Disease Management

2

Best Management Considerations

FIELD CROP DISEASE MANAGEMENT

Disease Diagnosis

Plant diseases are caused by pathogenic microorganisms, including fungi, bacteria, viruses and nematodes. Most field crop diseases are caused by fungi. Many diseases have distinctive symptoms, however it can often be difficult to diagnose a disease based on symptoms alone. It is important to correctly identify a disease in order to apply the most effective management practices, and to avoid unnecessary and expensive fungicide applications.

The BCMAL Plant Diagnostic Laboratory provides a service for identification of pathogenic and non-pathogenic disorders affecting commercial crops in B.C. There is a small fee for diagnosis. For more information and for copies of submission forms, please visit the lab website at:

www.al.gov.bc.ca/cropprot/lab.htm

Send samples to the following address:

Plant Diagnostic Lab,
B.C. Ministry of Agriculture and Lands

Abbotsford Agriculture Centre,
1767 Angus Campbell Road,
Abbotsford B.C., V3G 2M3

Tel: 604 556-3126 (directly) or
1-800-661-9903 (main office)
Fax: 604 556-3154

Disease Management Strategies

Most field crop diseases survive the winter on crop residue, and many are seed-borne. Good cultural management practices are critical to providing economic control of plant diseases. Foliar fungicide applications are an option for management of some diseases but should be applied only when necessary and when the value of the crop is high enough to recover the cost of application.

General best management practices to consider over the growing season include:

1. Select disease-resistant cultivars that are suitable for your location.
2. Seed at the recommended density and depth with good quality, pathogen-free seed to help the crop establish quickly and vigorously.
3. Fungicide seed treatments are a targeted and economical treatment for many soil and seed-borne diseases such as smuts, bunts and seedling blights.
4. Practice crop rotation along with good weed management to help prevent the buildup of pathogen populations.
5. Manage nutrients to optimize crop development and reduce susceptibility to many diseases.
6. Monitor crops for symptoms of plant diseases and obtain proper diagnosis of any unusual problems.
7. Maintain accurate records of crop and disease management activities in order to evaluate their outcomes and to make any necessary changes to overcome deficiencies the following season.

Information on application rates and timing, and other important instructions on proper use of fungicide products recommended in this chapter, are available on-line from the Pest Management

Regulatory Agency's label search web site at

http://pr-rp.pmra-arla.gc.ca/portal/page?_pageid=34,17551&_dad=portal&_schema=PORTAL

Technical information on recommended control products is also provided in the 2008 Guide to Crop Protection© developed jointly by Saskatchewan Agriculture & Food

www.agriculture.gov.sk.ca/Guide_to_Crop_Protection

and Manitoba Agriculture, Food, and Rural Initiatives

www.gov.mb.ca/agriculture/crops/cropproduction/gaa01d01.html

Fungicide Resistance Management

Fungicide resistance can become a problem when products with the same mode of action are used repeatedly. Resistance results in failure of the fungicide product, and all related products, to control the disease.

To prevent or delay the development of fungicide resistance, follow these best management practices when selecting and using fungicides:

1. Practice non-chemical control methods (e.g. crop rotation, resistant varieties) to minimize the need for fungicides.
2. Do not apply fungicides with the same mode of action repeatedly. Rotate products with different Group Numbers (displayed on product labels and in Tables 4 and 5).
3. Restrict the number of treatments applied per season, and apply only when necessary.
4. Maintain the manufacturers' recommended application rate.
5. Follow proper mixing and application instructions, and apply with properly calibrated equipment.
6. Keep accurate records of all fungicide applications, including product name, amount mixed per tank, volume of spray tank, spray volume per hectare or acre, date of application, and weather conditions.

Canola and Rapeseed Diseases

Alternaria Black Spot (Grey Leaf Spot) *(Alternaria brassicae, A. raphani, A. alternata)*

Blackspot occurs wherever canola-rapeseed is grown and can affect all stages of growth. It is most often seen on developing pods where it causes direct losses beneath each lesion, usually to 5 percent of the crop, but occasionally much higher. Serious losses have occurred in both wet and dry summers.

Symptoms

Infected seed may rot in the ground, or may produce infected seedlings with dark spots on the cotyledons. Leaf spots usually appear in early summer on lower leaves as circular, pale to brownish grey lesions with darker concentric lines. Leaf spots may vary in size and colour, depending on environmental conditions. They are sometimes almost black in colour. Leaf spots produce spores that subsequently infect pods and stems, forming circular, black or dark brown spots that may elongate into irregular blackish mottled elongate lesions. Pod lesions are frequently sunken, and the seeds beneath them are shrivelled. Infected pods may ripen prematurely, and shatter before the crop is mature resulting in yield loss.

Life Cycle

Alternaria fungi survive the winter on infected crop debris, seed, and on mustard family weeds, particularly stinkweed. Wind-blown spores are produced on crop residue in the spring, which are able to infect canola leaves during favourable (moist) environmental conditions. New spores are produced on diseased plants, which may cause more leaf, stem and pod infections. Seeds may become infected following pods infection.

