Chapter 8: Diseases

Historically, fusarium wilt and rust have been considered major limiting factors in flax production in Western Canada. However, these two diseases have been effectively managed by multigenic resistance incorporated in all commercially registered flax varieties in Canada. Recently, pasmo and powdery mildew have been widespread causing local disease epidemics. Maintaining resistance to rust and wilt and breeding for resistance to pasmo and powdery mildew are objectives in developing new varieties.

Refer to the Guide to Crop Protection publication available on provincial department of agriculture websites. The Guide to Crop Protection is updated annually and contains pertinent additional information on disease control management including a listing of currently registered fungicides.

Rust

Rust is potentially the most destructive disease affecting flax. The last major rust epidemic occurred in the 1970's. Although it is effectively controlled by genetic resistance, it remains a potential threat to flax production as it can survive locally and complete its life cycle on flax, thus having the ability to produce new races that attack hitherto resistant varieties.

The causal organism is *Melampsora lini*, a fungus that overwinters by means of teliospores on flax debris. Early infections produce the aecial stage with aeciospores on volunteer flax seedlings which subsequently produce the uredial stage. Urediospores can cycle through several generations during the growing season resulting in completely defoliated flax plants and reduction of seed yield and fiber quality. Flax rust completes its life cycle on the flax plant, unlike many other rusts that require an alternate host.

Symptoms: Rust is readily recognized by the presence of bright orange and powdery pustules, also called uredia (Photo 8-1). Rust pustules develop mostly on leaves (Photo 8-2), but also on stems (Photo 8-3) and bolls (Photo 8-4). The pustules produce numerous urediospores which are airborne and cause new cycles of infections during the season. Spread and infections are favored by high humidity during cool nights, warmer day temperatures and on plants growing vigorously. As the season progresses, the orange pustules turn black and produce overwintering telia and teliospores (Photos 8-3 and 8-4). The black pustules are most common on stems.

Control: Complete control is achieved by the use of rust-resistant varieties. All registered Canadian varieties listed in Table 11-1 are immune to local races of rust. Planting susceptible varieties may not only result in serious yield loss, but also affords the fungus a chance to produce new races that may attack resistant varieties. Additional safeguards include: destroying plant debris, using certified and disease-free seed of a recommended variety, crop rotation and planting the flax crop in a field distant from that of the previous year.

Photo 8-1–Flax rust

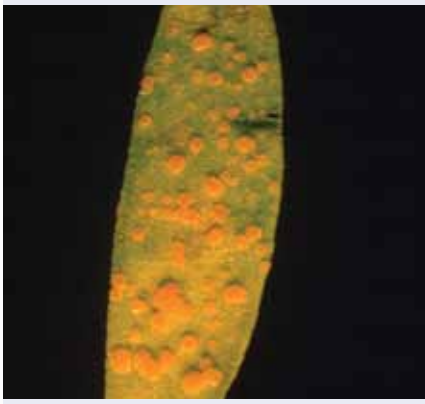

Photo 8-2–Flax rust on leaf

Photo 8-3–Rust uredia and telia on flax stems

Photo 8-4–Uredia and telia on flax boll

Photo 8-5–Flax fusarium wilt at seedling stage

Photo 8-6–Flax fusarium wilt at adult stage

Fusarium Wilt

Flax wilt or fusarium wilt is caused by the seedborne and soilborne fungus *Fusarium oxysporum* f.sp. *lini*. The fungus invades plants through the roots at any growth stage during the growing season and continues infection inside the water-conducting tissue of the root. This interferes with water uptake and warm weather therefore aggravates plant symptoms from the disease. All Canadian flax varieties are resistant/moderately resistant to fusarium wilt (Table 11-1).

Symptoms: Early infections may kill flax seedlings shortly after emergence (Photo 8-5), while delayed infections cause yellowing and wilting of leaves, followed by browning and death of plants (Photo 8-6). Roots of dead plants turn ashy grey. The tops of wilted plants often turn downward and form a "shepherd's crook". Affected plants occur more commonly in patches but may also be scattered throughout the field. The fungus persists in the soil, as mycelia and spores survive for many years in debris of flax and other organic matter in the soil. Wind-blown and water run-off soil may spread the fungus from one field to another.

Control: The most important control measure is the use of available resistant/moderately resistant varieties (Table 11-1). Crop rotation of at least three years between flax crops helps to maintain low levels of inoculum in the soil. Seed treatment with recommended fungicides may protect the crop from early infection at the seedling stage and helps maintain good stands and seedling vigor.

Pasmo

The causal organism of this disease is *Septoria linicola*, a fungus that attacks above-ground parts of flax and overwinters in the soil on infected flax stubble. Flax is susceptible to pasmo from the seedling stage to maturity. Epidemics can occur early in the season when favorable conditions of high humidity with frequent rain showers prevail. Pasmo can cause defoliation; premature ripening and can weaken the infected pedicels resulting in heavy boll-drop under rain and wind conditions. Depending on the earliness and severity of the infection, pasmo reduces seed yield as well as seed and fiber quality. Commercial flax varieties lack resistance to this pathogen.

