south direction, and shading provided by crop residue.

Resistant Cultivars: None.

Chemical: None.

References:

1. Vanterpool, T.C. 1961. Effects of high surface-soil temperature on cereals and flax. Can. Plant Dis. Surv. 41: 306-309.

2. Vanterpool, T.C. 1963. Note of a non-parasitic canker of flax seedlings - an interpretation. Can. J. Plant Sci. 43: 408-410.

PASMO

Mycosphaerella linorum (imperfect state *Septoria linicola*)

Cultural: Practise crop rotation with at least three years between flax. Clean seed thoroughly as the fungus can be seed-borne. Sow flax early to avoid disease build-up at maturity in wet autumn weather. Seed the recommended rates and control weeds to prevent high moisture levels in crop canopy.

Resistant Cultivars: None (see Notes).

Chemical: None.

Notes: Cultivars currently grown in Western Canada are moderately susceptible. The disease usually occurs late in the season with increasing moisture in the fall. However, high disease incidence and severity can occur in mid-season after prolonged rainfall and build-up of moisture in crop canopy.

POWDERY MILDEW

Oidium lini

Cultural: Seed flax early to avoid disease build-up at maturity. Seed recommended rates and control weeds to prevent high moisture levels in crop canopy. Crop rotation will help reduce the inoculum pressure.

Resistant Cultivars: CDC Bethune, AC Carnduff, AC Emerson, CDC Gold, Hanley, Lightning, Linola 1084, AC McDuff, McGregor, Prairie Blue, Shape, CDC Sorrel, AC Watson, 2149.

Intermediate: CDC Mons, Flanders, Taurus, Macbeth, 2047, 2090, 2126, Prairie Thunder, Prairie Grande.

Susceptible: CDC Arras, AC Linora, NorLin, NorMan, CDC Normandy, Somme, CDC Valour, Vimy.

Chemical: None.

Notes: This disease has been first reported in Canada in 1997, and has increased rapidly since then. Little is known about host range and race specificity. Use of resistant cultivars is the only practical control.

References:

1. Rashid, K.Y. 1998. Powdery mildew on flax; a new disease in western Canada. Can. J. Plant Pathol. 20: 216.

RUST

Melampsora lini

Cultural: Clean seed carefully to eliminate any pieces of plant debris that might be carrying rust. Early planting may help the crop mature before rust becomes serious. Flax should not be planted on flax stubble and preferably, new flax fields should be located as far as possible from previous year's flax crops. Since volunteer flax can carry the disease from year to year, control volunteers in the field, along field edges, and around sloughs or low areas.

Resistant Cultivars: All registered cultivars: CDC Arras, CDC Bethune, CDC Gold, AC Carnduff, AC Emerson, Flanders, Hanley, Lightning, AC Linora, Macbeth, AC McDuff, McGregor, CDC Mons, NorLin, NorMan, CDC Normandy, Prairie Blue, Shape, Somme, CDC Sorrel, Tauras, CDC Valour, Vimy, and AC Watson, 1084, 2047, 2090, 2126, 2149.

Susceptible: None of the registered cultivars in Canada.

Chemical: None.

Notes: The rusts found on blue-flowered wild flax (*L. lewisii, L. perenne*) do not infect common flax, nor do those generally found on yellow flowered wild flax (*L. rigidum, L. sulcatum*) (1). However, rust races that infect common flax can infect yellow-flowered flax but not blue-flowered flax.

References:

1. Zimmer, D.E. and Hoes, J.A. 1974. Race 370, a new and dangerous North American race of flax rust. Plant Dis. Rep. 58: 311-313.

2. Hoes, J.A. and Kenaschuk, E.O. 1980. Post seedling resistance to rust in flax. Can. J. Plant Pathol. 2: 125-130.

SEED DECAY, SEEDLING BLIGHT, ROOT ROT

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

Cultural: Practice crop rotation for at least 3 years between flax but avoid legumes and sugar beets because these crops are susceptible to the same strains of *Rhizoctonia solani*. Sowing into a firm seedbed and sowing on cropped land (stubble) rather than summerfallow should reduce losses from *Rhizoctonia solani* since this fungus is more destructive on loose soil.

Resistant Cultivars: None.

Chemical: Because flax is very susceptible to seedling blight, all flax used as seed should be treated with a fungicide to control seed-borne and soil-borne diseases and to promote good seedling growth. Treat seed with carbathiin (COM) SU; carbathiin + thiram (COM) SU; fludioxonil (COM) SN.

Limitations: As per label. For carbathiin + thiram, do not store treated seed over 18 months and do not graze fields sown with treated seed for 4 weeks after emergence.

WILT

Fusarium oxysporum f. sp. *lini*

Cultural: To prevent build-up of the pathogen, practice a 3-year rotation using cereals, corn or grasses.

Resistant Cultivars: AC Emerson, Hanley, Lightning, AC Linora, Macbeth, Prairie Thunder, Shape.

Intermediate: All other currently registered cultivars.

Susceptible: None.

Chemical: None.

Notes: In the absence of flax, the fungus can survive indefinitely in the soil, so the only practical control is the use of resistant cultivars. Avoid the use of trifluralin herbicide in previously infected fields because this will result in a large reduction of flax emergence (2).

References:

1. Kommedahl, T., *et al.* 1970. A half century of research in Minnesota of flax wilt caused by *Fusarium oxysporum*. Minn. Agric. Exp. Sta., Tech. Bull. 273. 35 pp.

2. Rashid, K.Y. and Kenaschuk, E.O. 1993. Effect of trifluralin on fusarium wilt in flax. Can. J. Plant Sci. 73: 893-901.