Control

Cultural

Use disease-free seed of high germinability. If seed from an infected crop must be used, the seed should be cleaned thoroughly to remove shrunken, severely

infected seed before planting. Rotate with non-cruciferous crops for at least three years. Control volunteers and cruciferous weeds (e.g. stinkweed, shepherd's-purse, wild mustard) during the rotation. Incorporate infected stubble into soil thoroughly. Swath badly infected crops on time to prevent serious losses from shattering and seed shrinkage.

Resistant Cultivars

B. rapa (Polish type) cultivars are more susceptible than *B. napus* (Argentine type) cultivars. *B. juncea* (brown and oriental mustard) is also susceptible.

Chemical

The fungicides Quadris (azoxystrobin) and Lance (boscalid) are registered for control of Alternaria black spot on canola. Rovral Flo (iprodione) is registered for suppression of black spot. Good coverage of plants is essential. Follow label directions.

- Quadris: Apply once as a broadcast foliar spray at the early pod stage (90% petal fall) of canola. Do not apply within 30 days of harvest.
- Lance: Apply at late flowering to early green pod. Do not make more than 2 applications per season. Do not apply within 21 days of harvest.
- Rovral Flo: Apply as a single spray at early green pod, or as split application: the first at full bloom, followed by a second application at early green pod stage. Do not make more than 2 applications per season. Do not apply within 38 days of harvest.

Using fungicide-treated seed may help to increase stand establishment when infected seed is planted. Seed treatments registered for control of seed-borne Alternaria include: Foundation Lite, Gaucho CS FL, Helix, Helix XTra, Prosper FL and Vitavax RS Fungicide.

Aster Yellows

Aster yellows is usually a minor disease that occurs only at trace levels in a field.

Symptoms

Aster yellows causes malformation of the floral parts. Infections appear as round to oval, blue-green, hollow bladder-like structures, which replace pods. Incidence rarely exceeds 5%.

Life Cycle

Aster yellows is caused by a phytoplasma (a microbe similar to a bacterium, but lacking a cell wall). The aster yellows phytoplasma is spread by leafhoppers, primarily the six-spotted leafhopper (*Macrosteles fascifrons*). Aster yellows has a wide host range, and can also affect other crops such as flax. It can overwinter in infected perennial weeds and biennial or perennial crops such as echinacea, but most infections are caused by leafhoppers that migrate north from the United States. Prevalence of the disease depends largely on the abundance and timing of the arrival of migrating leafhoppers

Control

Control is not usually necessary. Early seeded crops may escape infection.

Blackleg of Canola *(Leptosphaeria maculans, Leptosphaeria biglobosa)*

Blackleg of canola is a serious fungal disease that can cause major yield losses in susceptible cultivars. It attacks leaves, stems and pods, and causes stem cankers, girdling and lodging. Seedlings may be killed shortly after emergence, resulting in symptoms that may be mistaken for damping-off. Infections occurring before the six leaf stage cause the most severe yield loss.

Two types of blackleg can infect canola -- avirulent and virulent. The avirulent, or mild strain (*Leptosphaeria biglobosa*) is commonly found in canola fields in the Peace. This weak pathogen causes superficial stem cankers late in the season, but does not affect the crop yield. The virulent, or aggressive strain (*Leptosphaeria maculans*) can infect canola from germination through to maturity, however the seedling stage is the most susceptible.

Virulent blackleg was first found in the BC Peace in 1995, and the Alberta Peace in 1992. The disease has not yet become a serious problem in the Peace region and remains present at a low incidence.

Symptoms

Leaf spots

Blackleg produces pale tan-grey, roughly circular lesions on leaves that eventually become speckled with

small, black dots (pycnidia, or fungal spore-producing structures). The mild strain attacks only older, dying leaves, whereas the virulent strain can attack young leaves and cotyledons. The presence of blackleg leaf spots early in the season is a good indication that the virulent strain of blackleg is involved.

Stem cankers

Stem lesions are whitish-grey or dull-brown, often with a darker border. Eventually black dots (pycnidia) are formed on the lesions. Under conditions of high relative humidity pink masses of spores are extruded from the pycnidia. Stem cankers formed early in the season may girdle the stem causing premature ripening, lodging and plant death. The weakly virulent strain of blackleg also causes stem lesions, but these tend to be superficial, non-girdling lesions that occur late in the season and do not affect the yield.

Pod Lesions

Blackleg pod lesions are less conspicuous than leaf or stem lesions. They also become speckled with black pycnidia, and pods may shatter prior to harvest. Pod infections also result in infection of the seed.

Life Cycle

The blackleg fungus survives the winter on infected canola stubble. Larger stem pieces can take up to 4 years or longer to break down during a series of dry seasons. Blackleg-infested stubble can continue to produce spores (ascospores) until the stubble is decomposed. On the Canadian Prairies, peak ascospore production has been observed to occur two years after infection. The spores can be carried by air currents for long distances, but most are deposited within 1 to 2 km of the field where they originated. Spores that land on canola plants or susceptible weeds may result in new infections. Once plants become infected with blackleg, additional spores are produced on the leaves, stems and pods in thousands of black, pin-head sized pycnidia (fungal fruiting bodies). These secondary spores spread short distances within a field, mainly by splashing rain, causing additional infections on nearby plants. Hail injury may intensify infection levels.

Long distance spread of the disease occurs through the movement of infected seed. When infected seed is sown, the seedlings that emerge may have cotyledon, leaf or stem infections. Each infected seedling produces spores resulting in spread to many surrounding plants. A seed-lot with a low level of infection could easily result in areas of infection throughout the entire field.