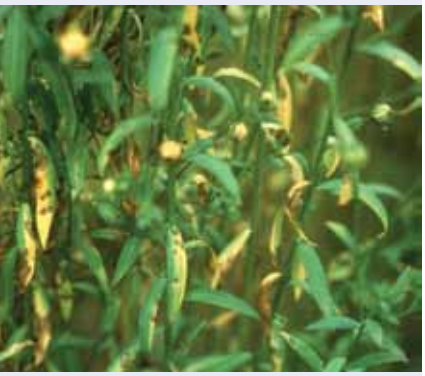

Photo 8-7–Pasmo on flax leaves

Photo 8-8–Pasmo brown banding on stems

Symptoms: Pasmo is characterized by circular brown lesions on the leaves (Photo 8-7) and brown to black infected bands that alternate with green and healthy bands on the stem (Photo 8-8 and Photo 8-9). Infected flax tissue is characterized by tiny black pycnidia which are the fruiting bodies of the fungus. The debris carries numerous pycnidia which overwinter and produce masses of spores that cause the initial infections on leaves and stems. Spores are dispersed by rain and wind. High moisture and warm temperatures favor the disease. Lodging favors the development of pasmo, because of increased humidity within the crop canopy and this may result in patches of dead plants completely covered with the fungus.

Control: In the absence of genetic resistance to this pathogen, the best disease management is achieved by early seeding to avoid high moisture conditions in late summer and fall, using clean seed with recommended seed treatment to protect the crop at the seedling stage, using lodging-resistant varieties, applying the recommended seeding rate and control of weeds to avoid a thick crop canopy which create favourable microclimate conditions for disease development. Growers should follow a crop rotation of at least three years between flax crops to minimize the inoculum pressure of the pathogen. Foliar application(s) using recommended fungicides can be applied around early flowering to protect the crop from disease spread and the development of epidemics, thus reducing the loss in yield and quality of harvested seed.

Powdery Mildew

This disease was first reported in Western Canada in 1997. Powdery mildew has spread quickly and its incidence and severity have increased sharply in Manitoba and Saskatchewan.

The causal agent is the fungus *Oidium lini* and little is known about the overwintering and host range of this fungus in Western Canada. Early infections may cause severe defoliation of the flax plant and reduce seed yield and quality. Some flax varieties are resistant/moderately resistant to this disease (see Table 11-1).

Symptoms: The symptoms are characterized by a white powdery mass of mycelia that start as small spots and rapidly spread to cover the entire leaf surface (Photos 8-10 and 8-11). Heavily infected leaves dry up, wither and die. Early infections may cause complete defoliation of flax plants.

Control: The most economical control is through the use of resistant varieties (see Table 11-1). Early seeding will reduce the impact of this disease on yield loss by avoiding early infections and buildup of epidemics. Foliar application of recommended fungicides around flowering time may protect the crop from severe powdery mildew epidemics and reduce losses in yield and seed quality.

Stem Break and Browning

Stem break and browning are phases of a disease caused by the seedborne and soilborne fungus, *Aureobasidium pullulan* var. *lini*, also called *Polyspora lini*. This disease is of minor importance in Western Canada; however, it may cause some damage in the Parkland regions of Saskatchewan and Alberta in some years.

Symptoms: Stem break is the first conspicuous disease symptom. Development of a canker at the stem base weakens the plant. The stem may break at this point when the plants are still young, or at a later stage (Photo 8-12). Plants may remain alive after stem breakage, but any seed produced may still be lost in harvesting as seed produced will be smaller and thin. Initial infections in spring may start from spores produced on diseased stubble and are spread by wind and rain. Infections may start during seedling emergence when seed coats of diseased seed are lifted above the ground and the fungus produces the first cycle of spores of the season.

The browning phase is initiated by infections on the upper part of the stem that appear as oval or elongated brown spots, often surrounded by narrow, purplish margins. The spots may coalesce, and leaves and stem turn brown. Patches of heavily infected plants appear brown, giving the disease the name of 'browning'. The fungus may penetrate bolls as well as seeds, or may produce spores on the seed surface. Affected seeds may remain viable.

Control: Use of disease-free seed produced by healthy plants is the most important control measure. Fungicidal seed treatment controls surface-borne inoculum, but is unlikely to be effective against inoculum borne inside the seed. Rotating crops and planting flax in a field distant from that of the previous year reduces spread of infection from diseased stubble.

Photo 8-9–Severe pasmo on flax stems

Photo 8-10–Powdery mildew on flax

Photo 8-11–Severe powdery mildew in flax field

Photo 8-12–Flax browning and stem break

Photo 8-13–Flax seedling blight

Photo 8-14–Sclerotinia stem shredding

Photo 8-15–Sclerotia of sclerotinia inside flax stem

Seedling Blight and Root Rot

In spite of seed treatment, seedling blight and root rot can develop, leading to reductions in yield. Seedling blight and root rot may be due to soilborne fungi such as species of Fusarium, Pythium and Rhizoctonia. However, *Rhizoctonia solani* is the principal causal agent and can be particularly destructive in soils that are loose, warm and moist. *R. solani* survives as a composite of strains that differ in host range and pathogenicity. Strains attacking sugar beets and legumes such as alfalfa and field peas, also attack flax. Seed coats of yellow-seeded flax varieties are more prone to cracking and splits, which renders them more susceptible to infections causing seedling blight and root rot than brown-seeded varieties.