OTHER DISEASES

The following diseases of flax are currently of minor importance (MI) and/or are diseases for which no practical control measures are currently recommended (NC):

Anthracnose & Seedling Blight (*Colletotrichum lini*) NC

Aster Yellows (aster yellows phytoplasma) MI

Boll Blight (Nonparasitic) NC

Brown Stem Blight (*Alternaria linicola*) NC

Crinkle (Oat Blue Dwarf) (oat blue dwarf virus) MI

Dieback (Nonparasitic) NC

CANOLA (RAPESEED) AND MUSTARD (*Brassica* spp. and *Sinapis alba*)

ALTERNARIA BLACK SPOT (GRAY LEAF SPOT)

Alternaria brassicae, A. raphani

Cultural: Rotate with non-cruciferous crops. Control volunteers and cruciferous weeds during the rotation. Early swathing of badly infected crops may prevent serious losses from shattering and seed shrinkage. All seeds should be cleaned thoroughly to remove shrunken, severely infected seed. Seed from southern or drier areas of the prairies carries less inoculum and could be used as a seed source (see Note 1). Storage of seed lightly infected with *Alternaria* may improve germination (see Note 3).

Resistant Cultivars: None (see Note 2).

Chemical: Treat seed destined for planting with an appropriate seed treatment (see Appendix I). Spray with azoxystrobin (COM) SU, boscalid (COM) WG, or iprodione (COM) SU.

Notes:

1. Seed germination and seedling emergence were not directly related to seed infestation by pathogenic *Alternaria* species (2).

2. *Brassica rapa* (= *B. campestris*) and *Brassica juncea* cultivars are much more susceptible than *B. napus* cultivars.

3. Seed-borne *Alternaria* reduces germination, but the viability of the fungi declines during storage with a corresponding increase in germination. This may be important for seed growers, but may not improve grade in commercial production (Robin Morrall, personal communication).

References:

1. Clear, R.M. and S.K. Patrick. 1995. Frequency and distribution of seedborne fungi infecting canola seed from Ontario and western Canada - 1989 to 1993. Can. Plant Dis. Surv. 75: 9-17.

2. Dorrance, M.J. 1994. Practical Crop Protection: Weeds, insects, diseases. Alberta Agriculture, Food & Rural Development, Edmonton AB.

3. Petrie, G.A. 1973. Diseases of *Brassica* species in Saskatchewan. 1970-72. II. Stem, pod and leaf spots. Can. Plant Dis. Surv. 53: 83-87.

4. Petrie, G.A. 1974. Fungi associated with seeds of rape, turnip rape, flax and safflower in Western Canada, 1968-1973. Can. Plant Dis. Surv. 54: 155-165.

BLACKLEG

Leptosphaeria maculans (imperfect state *Phoma lingam*)

Cultural: Use a minimum 4 year rotation, especially under dry conditions where infested stubble decomposes slowly. Never seed rapeseed or mustard on stubble of these crops or adjacent to a field which had the disease the previous 2 years. Control wild mustard (*Sinapis arvensis*) and volunteer plants between crops.

Cultivar Resistance: **Blackleg resistance ratings for some of the current varieties and hybrids are listed in the table below.** For disease reaction on additional canola products please see the Canola Council of Canada website http://www.canola-council.org, click on Grow Canola, then Canola Variety Comparisons, then POD (performance on-line data), accessed Nov. 16, 2008. For the complete list of currently registered cultivars see the Canadian Food Inspection Agency website: **http://www.inspection.gc.ca/english/plaveg/variet/rapecole.shtml** (accessed Nov. 16, 2008).

The resistance ratings of some of the canola products may be lowered if they are infected with new strains of the blackleg fungus. Very little information is available on blackleg disease reaction of canola products to new strains.

RESISTANT	MODERATELY RESISTANT	MODERATELY SUSCEPTIBLE
289CL, 292CL, 71-20CL, 5020, 5030, 5070, 624RR, 829RR, 997RR, 1818, 1841, 1849, 1852H, 71-20CL, 71-25RR, 71-85RR, 32-75, 33-95, 34-65, 35-85, 423-02, 458RR, 45H72, 45H73, 45H21, 45H24, 45H25, 45H26, 45P70, 46A65, 46A76, 46H02, 46H23, 46H70, 46P50, 9550, 9590, FortuneRR, Reaper, CougarCL, SP Banner, SP Craven, SP DesirableRR, SP Force CL, SW WIZZARD, Café, v1035, Nex 824CL, Nex 828CL, Nex 830CL, LDB588RR, LDB644RR, NR01-5660, Prairie 717RR, Prairie 719RR	1759S, 1812, 1839V, 1851H, 1862, 1878V, v1030, v1031, v1032, 3235,34-55, 43A56, 6045CL,71-45RR, 821RR, 904_02, 9451, 9551, 99CH01, CC504-03, IMC109RR, IMC09RR, SP442CL, SP451RR, SP621RR, SP AdmirableRR, SP CANWOOD SP DeliverCL, SP DistinctionCL, SP FavourableRR, SW 3950, SW 6802, SW 9803, SW GladiatoRR, SW Hymark 3944RR, SW Razor	Manor, 74POO LL

Chemical: Treat seed destined for planting with appropriate seed treatment (see Appendix I). Spray with azoxystrobin (COM) SU or propiconazole (COM) EC.

Limitations: As per label.

Notes:

1. The virulent strain of the blackleg fungus caused significant losses in some parts of the prairies. In specific instances losses in yield of 50% or more were recorded. Losses have been reduced by the development of resistant cultivars. Recently, new aggressive strains of blackleg have been reported.

2. Seed may be a very important means by which the disease spreads to new areas. However, in areas where the disease is established, seed treatment is ineffective because seed infection is insignificant in comparison to ascospore infection from plant residues. Since the fungus infects the seed coat and embryo, a systemic fungicide or hot water treatment (50^{o}C for 20 min.) would be necessary for seed treatment.

3. All currently registered varieties of brown (*Brassica juncea*), oriental (*B. juncea*) and yellow (*Sinapis alba*) mustard are resistant to the strains of *Leptosphaeria maculans* prevalent in western Canada.