Prevention

Because the virulent strain is not yet widespread in B.C., precautions against introduction of the disease should be taken.

Blackleg seed test

To prevent virulent blackleg from infesting your land you should purchase seed that has been tested for blackleg. A laboratory certificate is issued for all seed lots tested for virulent blackleg and shown to be negative for the disease.

Seed treatment

All seed should be treated with one of the following fungicide seed dressings at recommended rates: Foundation Lite, Gaucho CS FL, Helix, Helix XTra, Prosper FL, or Vitavax RS. Even if a seed lot has tested negative, there could be a few infected seeds. The seed treatment will reduce seed-borne blackleg, as well as provide protection for other problems such as seedling blight and flea beetles. Seed treatment will not protect canola that is planted on blackleg-infested land.

Identification of blackleg

If you see symptoms that resemble blackleg during the growing season, have the disease identified. Samples may be submitted to your local district agrologist, or sent to the provincial Plant Diagnostic Laboratory.

Control

An integrated approach to control of blackleg is the most effective. No single component is likely to succeed. Crop rotation will not be effective if volunteers and weeds are allowed to flourish. Growing resistant varieties does not mean that rotations can be shortened. Fungicides alone are not likely to be successful. Following blackleg control recommendations may also help to control other diseases, such as sclerotinia stem rot and alternaria pod spot.

Crop Rotation

Follow a crop rotation with at least three years between canola crops. Plant non-host crops such as

cereals, grasses, alfalfa, clover and pulses during the rotation. If possible, avoid planting canola adjacent to infested land for at least 2 years. Long rotations should be practiced by all growers to ensure that any disease-carrying stubble has rotted. Even a field that did not have a visible blackleg problem could be carrying a low level of infection, which will quickly build up to damaging levels under short rotations.

Weed control

Control volunteer canola and mustard family weeds during the crop rotation. Volunteers and weed hosts will maintain the disease in the field from year to year if they are allowed to persist. Good weed control in the non-canola years will help to break the disease cycle. Weeds that have been shown to carry virulent blackleg include wild mustard, stinkweed, flixweed, shepherd's purse, and tumbling mustard.

Tillage

Bury canola stubble as deeply as possible in the fall. This will minimize spore production and hasten decomposition. Alternatively, where soil erosion is a problem, incorporate the canola stubble just before planting.

Sanitation

Clean plant debris and seed from machinery before moving from field to field.

Cultivar Resistance

Plant canola cultivars with resistance to blackleg. There are many *B. napus* (Argentine) cultivars with moderate to high levels of resistance, although none are completely immune. Almost all *B. rapa* (Polish) cultivars are susceptible to blackleg. Refer to the BCMAL website at

www.al.gov.bc.ca/cropprot/canolaratings.htm

for cultivar resistance ratings.

Chemical

Foliar application of the fungicides Tilt (propiconazole), Quadris (azoxystrobin) and Bumper 418EC (propiconazole) are registered for control of blackleg during the early stages of growth (2-6 leaf stage). Follow label directions. These fungicides have been shown to cause reduction in disease levels if applied early in the season. Cost of application should be weighed against the potential increase in yield and the current market price of canola. Crops at highest risk will include susceptible varieties grown under short crop rotations in an area with a history of severe blackleg losses.

Brown Girdling Root Rot
(Rhizoctonia solani, Fusarium spp.*)*

Brown girdling root rot is the most serious disease of canola in the B.C. Peace. It is caused primarily by the fungus *Rhizoctonia solani* with secondary infections by *Fusarium* species. The disease may even occur in freshly broken fields and on many soil types. It affects all varieties, although Argentine varieties are more resistant. Infection levels may reach 80 to 100% in some fields, with losses approaching 50%. Average losses over the whole Peace district are estimated to be in the range 8-18%. Losses are highest when wet soil conditions occur at early flowering, followed by dry weather later in the season.

Symptoms

Early symptoms consist of light-brown lesions on the taproot or main lateral roots well below the soil line. These enlarge and coalesce, become sunken and girdle the taproot. Only a short taproot stub may be left. Plants ripen prematurely in the field, often before any seed has been set. Girdled plants are subject to death from desiccation or uprooting by wind.

Control

Cultural

Shallow seeding reduces root rot. Optimal soil fertility, including balanced levels of phosphorus, potassium and nitrogen will help to minimize yield losses. Rotate with cereals for three to four years and control weeds of the mustard family and volunteer plants to help prevent a build-up of root pathogens in the soil.

Resistant Cultivars

Polish varieties are generally more susceptible. Use Argentine varieties in suitable climatic regions, as they are only moderately susceptible. Plant breeders are making good progress on the development of Polish varieties with resistance to brown girdling root rot.

Chemical

There is no chemical control available for brown girdling root rot.

Clubroot *(Plasmodiophora brassicae)*

Clubroot is a fungal disease of plants in the cabbage family that causes the roots to be swollen and malformed. It can lead to stunted growth and reduced yields. Clubroot has not been found on canola in the Peace River area. It is currently found in the Edmonton area of Alberta in several crop districts. It also occurs in the B.C. lower mainland in vegetable crops.