Symptoms: Blighted seedlings turn yellow, wilt and die. Infected seedlings may occur singly or in patches (Photo 8-13). Seedling blight may be inconspicuous and gaps in the row may be the principal sign of disease occurrence. Roots of recently affected plants show red to brown lesions, and may later turn dark and shrivel. Diseased plants are often difficult to distinguish from those killed by the wilt fungus.

Root rot symptoms usually appear in plants after the flowering stage. Plants may wilt on warm days and turn brown prematurely. Plants with root rot usually set little or no seed.

Control: Seedling blight and root rot can be controlled by a combination of farm practices. Use certified seed of a recommended variety. Reduce cracking of seed by adjusting combine settings during harvest. Treat the seed with a fungicide. Practice a crop rotation of at least three years between flax crops and plant in a field that is distant from fields sown to flax in the previous year. Avoid legumes and sugar beets in the rotation. Prepare a firm seedbed and use recommended fertilizer and seeding practices to promote vigorous stands. Sow flax on cereal stubble rather than on summerfallow.

Sclerotinia Stem Rot

This disease has been reported from Alberta, Manitoba and Saskatchewan in lodged flax crops with saturated soil moisture conditions. Severity of the disease depends on the level of Sclerotinia inoculum in the soil from previous crops, the soil water saturation and the severity of lodging.

The causal agent is *Sclerotinia sclerotiorum* which is a widespread pathogen causing diseases on canola, sunflower, soybean, leguminous crops, and 100s of plant species.

This fungus survives for 3-4 years in the soil as compact masses of mycelia called sclerotia. The infection in flax is caused by mycelial infection on plants touching the infested soil in heavily lodged flax. No evidence of airborne ascospores infection of this pathogen in flax.

Symptoms: The symptoms are water-soaked longitudinal lesions on the stems girdling the stems resulted in bleaching, shredding of the stems (Photo 8-14), breakage and lodging in Sclerotinia heavily infested fields. Mycelia grow on the stem surface and cylindrical shaped sclerotia are formed inside the stem (Photo 8-15).

Control: As Canadian flax varieties do not have genetic resistance to Sclerotinia, it is recommended to use lodging resistant varieties, proper seeding rate and recommended fertilizer rate to avoid dense crop canopy. Producers should avoid fields with previous history of heavy Sclerotinia inoculum and water saturated or heavily irrigated fields.

Aster Yellows

The six-spotted leafhopper is the main vector which transmits the phytoplasma organism that causes aster yellows in flax, canola, sunflower and some weeds. The disease occurs annually but commonly only traces and low level infections occur in Western Canada. However, early migrations of leafhoppers from the United States resulted in aster yellows epidemics in 1957 and 2012, causing widespread severe yield losses in flax and other crops.

Symptoms: Aster yellows symptoms include yellowing of the top part of the plant, conspicuous malformation of the flowers and stunted growth (Photo 8-16). All flower parts including the petals are converted into small, yellowish green leaves (Photo 8-17). Diseased flowers are sterile and produce no seed. The severity of the disease depends at the stage plants become infected and the number of insect vectors that carry the pathogen. The mycoplasma-like organism overwinters in perennial broadleaved weeds and crops, but most infections are carried by leafhoppers that migrate from the United States.

Control: Seed early to avoid the migrating leafhoppers in mid to late season. Early summer migration of leafhoppers occurs when abnormal warm weather prevails early in the growing season thus resulting in major epidemic and yield loss.

Crinkle

Crinkle is caused by a virus called oat blue dwarf that also causes disease in oats, wheat, and barley. Only traces of the disease occur in flax in Western Canada.

Symptoms: The symptoms are characterized by a conspicuous puckering of leaves, stunted growth and reduced branching. Flowering may appear normal but seed production is reduced. Like aster yellows, crinkle is a disease of flax that depends for infection via transmission by the six-spotted leafhopper.

Control: Seed early to avoid migrating leafhoppers in mid to late season.

Minor Diseases

In certain localities, occasional fungal diseases may be due to *Alternaria linicola* causing seedling and stem blight, *Colletotrichum lini* causing anthracnose of leaves and seedling blight, *Phoma exigua* causing root rot and *Selenophoma linicola* causing dieback. *Alternaria* and *Colletotrichum* are seedborne and may be controlled by fungicide seed treatment. Occasionally, *Sclerotinia sclerotiorum* causes stem mold, stem shredding and breakage in heavily lodged flax sown in Sclerotinia infested fields.

Photos are courtesy of AAFC, and remain property of AAFC.

Photo 8-16–Flax Aster Yellows stunting and malformed flowers

Photo 8-17–Flax Aster Yellows, petals turn to yellowish-green small leaves

Production Tip

Use a variety that is resistant to rust and wilt and adapted to the growing conditions in your area.