4. Lindane products are no longer registered for use on canola.

References:

1. Fernando, W.G.D. and Y. Chen. 2003. First report on the presence of *Leptosphaeria maculans* pathogenicity group-3, the causal agent of blackleg of canola in Manitoba. Plant Dis. 87: 1268.

2. Gabrielson, R.L. *et al.* 1977. Fungicidal eradication of seed borne *Phoma lingam* on crucifers. Plant Dis. Rep. 61: 118-121.

3. Guo, X.W. *et al*. 2005. Effects of crop rotation and tillage on blackleg disease of canola. Can. J. Plant Pathol. 27: 53-57.

4. Gugel, R.K. and Petrie, G.A. 1992. History, occurrence, impact, and control of blackleg of rapeseed. Can. J. Plant Pathol. 14: 36-45.

5. Hall, R. 1992. Epidemiology of blackleg of oilseed rape. Can. J. Plant Pathol. 14: 46-55.

6. Keri, M., H.R. Kutcher and S.R. Rimmer. 2001. Virulence of isolates of *Leptosphaeria maculans* from western Canada on *Brassica napus* differentials. Can. J. Plant Pathol. 23: 199.

7. Kharbanda, P.D. 1993. Blackleg of Canola in Alberta: Investigations on biology, epidemiology and management. Alberta Environmental Centre Publication # AECV93-R5. 86 pp.

8. Petrie, G.A. 1995. Long term survival and sporulation of *Leptosphaeria maculans* (blackleg) on naturally infested rapeseed/canola stubble in Saskatchewan. Can. Plant Dis. Surv. 75: 23-34.

9. Rimmer, S.R. and Buchwaldt, L. 1995. Diseases. *In* Brassica Oilseeds Production and Utilization. Ed. D.S. Kimber and D.I. McGregor. CAB International, Oxford UK. Pp. 111-140.

10. West, J.S, *et al.* 2001. Epidemiology and management of *Leptosphaeria maculans* (phoma stem canker) on oilseed rape in Australia, Canada, and Europe. Plant Pathol. 50: 10-27.

CLUBROOT

Plasmodiophora brassicae Woronin

Cultural: Allow at least 5 years between susceptible crops. However, the effect of crop rotation is reduced if contaminated soil is introduced via equipment transport from infested fields, or if volunteer canola and cruciferous weeds are not well controlled. Sanitation of equipment will help contain the disease. Wind and water erosion should be controlled to prevent introduction from infested adjacent fields. Cereals and most grasses are immune while canola, rapeseed, mustard, vegetable cole crops, and cruciferous weeds, are susceptible. Control canola volunteers and susceptible weed species. Do not use canola or other untreated seed grown on infested fields. Liming acid soils to above 7 may reduce clubroot severity in infested fields.

Cultivar Resistance: None.

Chemical: None (see Note 2).

Notes:

1. No clubroot resistant canola or mustard cultivars are registered in Canada, although cultivars with partial resistance are registered in Europe.

2. There are no registered fungicides for clubroot control in oilseed crops in Canada or other countries. There are fungicides registered for clubroot control in cole crops.

References:

1. Hartman, M. 2007. Clubroot Disease of Canola and Mustard. Alberta Agriculture, Food and Rural Development, Agdex 140/638-1. Available on-line, accessed November 16, 2008 at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex8593

2. Tewari, J.P., Strelkov, S.E., Orchard, D., Hartman, M., Lange, R.M. and Turkington, T.K. 2005. Identification of clubroot of crucifers on canola (*Brassica napus*) in Alberta. Can. J. Plant Pathol. 27:143-144.

FUSARIUM WILT

Fusarium oxysporum f. sp. *conglutinans*

Cultural: None.

Cultivar Resistance: Of the known susceptible canola cultivars, the only ones currently on the market are Canterra 1604 and Roper. All new cultivars/hybrids that are registered are required to be resistant to Fusarium wilt. Some of the brown mustard varieties are known to be susceptible.

Chemical: None.

References:

1. Benard, D. and Lange, R.M. 2002. Identification and quantification of a new canola wilt in western Canada. Final Project Report, Canola agronomic research program AG #2000-6 and Farming for the Future matching Grants Research Program Project #2000M633: 30 pp.

2. Benard, D. *et al.* 2002. Survey of Fusarium wilt and other canola diseases in Alberta, 2001. Can. Plant Dis. Surv. 82: 80-82.

3. Benard, D. *et al.* 2001. Survey of Fusarium wilt and other canola diseases in Alberta, 2000. Can. Plant Dis. Surv. 81: 102-104.

ROOT ROT COMPLEX AND FOOT ROT

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

Cultural: Rotate with cereals, and control cruciferous weeds and volunteer plants. Shallow seeding reduces root rot. Maintaining fertility levels may help to decrease the severity of the root rot complex (brown girdling root rot).

Resistant Cultivars: None.

Chemical: None.

Notes:

1. From survey work, *B. juncea* (Brown and Oriental Mustard) may be more susceptible than other *Brassica* spp.

2. *B. rapa* (= *B. campestris*) generally is more susceptible than *B. napus* to the root rot complex (7).

References:

1. Acharya, S.N. *et al.* 1984. Screening rapeseed/canola for resistance to damping-off and seedling root rot caused by *Rhizoctonia solani*. Can. J. Plant Pathol. 6: 325-328.

2. Berkenkamp, B. and Vaartnou, H. 1972. Fungi associated with rape root rot in Alberta. Can. J. Plant Sci. 52: 973-976.

3. Harrison, L. *et al.* 1997. Blackleg of canola. Agdex 149/632-3. Alberta Agriculture, Food & Rural Development, Edmonton.

4. Harrison, L. 1995. Personal communication, Alberta Agriculture, Food and Rural Development, Fairview.

5. Kaminski, D.A. and Verma, P.R. 1985. Cultural characteristics, virulence, and in vitro temperature effect on mycelial growth of *Rhizoctonia* isolates from rapeseed. Can. J. Plant Pathol. 7: 256-261.