Symptoms

Root symptoms include galls ranging from tiny nodules to large, club-shaped growths. Galls are initially white but turn brownish as they mature and decay. Plants infected early in the season may show symptoms of yellowing, stunting and wilting. Plants infected late in the season have milder symptoms but may still ripen prematurely. Yield and quality are reduced.

Disease Cycle

Club root resting spores can overwinter in the soil for up to 20 years. In the spring the resting spores germinate in the presence of the crop, producing swimming zoospores that can infect canola root hairs. The pathogen forms plasmodia inside the roots, which produced secondary zoospores and eventually new resting spores that are released back into the soil when the root galls decay. Club root is favoured by warm soil and high soil moisture, as well as acid soils (pH under 6.5).

Control

Prevention

Since clubroot is not currently a problem in B.C. canola producing areas, precautions should be taken to prevent introducing the disease. Practice long crop rotations with non-susceptible crops, and good control of volunteers and cruciferous weeds Clean soil and debris from any equipment brought in from potentially infested areas before entering fields. Avoid the use of straw and manure from infested or suspicious areas. Use certified seed from reliable sources.

Scout canola fields regularly. Identify causes of wilting, stunting, yellowing and premature ripening. If clubroot is suspected, submit a sample to the Plant Diagnostic Laboratory.

Disease Management

Management of clubroot, once introduced, is very difficult. Crop rotations with at least 4 years between canola or mustard crops in slightly infested fields and 7 years in severely infested fields are recommended in Alberta. There are no chemical controls available.

Damping-Off & Seedling Blight *(Rhizoctonia solani, Fusarium* spp.*, Pythium* spp.*)*

Symptoms

Seedling blight, also known as damping-off, is a common problem both before and after emergence. Seed decays in the soil and fails to emerge or seedlings shrivel and die shortly after emergence. Stems appear water-soaked or constricted at or below the soil line. The result may be a reduction in plant density, or bare patches in the field.

Control

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 °C. Avoid low, wet areas. Rotate with non-cruciferous crops and control volunteers and mustard family weeds (e.g. shepherd's-purse, wild mustard, stinkweed) during the rotation. Fertilizer placed with the seed may delay and reduce emergence. Current seeding rates compensate for the fact that 30 to 70 percent of viable seeds damp-off during "normal" stand establishment.

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.

Best yields are correlated with rapid, vigorous establishment, warmer soils and adequate soil moisture. Soil type, slope, aspect and moisture content influence soil temperature, and therefore also influence the optimum seeding date. In an average season in the Peace River area, best yields come from seeding during the last third of May for Polish varieties and 10-14 days earlier for Argentine types.

Chemical

Use one of the following fungicide seed treatments: Foundation Lite, Gaucho CS FL, Helix, Helix XTra, Maxim 480FS, Prosper FL, or Vitavax RS according to label instructions, or purchase pre-treated seed. As flea beetle control may be required for canola and mustard seedlings, many seed treatments registered are dual purpose.

Fusarium Wilt *(Fusarium oxysporum, F. avenaceum)*

Fusarium wilt is a recently discovered fungal disease that was affecting canola in northern Alberta. Infected fields have also been observed in Saskatchewan and Manitoba. Reports show that losses ranged from neglible to almost 100% in susceptible varieties.

Symptoms

Symptoms are similar to drought stress and include stunting, premature death and poor seed set. Purple, grey or brown streaks may be seen on the lower stem and also in the vascular tissue inside the stem. Fusarium wilt symptoms may appear on only one side of the plant or only a few branches.

Disease Cycle

Fusarium wilt infects plants through the roots and plugs their vascular system, limiting the flow of water and nutrients up the stem. *Fusarium oxysporum* is able to survive for many years in the soil, while *Fusarium avenaceum* is commonly found in soils and is also able to survive on plant debris. The exact conditions that favour infection are not yet known, but warm dry conditions may make symptoms and yield loss more severe.

Control

Crop rotation with non-host crops such as cereals may reduce inoculum levels. Some canola cultivars are less susceptible than others. The incidence of fusarium wilt in Alberta was noted to be much lower in 2004 than in 1999-2003, most likely due to the removal of susceptible cultivars from the market.

Sclerotinia Stem Rot *(Sclerotinia sclerotiorum)*

Sclerotinia stem rot (also known as white mold) attacks numerous species of broadleaf plants, including canola, peas, beans, sunflowers, sweetclover and many broadleaved weeds. Cereals and grasses are immune. It spreads very rapidly in warm humid weather and can cause heavy losses if infection occurs during flowering. Yield losses in canola are generally considered to be proportional to the percentage infection in a field, with yield loss roughly one-half the disease incidence. For example, if a field has 20% infection (20/100 infected plants), then the yield loss will be about 10%. Sclerotinia can also cause heavy losses in wet swaths.

Sclerotinia produces large numbers of sclerotia (fungal "seeds" - pictured below) in plant tissue. Sclerotia can also contaminate the seed at harvest. Grading standards for sclerotinia in canola allow up to 0.05% sclerotia by weight for No. 1 Canada, up to 0.1% for No. 2 Canada, and 0.15% for No. 3 Canada. Samples with over 0.15% will be graded "Canola, Sample Canada, Account Admixture".