6. Petrie, G.A. 1973. Diseases of *Brassica* Species in Saskatchewan 1970-72. III. Stem and root rots. Can. Plant Dis. Surv. 53: 88-92.

7. Sippell, D.W. *et al.* 1985. Rhizoctonia root rot of rapeseed in the Peace River region of Alberta. Can. J. Plant Pathol. 7: 184-186.

8. Turkington, T.K. *et al.* 1995. The influence of tillage and nitrogen fertilizer on brown girdling root rot of canola. Can. J. Plant Pathol. 17: 363 (abstr).

9. Vanterpool, T.C. 1974. *Pythium polymastum* pathogenic on oilseed rape and other crucifers. Can. J. Bot. 52: 1205-1208.

SCLEROTINIA STEM ROT

Sclerotinia sclerotiorum

Cultural: Allow at least 4 years between susceptible crops. However, the effect of crop rotation may be reduced if inoculum is blown from adjacent fields. Cereals and grasses are immune while rapeseed, mustard, field peas, beans, lentils, soybeans, sunflowers, and clovers are susceptible. Control volunteers and susceptible weed species. Use cleaned seed free of sclerotia (see Note 1). In severely infected fields, early swathing may reduce losses due to shattering.

Resistant Cultivars: None, although cultivars prone to lodging are more at risk of infection.

Chemical: Azoxystrobin (COM) SU at 20-50% bloom; boscalid (COM) WG at 20 to 30% bloom; iprodione (COM) SU at 20-50% bloom; or vinclozolin (COM) WG. (See Appendix I, see note 2).

Limitations: As per label. Preharvest interval - 21 days (boscalid); 30 days (azoxystrobin); 38 days (iprodione); 40 days (vinclozolin). The above fungicides are registered for use on canola but not mustard.

Notes:

1. The standard for No. 1 seed (pedigreed and non-pedigreed) is a maximum of 20 sclerotia/kg of seed and for No. 2 seed (pedigreed and non-pedigreed), a maximum of 40 sclerotia/kg of seed. Sclerotia in seed can be removed by using a spiral cleaner.

2. To decide whether the use of a fungicide is economical, estimate disease risk using (1) the sclerotinia stem rot check list and (2) petal testing as described in the Canola Growers Manual.

References:

1. Bradnock, W.T. 1979. Standards for sclerotia of *Sclerotinia sclerotiorum* in rapeseed. Trade Memorandum T-2-97. Can. Dep. Agric., Ottawa.

2. Evans, I.R., and P. Thomas. 1995. Disease forecasting for sclerotinia white rot in canola. Agdex 149/632-4. Alberta Agriculture, Food & Rural Development, Edmonton AB.

3. Kutcher, H.R., T.K. Turkington and G. Clayton. 2001. Effect of lodging resistance and apetalous canola cultivars on sclerotinia stem rot. Can. J. Plant Pathol. 23: 323.

4. Morrall, R.A.A. and Dueck, J. 1982. Epidemiology of sclerotinia stem rot of rapeseed in Saskatchewan. Can. J. Plant Pathol. 4: 161-168.

5. Thomson, Jill, R. *et al*. 1984. Efficacy of aerial application of benomyl and iprodione for the control of Sclerotinia stem rot of canola (rapeseed) in central Alberta. Can. J. Plant Path. 6: 75-77.

6. Turkington, T.K., and R.A.A. Morrall. 1993. Use of petal infestation to forecast sclerotinia stem rot of canola: The influence of inoculum variation over the flowering period and canopy density. Phytopathology 83: 682-689.

7. Turkington, T.K., R.A.A. Morrall, and R.K. Gugel. 1991. Use of petal infestation to forecast sclerotinia stem rot of canola: evaluation of early bloom sampling, 1985-90. Can. J. Plant Pathol. 13: 50-59.

SEEDLING BLIGHT (DAMPING OFF)

Rhizoctonia solani, *Fusarium* spp., *Pythium* spp. (2) and (3).

Cultural: Sow sound seed into a firm, moist seedbed. Do not seed too deep, 1.25-2.5 cm is optimal, and seed when the soil temperature at seeding depth is at least 10^{o}C (see Notes). Rotate with non-cruciferous crops and control volunteers and cruciferous weeds during the rotation. Fertilizer placed with the seed may delay and reduce emergence (4).

Resistant Cultivars: None.

Chemical: Treat seed with carbathiin + thiram (COM) SU; clothianidim + carbathiin + thiram + metalaxyl (COM) SU; fludioxonil (COM) SN; imidacloprid + carbathiin + thiram (COM) SU; iprodione + thiram (COM) SU; thiamethoxam + fludioxonil + difenoconazole + mefenoxan (COM) LI (see Appendix I). Metalaxyl (COM) SU seed treatment for *Pythium* spp.

Limitations: As per label.

Notes:

1. Early and deep seeding into cold, dry soil can result in losses of up to 100% of the stand. Severe damage can also result when canola is sown after canola or a canola-summerfallow rotation. Reseeding may be successful if soil temperature and soil moisture levels are adequate after the initial seeding failure (1,5).

2. If flea beetle control is required for canola and mustard seedlings, use seed treated with a dual purpose seed treatment.

3. Lindane products are no longer registered for use on canola.

References:

1. Committee. 1980. Soil temperature for germination. Alberta Agric. Agdex 590-1.

2. Gugel, R.K. *et al.* 1987. Etiology of the rhizoctonia root rot complex of canola in the Peace River region of Alberta. Can. J. Plant Pathol. 9: 119-128.

3. Hwang, S.F. *et al.* 1986. Characterization of *Rhizoctonia solani* isolates from canola in west central Alberta. Plant Dis. 70: 681-683.