Symptoms

Early signs of sclerotinia include soft, watery lesions on leaves and stems, often beginning at the point where a flower petal has fallen and stuck onto the plant. Greyish-white lesions continue to expand, and sometimes have a concentric ring pattern. Infected stems (often lower stems) become bleached in appearance, and the outer stem tissues tend to shred. Death of the stem and premature ripening of the tops follow. Plants infected at flowering produce little to no seed. Infections can

occur in all above ground plant parts especially in dense or lodged stands. Splitting the infected stems open reveals a cottony white mold in which hard black fungal structures, known as sclerotia, may be found. Sclerotia may also be found in patches of white mold growing on the outsides of the stems, especially under damp conditions. Sclerotia may be round, elongate or irregular in shape, and vary in size from about 1 mm to 2 cm (3/4 inch) in length.

Life Cycle

Sclerotinia overwinters in the soil and crop residue as sclerotia. Sclerotia can also contaminate seed. Sclerotia are persistent fungal "resting bodies" which can survive for three to five years or more in the soil. Under favourable environmental conditions (including moist soil and moderate temperatures), sclerotia at or near the soil surface germinate in the spring to produce little mushroom-like spore producing structures called apothecia. These are shaped like miniature golf tees, and usually appear about the time that canola starts to bloom, often under the protective canopy of a cereal or canola crop. The apothecia produce air-borne spores (ascospores) that are carried by air currents as far as several kilometers. The ascospores do not directly infect canola plants. Only the spores that land on canola flowers or petals are able to cause infections. When the petals fall, many will adhere to leaves and stems. The spores are then able to use the flower parts as a food source to germinate and infect the plant. Moist conditions lasting for two to three days from rain or dew are also required for infection. Thus dense, vigorous canola stands are more likely to have a sclerotinia problem than thin stands. Once plants are infected, the mold continues to grow into the stem and invade healthy tissue. New sclerotia are formed to carry the disease over to the next season.

Control

Cultural

Allow at least 4 years between susceptible crops. The benefit 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. In severely infected fields, swath in time to reduce losses from shattering.

Plant good quality seed, free of sclerotia. Sclerotia can be removed from seed before planting by using a spiral cleaner.

Resistant Cultivars

Canola cultivars that produce few or no petals show much less infection than cultivars with normal flowers.

Chemical

Rovral (iprodione), Ronilan (vinclozolin), Quadris (azoxystrobin) and Lance (boscalid) are registered for control of sclerotinia on canola in Canada. If a heavy infestation of sclerotinia stem rot is expected, and expected yields are in the 35 to 40 bushel per acre range, a fungicide spray may be applied as per label instructions at 20 to 30% bloom. Because fungicides must be applied before there are any symptoms present in the field, it makes sense to do a risk assessment on your field before deciding whether or not to spray. See Forecasting Sclerotinia, below.

Forecasting Sclerotinia

To decide whether the use of a fungicide is economical, growers should attempt to estimate the disease risk for each canola field. This can be done by using the Sclerotinia stem rot check list

Guidelines for estimating blooms			
	Number of flowers on main stem for:		
Percent Bloom	**10%**	**20%**	**30%**
Polish varieties (*B. campestris*)	6-7	11	15
Argentine varieties (*B. napus*)	10	15	20

provided by the Canola Council in the Canola Growers Manual

www.canola-council.org/sclerotiniaforecast.aspx

and/or by using a petal testing kit.

The petal test kit consists of two parts, each sold separately:

Part 1 includes a manual, videotape and forceps.

Part 2 includes enough culture plates, dishes and disinfectant to test one field.

Using the petal testing kit is not hard. The grower collects canola petals during early bloom, which are placed on a specialized growing media inside culture plates. The cultures are allowed to grow for a few days, then the colonies of fungus are compared against colour pictures in the manual, which help to identify which ones are sclerotinia. If the percentage of infected petals is high enough, then it may be economical to spray. Other factors should also be considered, including potential yield, the market price of canola, the cost of fungicide application, weather conditions and previous disease history. The video discusses these issues, as well as showing how to collect petals, plate them out, and interpret the results.

Petal test kits are available from:

Discovery Seed Labs Ltd.

450 Melville St.

Saskatoon, Saskatchewan S7J 4M2

(306) 249-4484

Place orders by May 15 of the crop year to ensure delivery.

White Rust (Staghead) and Downy Mildew *(Albugo candida, Peronospora parasitica)*

White rust, or staghead tends to be more spectacular than serious, but can be severe, especially in moist seasons on highly susceptible *B. rapa* cultivars. It occasionally infects the whole crop causing yield losses of 10 to 20% or more. *B. napus* (Argentine) cultivars are highly resistant. A new race of staghead that can attack all *B. rapa* cultivars is now the predominant race on the prairies. Downy mildew often occurs in association with white rust. Infection by the two diseases together is usually more damaging than either one alone.

Symptoms

All above ground parts of the plant may be affected. White pustules develop on the undersides of lower leaves, sometimes before heading. Spores from these white pustules infect developing stem and floral tissues causing stem blisters and the distortions of flowers known as "stagheads" due to their spiny appearance. Blisters and stagheads are initially brownish green, and may develop white rust pustules. A fine white cottony mold due to downy mildew may develop on the stagheads that become grey to dark brown or greenish black at maturity. Downy mildew may also appear on the lower surface of leaves.