4. Nyborg, M. 1961. The effect of fertilizers on emergence of cereal grains, flax and rape. Can. J. Soil Sci. 41: 89-98.

5. Teo, B.K. *et al*. 1988. Influence of soil moisture, seeding date, and Rhizoctonia solani isolates (AG2-1 and AG4) on disease incidence and yield in canola. Can. J. Plant Pathol. 10: 151-158.

WHITE LEAF SPOT (GREY STEM)

Pseudocercosporella capsellae (Mycosphaerella capsellae)

Cultural: Rotate with non-cruciferous crops. Control volunteers and cruciferous weeds.

Resistant Cultivars: None.

Chemical: None.

Notes: White leaf spot, which occurs early and could be economically important, has been overlooked because it has been confused with alternaria leaf spot.

References:

1. Petrie, G.A. 1973. Diseases of *Brassica* species in Saskatchewan, 1970-72. II. Stem, pod, and leaf spots. Can. Plant Dis. Surv. 53: 83-87.

2. Petrie, G.A. and Vanterpool, T.C. 1975. *Pseudocercosporella capsellae* the cause of white leaf spot and gray stem of cruciferae in Western Canada. Proc. Can. Phytopath. Soc. 42: 20.

WHITE RUST (STAGHEAD)

Albugo candida

Cultural: Rotate with non-cruciferous crops. Control volunteers and cruciferous weeds (see Note 1).

Cultivar Resistance: All *Brassica rapa* cultivars are susceptible to the prevalent pathotype (7V) and all *Brassica juncea* cultivars are susceptible to race 2V. [*B. juncea* is attacked by races 2A and 2V of *A. candida*, whereas *B. rapa* is attacked by races 7A and 7V. The cultivars do differ in resistance to races 2A and 7A for *B. juncea* and *B. rapa*, respectively].

Chemical: None.

Notes: Stinkweed (*Thlaspi arvense*), marsh yellow cress (*Rorippa islandica*) and wild mustard (*Sinapsis arvensis*) carry strains of *A. candida* that can infect Torch (*B. rapa*) while an isolate from shepherd's purse did not infect Torch (2).

References:

1. Petrie, G.A. 1973. Diseases of Brassica species in Saskatchewan. 1970-72. I. Staghead and aster yellows. Can. Plant Dis. Surv. 53: 19-25.

2. Rimmer, S.R. *et al.* 2000. Virulence of isolates of *Albugo candida* from western Canada to *Brassica* species. Can. J. Plant Pathol. 22: 229-235.

3. Thomas, P.L. Personal communication. Alberta Agriculture, Food & Rural Development, Lacombe.

4. Verma, P.R. and Petrie, G.A. 1980. Effect of seed infestation and flower bud inoculation on systemic infection of turnip rape by *Albugo candida*. Can. J. Plant Sci. 60: 267-271.

SULFUR DEFICIENCY

Nonparasitic

Cultural: Apply fertilizer containing sulfate at 30 kg/ha of sulfur to sulfur-deficient soils.

Resistant Cultivars: None.

Chemical: None.

Notes:

1. Soils on which it is most likely to occur include leached Luvisolic (gray wooded) soils and any well drained, non-calcareous soils.

2. The typical sulfur deficiency symptom in canola at an early stage of growth is cupped and purplish leaves. In later stages, plants have small, poorly filled pods.

References:

1. Anon. 1977. Principles and practices of commercial farming. Univ. Manitoba, Winnipeg. 520 pp.

2. Malhi, S.S. and Gill, K.S. 2002. Effectiveness of sulphate-S fertilization at different growth stages for yield, seed quality, and S uptake of canola in northeastern Saskatchewan. Can. J. Soil Sci. 82: 665-674.

3. Malhi, S.S., Schoenau, J.J. and Grant, C.A. 2005. A review of sulphur fertilizer management for optimum yield and quality of canola in the Canadian Great Plains. Can. J. Plant Sci. 85: 297-307.

OTHER DISEASES

The following diseases of canola and mustard are currently of minor importance (MI) and/or are diseases for which no practical control measures are currently recommended (NC):

Aster Yellows (aster yellows phytoplasma) NC

Black Rot (*Xanthomonas campestris*) MI

Downy Mildew (*Peronospora parasitica*) NC

SAFFLOWER (*Carthamus tinctorius*)

ALTERNARIA BLIGHT

Alternaria carthami

Cultural: Plant populations that allow good air circulation and fast drying of the leaves should help reduce severity of the disease. In years or areas with frequent rains *Alternaria* may cause severe damage to the leaves, flower bracts, and staining of the seed (1, 2). Use seed produced in areas of low rainfall.

Resistant Cultivars: None (see Note 1).

Chemical: None (see Note 2).

Notes:

1. AC Stirling, AC Sunset and Saffire are moderately susceptible.

2. Contaminated seed appears to be important in the epidemiology of this disease.

3. Hot water treatment (50^{o}C for 30 min.) has been shown to be effective in reducing the percentage of safflower seeds with viable *Alternaria* spp. without altering the germination of seeds (3).

References:

1. Cormack, M.W. and Harper, F.R. 1952. Resistance in safflower to root rot and rust in Alberta. Phytopathol. 42(5): 5 (Abstr.)

2. Howard, R.J. 1990. Personal communication. Alberta Special Crops and Hort. Res. Ctr., Brooks, AB.

3. Zazzerini, A. *et al.* 1985. Use of hot-water treatment as a means of controlling *Alternaria* spp. on safflower seed. Plant Dis. 69: 350-351.

SCLEROTINIA HEAD ROT

Sclerotinia sclerotiorum

Cultural: Allow at least 4 years between susceptible crops (see Note). Fababeans, field beans, field peas, mustard, canola (rapeseed), lentils, soybeans and sunflowers are susceptible; cereals and grasses are immune. Sow seed free of sclerotia.

Resistant Cultivars: Saffire, AC Sunset.

Intermediate: AC Sterling.

Susceptible: S-208, S-541, 175, 176.

Chemical: None.

Notes: The effect of crop rotation may be reduced if inoculum is blown in from adjacent fields.

References:

1. Mundel, H.H. *et al.* 1985. Sclerotinia head rot in safflower; assessment of resistance and effects on yield and oil content. Can. J. Plant Sci. 65: 259-265.

SEED DECAY, SEEDLING BLIGHT, ROOT ROT

Alternaria carthami, Pythium spp., *Rhizoctonia solani*

Cultural: Rotate crops, but avoid legumes and canola because these crops are susceptible to some of the same fungal pathogens. Avoid seeding too deep and into wet, heavy soils. Select and plant seed with low levels of seedborne fungi.

Resistant Cultivars: None. See Notes.

Chemical: Fludioxonil (COM) SN; thiram (COM) WP.

Notes:

1. Root rot resistant germplasm has been identified, but these lines are not recommended for planting in Canada.

2. Hot water treatment (50^{o}C for 30 min.) has been shown to be effective in reducing the percentage of safflower seeds with viable *Alternaria* spp. without altering the germination of seeds (3).

References:

1. Cormack, M.W. and Harper, F.R. 1952. Resistance in safflower to root rot and rust in Alberta. Phytopathol. 42(5): 5 (Abstr.).

2. Howard, R.J. 1990. Personal communication. Alberta Special Crops and Hort. Ctr., Brooks, AB.

3. Zazzerini, A. *et al.* 1985. Use of hot-water treatment as a means of controlling *Alternaria* spp. on safflower seed. Plant Dis. 69: 350-351.

OTHER DISEASES

The following diseases, observed on safflower in Western Canada, are of minor importance (MI) or are diseases for which no practical control measures (NC) are currently recommended.

Gray Mold (*Botrytis cinerea*)

Rust (*Puccinia carthami*)

SUNFLOWER (*Helianthus annuus*)

DOWNY MILDEW

Plasmopara halstedii

Cultural: Control volunteer sunflowers and susceptible weeds, such as ragweed, wild sunflower, and thistle. Use seed from healthy plants, as the fungus is seed-borne. Sunflowers should not be sown in low, wet fields as this favours the development and spread of the fungus.

Resistant Cultivars: Defender Plus, Defender HO, Proseed 9215, Proseed 9310, 8N337DM, 8N453DM, 3311, 6111, 6322, 6511 (Hysun 511), 8242NS, 63A81, 63M52, AC 60, IS 3433NS/DM, IS 5757, IS 6039, IS 6131NS/DM, KS 8300, (Defender Plus and Defender HO are resistant to races 2 and 3. See notes.)

Intermediate: 6150, 6230, 7240, CLOL 803, IS 7111, IS 8089, MRS 40, 63M40, 8N386CL.

Susceptible: AC Aurora, Cougar, IS 7000, IS 8004, IS 8048, IS 8135, Kodiak, Panther, RH 316, RH 1122, RH 3703, AC Sierra, SF 187, SF 270, ST 439, X4407, 8C416, 8C481, 8C482, 8N270, 8N358CL, 63A21, 63A70, 63A84, 63C71, 63M80, 63M02, 828, 6946, 9338, 9530, 9532.

Chemical: Resistance to the seed treatment metalaxyl has been widely detected in this pathogen in Manitoba. The new recommendation is to treat sunflower seed with a mixture of Apron-Maxim to prevent seed-borne infection and to protect seedlings from soil-borne infection.

Notes: The resistance of these cultivars refers only to downy mildew race 2. Commercial hybrids and varieties are susceptible to other races that presently occur in Manitoba (Ref. 2). Only Defender Plus, Defender HO, Hysun 311 and Hysun 323 are resistant to race 3.

References:

1. Goossen, P.G. and Sackston, W.E. 1968. Transmission and biology of sunflower downy mildew. Can. J. Bot. 46: 5-10.

2. Rashid, K.Y. 1993. Incidence and virulence of *Plasmopora halstedii* on sunflower in western Canada during 1988-1991. Can. J. Plant Pathol. 15 (3): 206-210.

3. Zimmer, D.E. 1975. Some biotic and climatic factors influencing sporadic occurrence of sunflower downy mildew. Phytopathology 65: 751-754.

LEAF MOTTLE AND WILT

Verticillium dahliae

Cultural: When planting susceptible cultivars, practice a crop rotation of at least 5 years, even if the disease is not yet known to occur in the particular field. Control volunteers and broad-leaved weeds. Use disease-free seed when expanding sunflower production into new areas because the fungus can be seed-borne.

Resistant Cultivars: AC 60, CLOL 803, Defender Plus, Defender HO, Hysun 311, Hysun 323, 6511 (Hysun 511), IS 3433NS/DM, IS 5757, IS 6039, IS 6131NS/DM , IS 7000, IS 7111, Kodiak, KS 8300, MRS 40, MY 7240, Proseed 9310, PRO 9215, SF 187, ST 439, Viper, 828, 3311, 6111, 6230, 6322, 6946, 8N358CL, 8N453DM, 63A70, 63A81, 63A84, 63C71, 63M02, 63M52, 63M80, 8242NS.

Intermediate: Cougar, IS 8048, IS 8089, IS8135, MY 9338, RH 3703, SF 270, 6150, 63A21, 8C416, 9530, 9532, 8N270, 8C481, 8C482, 8N337DM, 8N386CL, X4407.

Susceptible: AC Aurora, Cougar, Panther, AC Sierra, IS 8004.

Chemical: None.

References:

1. Zimmer, D.E. *et al.* 1973. Evaluation of sunflower to rust and Verticillium wilt. Plant Dis. Rep. 57: 524-528.

RUST

Puccinia helianthi

Cultural: Locate new fields as far as possible from fields where sunflowers were grown the preceding year. Control wild sunflowers and volunteers. Turn under rust-carrying debris of the previous crop.

Resistant Cultivars: 6300, IS 6131NS/DM (resistant to races 2, 3 and 4).