Disease Cycle

Stagheads are composed largely of persistent resting spores (oospores) of the fungus. At harvest, stagheads or fragments of stagheads are returned to the ground as chaff and contaminate seed. As the crop residue decomposes, the oospores are released in to the soil, where they can persist for many years. In the spring oospores germinate and infect the cotyledons and leaves of young plants, causing whitish pustules on the undersides of leaves. Pustules produce spores that are released into the air and spread the infection to additional plants. There may be several generations of spores in a season. Infections of the inflorescence result in formation of the characteristic stagheads. Downy mildew also persists in the soil as oospores. It is favoured by cool moist conditions.

Control

Cultural

Use seed from a staghead-free field, or clean fragments of staghead from seed. Rotate with non-cruciferous crops. Control volunteers and cruciferous weeds. A rotation of several years may be necessary in a heavily infested field to reduce soil-borne disease levels.

Note: All varieties of Polish type canola are susceptible to the new race of white rust. Stinkweed (*Thlaspi arvense*), marsh yellow cress (*Rorippa islandica*) and wild mustard (*Sinapsis arvensis*) may carry strains of white rust that can infect canola. *Brassica juncea* (mustard) is susceptible to a different race of white rust.

Chemical

None available.

Cereal Diseases

ALL CEREALS

Damping-Off, Seedling Blight *(Cochliobolus sativus, Fusarium* spp.*)*

Symptoms

Symptoms include seed decay, brown lesions on roots and leaves, yellowing, and death of seedlings before or after emergence. The fungi that cause damping-off are common in soils with a history of cereal production, and may also be seed-borne.

Control

- Rotate with non-cereal crops (flax, canola-rapeseed, legumes) to reduce the inoculum levels in the soil.
- Use high quality, disease-free seed.
- Avoid deep seeding, which can increase disease severity.
- Treat seed with a fungicide seed protectant according to label recommendations. See the table on page 56 for more information on registered seed treatments.

Common Root Rot *(Cochliobolus sativus, Fusarium* spp.*)*

Symptoms

Stand fails to grow or yield as well as expected. Plants appear healthy above ground, but the root system is poorly developed and discoloured with brown to black lesions on the subcrown internode. Severely infected plants ripen prematurely. This is a widespread but generally unrecognized disease since most of the symptoms are underground. Yield losses due to common root rot are commonly 7 to 10% annually. The disease tends to be more severe under hot, dry conditions.

Control

- Rotate with non-cereal crops (flax, canola-rapeseed, legumes) to reduce the inoculum levels in the soil.
- Use high quality, disease-free seed.
- Avoid deep seeding, which can increase disease severity.
- Use adequate levels of fertilizer (nitrogen and phosphorus).
- Seed treatment fungicides reduce seedling blight caused by these fungi but do not control root rot in post-seedling plants. However most fungicide seed treatment will help to suppress common root rot, including Baytan 30, Charter, DB-Red, Dividend, Gemini, Raxil and Vitaflo 280.
- Resistant varieties of wheat and barley are available. For more information, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

Ergot *(Claviceps purpurea)*

Rye is most severely damaged by this fungal disease, but wheat, barley, and many grasses especially bromegrass and ryegrass, are also commonly infected. Black ergot bodies (sclerotia) form in the place of some kernels three to four weeks after heading. These ergot bodies are several times the length of normal kernels and are very conspicuous on rye. They may fall to the ground where they overwinter or they may become mixed with the grain at harvest. Ergot is extremely poisonous to man and animals and must be carefully removed from grain that is to be used for flour or animal feed.

Disease Cycle

Ergot sclerotia germinate in the spring to produce apothecia (small mushroom like fruiting bodies) that release ascospores. Ascospores are dispersed by wind and infect cereals or grasses during flowering. Infected florets produce honeydew that contains conidia, which are spread by insects and rain to cause further infections. Ergot is favoured by cool, damp weather at flowering.

Control

- Use clean seed free of ergot or store seed for one year before use.
- Cut grasses bordering grain fields as soon as they head out (before flowering) to prevent the build-up of ergot infection and spread to nearby grain crops.
- Avoid sowing barley, wheat, rye or triticale on land where an ergoty crop was harvested the previous year. Rotate with oats, legumes, oilseeds or forage grasses and cut the latter immediately after heading. Ergots rarely survive more than a year in the soil. Bury crop residue (2.5 cm or more).
- Harvest headland swaths separately since they often have the highest ergot contamination.
- Avoid late application of herbicides that may cause floret sterility, as this will increase susceptibility to ergot.
- Some rye varieties have an intermediate level of resistance to ergot. For more information, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

Barley Yellow Dwarf Virus

Barley yellow dwarf virus (BYDV) is the most common virus disease of cereals in Canada. If affects barley, wheat, oats, rye, corn and many grass species. BYDV is spread by aphids. Epidemics are generally caused by migrations of winged aphids, carried by winds from the United States. The disease is not carried in the seed.

Symptoms

Symptoms of barley yellow dwarf on barley include bright yellow discolouration near the leaf tips, progressing towards the base, leaving a green stripe above the midrib area. On oats, leaf discolouration is reddish. Early infection may result in stunting and a reduction in tillers, as well as reduced vigour and yield.

Control

- Early seeded crops are more likely to escape high disease levels.
- Some barley and oat cultivars have tolerance for BYDV infection.

Fusarium Head Blight (*Fusarium graminearum* & other Fusarium species)

Fusarium head blight is a serious disease of wheat and barley in Eastern Canada, Manitoba and Eastern Saskatchewan. Oat and rye can also be infected, although it has been less serious on these crops. It is not a common problem in British Columbia, but has been observed in the Creston area. Fusarium infection of the heads results in reduced yields, shriveled seeds, and development of fungal toxins (mycotoxins) that are poisonous to livestock and humans.

Symptoms

Symptoms appear as premature bleaching of one or more spikelets in a head, often giving infected heads a mottled green and white appearance. Grain from infected heads is often shriveled and white (tombstone kernels). Under humid conditions a whitish or pinkish mold may be visible on fusarium-infected heads. The fungus overwinters on crop residue. Head blight develops when spores carried by wind or rain splash from crop residue to the heads. The disease is favoured by high rainfall and warm temperatures during flowering.

Prevention

- Plant seed from areas where Fusarium head blight does not occur.
- Fungicide seed treatments may help to control seed-borne and soil-borne diseases caused by Fusarium spp., and may also help to prevent introduction of Fusarium spp. that are not common in B.C. See the table on page 56 for more information on registered seed treatments.
- If Fusarium head blight is suspected, submit samples for confirmation to the BCMAL Plant Diagnostic Laboratory.

Control

- Rotate with non-susceptible crops such as oilseeds or legumes. Avoid seeding cereals into corn stubble, as corn is highly susceptible.
- Turning under crop residues will reduce inoculum levels in the spring.
- Grow resistant cultivars. For more information, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm
- The fungicide tebuconazole (Folicur) is registered for suppression of fusarium head blight in wheat.

BARLEY DISEASES

Covered Smut and False Loose Smut of Barley *(Ustilago hordei, U. nigra)*

Kernels are replaced by black masses of spores which remain covered by a thin membrane until harvest. Spores of covered smut contaminate the grain at harvest.

Control

- Use seed from a smut-free field.
- Apply a fungicide seed treatment registered for covered smut control, or purchase treated seed. See the table on page XX for more information on registered seed treatments.
- Select cultivars with resistance to smut. For more information, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

Loose Smut of Barley *(Ustilago nuda)*

Kernels are replaced by dark-brown spore masses enclosed in a thin, silvery membrane that ruptures, releasing the spores which infect other heads at flowering. The fungus grows into the embryo of the developing seeds, resulting in seed infection. The quality of the grain is not visibly affected, since spores are dispersed early in the season.

Control

- Use smut-free seed.
- Apply a systemic fungicide seed treatment registered for loose smut control, or purchase treated seed. Seed treatments that control loose smut include Baytan, Charter, Gemini, Raxil, Vitaflo-220 and Vitaflo-280. See the table on page 56 for more information on seed treatment products.
- Most barley cultivars are susceptible to loose smut. For more information please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

Net Blotch of Barley *(Pyrenophora teres)*

Net blotch is a common fungal disease of the leaves, sheaths and glumes of barley. It appears at anytime from spring onward in association with damp weather.

Symptoms

Leaf blotches are yellowish at first, rapidly turning dark brown. They develop parallel to the veins and therefore appear linear. Between infected brown veins, a characteristic net of crossed lines develops at first but soon becomes solid brown. Lesions coalesce to give characteristic dark brown stripes. There is also a spot producing form of this fungus that produces dark brown spots with yellow margins. Yield reductions are most severe when the top two leaves are affected.

Disease Cycle

The fungus overwinters on crop debris, and in the seed. In the spring, spores are produced on crop residue, which are spread by wind and rain. Direct infection of seedlings from infected seed may also occur. Spores are produced on infected plants causing further spread and intensification of the disease during the growing season.

Control

- Crop rotation is the most effective disease management practice. Allow 2 years between barley crops.
- Incorporating barley crop residue into the soil may help to reduce disease build up, but it is less effective than crop rotation.
- Use disease-free seed.
- Seed treatment with Vitaflo-280, Vitaflo-220 or Baytan according to label directions reduces the chance of introducing new races of the disease into an area and may reduce infection of seedlings.
- Use resistant cultivars where net blotch is a problem. For more information on resistant varieties, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm
- Foliar fungicide treatments are an option to protect plants from net blotch infection as well as other foliar diseases. Apply 1 to 2 sprays of propiconazole (Bumper 418EC, Pivot 418EC, Tilt 250E), pyraclostrobin (Headline EC) or propiconazole + trifloxystrobin (Stratego 250EC) according to label directions. Foliar fungicides are more likely to be economic on high value, high yielding crops where severe disease problems are anticipated. See the table on page 53 for more information on fungicide products.

Scald of Barley

This fungal disease commonly infects barley and can also affect rye, bromegrass and quackgrass.

Symptoms

Scald lesions appear as light grey or tan, oval leaf spots with a dark brown border. Spots can be so numerous that leaves are killed. Yield reductions are most severe when the top two leaves are affected.

Disease Cycle

The fungus overwinters on crop debris. In the spring, spores are produced on crop residue that are spread by wind and rain. Spores are also produced on infected plants causing further spread and intensification of the disease during the growing season. Scald is favoured by cool, wet weather.