Intermediate: AC 60, CLOL 803, Hysun 311, IS 8048, IS 7000, IS 7111, 63A70, 6946, Kodiak, KS 8300, MRS 40, PRO 9215, Proseed 9310, SF 187, ST 439, 828, 3311, 6111, 6230, 6322, 63A84, 9530, IS8135, Panther, X4407 (See notes).

Susceptible: AC Aurora, AC Sierra, Cougar, Defender Plus, Defender HO, 6511 (Hysun 511), IS 3433NS/DM, IS 5757, IS 6039, IS 8004, IS 8089, MY 9338, MY 7240, RH 3703, SF 270, 8242NS, 63A21, 63A81, 63C71, 63M02, 63M40, 63M52, 63M80, 8C416, 8C841, 8C842, 8N270, 8N337DM, 8N358CL, 8N386CL, 8N453DM, 6150, 9532.

Chemical: One and/or two applications of the fungicides mancozeb, propiconazole, fluazinam, chlorothalonil, and myclobutanil reduce rust severity and improve yield (non-registered fungicides, ref. 3).

Notes: The reaction of these hybrids refers only to sunflower rust race 2 which was predominant in Manitoba a few years ago. Most commercial hybrids are susceptible to the new rust races 3 and 4 common in southern Manitoba and eastern Saskatchewan.

References:

1. Rashid, K. 1991. Incidence and virulence of *Puccinia helianthi* on sunflower in western Canada during 1988-1990. Can J. Plant Pathol. 13: 356-360.

2. Zimmer, D.E. *et al*. 1973. Evaluation of sunflower for resistance to rust and verticillium wilt. Plant Dis. Rep. 57: 524-528.

3. Rashid, K. Y. 1997. Effects of fungicides on rust severity and yield in sunflower. HELIA 20: 43-48.

SCLEROTINIA WILT AND HEAD ROT

Sclerotinia sclerotiorum

Cultural: Sow well cleaned seed, free of sclerotia. Use cereals, corn or grasses in a crop rotation, allowing at least 4 years between susceptible crops such as beans, buckwheat, fababeans, lentils, mustard, and rapeseed. Control broadleaved weeds and volunteer susceptible crops. Since dense seeding promotes Sclerotinia wilt, do not exceed the recommended seeding rates, and seed uniformly. Plant spacings of 30 cm and greater reduce root contact and plant-to-plant spread of the disease.

Resistant Cultivars: None.

Intermediate: None.

Susceptible: All commercial hybrids and cultivars to wilt and head rot.

Chemical: None.

Notes:

1. Reaction to sclerotinia wilt is based on 3-year testing in naturally infested fields.

2. The pathogen may infect sunflower stems and heads and cause mid-stem breakage and head rot.

3. Survival of sclerotia of *Sclerotinia sclerotiorum* is affected by hyperparasites such as *Coniothyrium minitans*. The sclerotia produced on the underground portion of the host tissue are more readily killed by hyperparasites than those produced in above ground tissue (2).

References:

1. Hoes, J.A., and H.C. Huang. 1985. Effect of between-row and within-row spacings on development of sclerotinia wilt and yield of sunflower. Can. J. Plant Pathol. 7: 98-102.

2. Huang, H.C. 1977. Importance of *Coniothyrium minitans* in survival of sclerotia of *Sclerotinia sclerotiorum* in wilted sunflower. Can. J. Bot. 55: 289-295.

3. Rashid, K.Y., and W. Dedio. 1992. Differences in the reaction of sunflower hybrids to sclerotinia wilt. Can. J. Plant Sci. 72: 925-930.

OTHER DISEASES

The following diseases of sunflower are currently of minor importance (MI) and/or are diseases for which no practical control measures are currently recommended (NC):

Aster Yellows (aster yellows phytoplasma) MI

Bacterial Leaf Spot (*Pseudomonas syringae*) NC

Botrytis Head Rot (*Botrytis cinerea)* NC

Leaf and Stem Spot (*Alternaria zinnae, Septoria helianthi*) NC

Phialophora Yellows (*Phialophora asteris* f. sp. *helianthi*) NC

Phoma Black Stem (*Phoma oleracea* f. sp. *helianthi-tuberosi*) NC

Phomopsis Stem Canker (*Phomopsis helianthi*) NC

Powdery Mildew (*Erysiphe cichoracearum*) NC

Rhizopus Head Rot (*Rhizopus* sp.) NC

Septoria Leaf Spot (*Septoria helianthi*) NC

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2. Bergland, D.R. 1994. Sunflower production. Extension Bulletin 25. North Dakota State University Extension Service, Fargo, ND.

3. Burgess, L. *et al.* 1979. Insect pests and diseases of rape and mustard. Rapeseed Assoc. Can., Publ. 48.

4. Davidson, J.G.N. and Ellis, P.J. 1983. Disease control in canola/rapeseed. *In* Canola/rapeseed production and research review in the Peace River region. Agric. Can. Res. Sta., Beaverlodge, Publ. NRG-83-7.

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6. Gill, K.S. 1987. Linseed. Indian Council of Agricultural Research, new Delhi, India.

7. Gulya, T., K. Y. Rashid and S. Masirevic. 1997. Sunflower diseases. Pages 263-380 *in* (Ed. A.A. Schneiter) Sunflower Technology and Production, Agronomy #35. American Society of Agronomy, Madison, Wisconsin, USA.

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9. Hoes, J.A. 1975. Sunflower diseases in Western Canada. Pp. 425-433 *in* J.T. Harapiak (ed.). Oilseed and pulse crops in Western Canada. Western Cooperative Fertilizers Ltd., Calgary.

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11. Millikan, C.R. 1951. Diseases of Flax and Linseed. Tech. Bull. No. 9, Dept. Of Agric., Victoria Australia.

12. Multiple papers. 1992. Symposium on biology and control of *Leptosphaeria maculans*. Can. J. Plant Pathol. 14: 30-75.

13. Muskett, A.E. and J. Colhoun. 1947. The Diseases of the Flax Plant (*Linum usitatissimum* Linn.). W. & G. Baird Ltd. Belfast, Northern Ireland.

14. Paul, V.H. and Rawlinson, C.J. 1992. Diseases and Pests of Rape. Verlag Th. Mann, D-4560. Gelsenkirchen-Buer, Germany.

15. Petrie, G.A. 1975. Diseases of rapeseed and mustard. Pp. 399-413 *in* J.T. Harapiak (ed.). Oilseed and pulse crops in Western Canada. Western Cooperative Fertilizers Ltd., Calgary.

16. Rimmer, S.R., Shattuck,, V.I., Buchwaldt, L. 2007. Compendium of Brassica Diseases. APS Press, 136pp.

17. Rashid, K.Y. 2003. Principle diseases of flax. Pages 92-123 *in* A.D. Muir and N.D. Westcott (eds.) Flax - The genus Linum. Taylor and Francis, London.

18. Tewari, J.P. and Mithen, R.F. 1999. Diseases. *In* Biology of Brassica Coenospecies. Ed. C. Gomez-Campo. Elsevier, New York, NY. Pp. 375-411.

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APPENDIX I. Fungicides registered for use against diseases of oilseeds in Canada.

To search for currently registered seed treatments go to the PMRA website and use the label search, http://pr-rp.pmra-arla.gc.ca/portal/page?_pageid=34,17551&_dad=portal&_schema=PORTAL. In the Full-Text space, type in the crop type you are searching for and seed treatment (use the word and), ie canola and seed treatment or canola and fungicide.

Crop	Disease	Trade Name	Active Ingredient	Formulation	PCP #
Canola (rapeseed)	alternaria black spot (foliar)	Quadris	azoxystrobin	SU	26153
		Lance	boscalid	WG	27495
		Rovral RX	iprodione	SU	24378
	alternaria black spot (seed borne)	Foundation Lite	iprodione + thiram	SU	25592
		Helix Helix Xtra	thiamethoxam + fludioxonil + difenoconazole + mefenoxan	LI	26637 26638
	blackleg (seed borne)	Vitavax RS[a] Fungicide	carbathiin + thiram	SU	25862
		Prosper	clothianidim + carbathiin + thiram + metalaxyl	SU	27564
		Foundation Lite	iprodione + thiram	SU	25592
		Gaucho CS FL	imidacloprid + carbathiin + thiram	SU	27174
		Helix Helix Xtra	thiamethoxam + fludioxonil + difenoconazole + mefenoxan	LI	26637 26638
	blackleg (foliar)	Quadris	azoxystrobin	SU	26153
		Tilt 250 Bumper 418 Pivot 418	propiconazole	EC EC EC	19346 28107 28219
	sclerotinia stem rot (foliar)	Proline 480	prothioconazole	SC	28359
		Quadris	azoxystrobin	SU	26153
		Lance	boscalid	WG	27495
		Rovral RX	iprodione	SU	24378
		Ronilan EG	vinclozolin	WG	24894

[a] Vitavax RS Fungicide is a component of the Gaucho seed treatment system.

Appendix I. Fungicides registered for use against diseases of oilseeds in Canada (continued)

Crop	Disease	Trade Name	Active Ingredient	Formulation	PCP #
Canola (rapeseed) (continued)	seedling blight (damping off)	Vitavax RS[a] Fungicide	carbathiin + thiram	SU	25862
		Gaucho CS	imidacloprid + carbathiin + thiram	SU	27174
		Foundation Lite	iprodione + thiram	SU	25592
		Apron FL Allegiance FL	metalaxyl	SU	24262 26674
		Helix Helix Xtra	thiamethoxam + fludioxonil + difenoconazole + mefenoxan	LI	26637 26638
		Prosper	clothianidim + carbathiin + thiram + metalaxyl	SU	27564
	seed borne and soil-borne diseases caused by *Fusarium*, *Rhizoctonia*, *Aspergillus* and *Penicillium* spp.	Maxim 480 FS	fludioxonil	SN	27001
Flax	seed decay, seedling blight, root rot	Vitaflo 280	carbathiin + thiram	SU	11423
	seed rot and seedling blight	Vitavax FL Vitaflo-250	carbathiin	SU SU	27550 27697
	seed borne and soil-borne diseases caused by *Fusarium* and *Rhizoctonia* spp.	Maxim 480 FS	fludioxonil	SN	27001

[a] Vitavax RS Fungicide is a component of the Gaucho seed treatment system.

Appendix I. Fungicides registered for use against diseases of oilseeds in Canada (continued)

Crop	Disease	Trade Name	Active Ingredient	Formulation	PCP #
Mustard	seedling blight (damping off)	Vitavax RS[a] Fungicide	carbathiin + thiram	SU	25802
		Gaucho CS	imidacloprid + carbathiin + thiram	SU	27174
		Foundation Lite	iprodione + thiram	SU	25592
		Helix Helix Xtra	thiamethoxam + fludioxonil + difenoconazole + mefenoxan	LI	26637 26638
		Thiram 75	thiram	WP	27556
	seed borne and soil-borne diseases caused by *Fusarium*, *Rhizoctonia*, *Aspergillus* and *Penicillium* spp.	Maxim 480 FS	fludioxonil	SN	27001
Safflower	seed decay, seedling blight, damping off	Thiram 75 WP	thiram	WP	15933
	seed borne and soil-borne diseases caused by *Fusarium* and *Rhizoctonia* spp.	Maxim 480 FS	fludioxonil	SN	27001
Sunflower	downy mildew	Apron FL Allegiance FL	metalaxyl	SU	24262 26674
	seed borne and soil-borne diseases caused by *Fusarium* and *Rhizoctonia* spp.	Maxim 480 FS	fludioxonil	SN	27001

[a] Vitavax RS Fungicide is a component of the Gaucho seed treatment system.