Control

- Crop rotation is the most effective disease management practice. Do not plant barley two or more years in succession on the same location. Rotate with crops other than barley and bromegrass.
- Incorporating barley crop residue into the soil may help to reduce disease build up, but it is less effective than crop rotation.
- Use resistant cultivars where scald is a problem. For more information on disease resistant varieties, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm
- Baytan seed treatment will provide some suppression of scald.
- Foliar fungicide treatments are an option to protect plants from scald infection as well as other foliar diseases. Apply 1 to 2 sprays of propiconazole (Bumper 418EC, Pivot 418EC, Tilt 250E), pyraclostrobin (Headline EC) or propiconazole + trifloxystrobin (Stratego 250EC) according to label directions. Foliar fungicides are more likely to be economic on high value, high yielding crops where severe disease problems are anticipated. See the table on page 53 for more information on fungicide products.

Rust *(Puccinia graminis* f. sp*. tritici,* and f. sp. *secalis; P. striiformis* f. sp*. tritici)*

Cereal rusts are rare in the Peace River region, but may occur in other parts of British Columbia. Wheat and rye stem rusts are occasionally problems on barley.

Symptoms

Symptoms include orange to red coloured pustules on stems and leaves. Pustules contain spores that can be brushed off onto hands or clothing as a

dusty red powder. Pustules turn black as the crop matures. Stripe rust is also an occasional problem in Southern B.C. See wheat stem rust and wheat stripe rust sections for more information.

Control

- Grow cultivars with resistance to stem rust. For more information on resistant varieties, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

- Foliar fungicide treatments are an option to protect plants from rust infection as well as other foliar diseases. Apply propiconazole (Bumper 418EC, Pivot 418EC, Tilt 250E) or pyraclostrobin (Headline EC) according to label directions. Foliar fungicides are more likely to be economic on high value, high yielding crops where severe disease problems are anticipated. See the table on page 53 for more information on fungicide products.

WHEAT DISEASES

Common Bunt or Stinking Smut of Wheat *(Tilletia tritici, T. laevis)*

Kernels are replaced by "smut balls" that have a strong fishy odour. Spring wheat is infected only by smut spores adhering to the kernel, while winter wheat may also be infected by spores in or on the soil released from nearby infected crops of spring wheat. Bunt is difficult to detect in the field, unlike other smuts, but becomes evident during combining when the spores contaminate the grain.

Control

- Grow highly resistant varieties. For more information on resistant varieties, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

- Treat seed of moderately resistant or susceptible varieties with Baytan, Charter, DB-Red L, Dividend XL, Gemini, Raxil, Vitaflo-220 or Vitaflo-280 seed treatments.

Dwarf Bunt of Winter Wheat *(Tilletia controversa)*

Dwarf bunt is similar in appearance to common bunt, but also causes plants to become distinctly stunted in comparison to healthy plants. Dwarf bunt affects only winter wheat, and can survive in the soil for 10 or more years. Dwarf bunt occurs only in the Armstrong/Enderby/Kamloops area and the Creston Valley in B.C.

NOTE: Dwarf bunt is a disease of quarantine concern. There are movement restrictions on seed, grain, and straw of cereal crops originating from dwarf bunt-infested areas. Contact the Canadian Food Inspection Agency for further details.

Control

Dwarf bunt is more difficult to control than common bunt due to its long persistence in the soil and a lack of resistant cultivars. The only seed treatment effective against soil-borne dwarf bunt is Dividend (difenconazole). All winter wheat seed planted in infested areas should be treated with Dividend.

Loose Smut of Wheat *(Ustilago tritici)*

At the time of heading, black, dusty, diseased heads emerge from the boot. The heads shatter and the spores infect healthy heads at flowering. The fungus grows into the embryo of the developing seeds, resulting in seed infection. The quality of the grain is not visibly affected, since spores are dispersed early in the season.

Control

- Sow seed from a field free of loose smut.
- Apply a systemic fungicide seed treatment registered for loose smut control, or purchase treated seed. Seed treatments that control loose smut include Baytan, Charter, Dividend, Gemini, Raxil, Vitaflo-220 and Vitaflo-280. See the table on page 56 for more information on seed treatment products.
- Plant varieties with resistance to loose smut. For more information please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

Powdery Mildew *(Blumeria graminis* f. sp. *tritici)*

Symptoms

Under warm, humid conditions the surface of leaves, stems and occasionally heads develop a white, grey or buff-coloured powdery cushion of fungal growth. Severely infected leaves turn yellow, brown then die. The fungus overwinters on wheat stubble and straw, and on winter wheat. This disease tends to be more of a problem on winter wheat, which can infect adjacent fields of spring wheat.

Control

- Avoid excessive nitrogen applications. Improving air circulation by reducing seeding rates and stand density reduces damage. Soft red winter wheats are generally resistant.
- Baytan seed treatment will provide early season control of powdery mildew in spring and winter wheat.
- Foliar fungicide treatments are an option to protect plants from powdery mildew infection as well as other foliar diseases. Apply tebuconazole (Folicur), propiconazole (Bumper 418EC, Pivot 418EC, Tilt 250E), pyraclostrobin (Headline EC) or propiconazole + trifloxystrobin (Stratego 250EC) according to label directions. Foliar fungicides are more likely to be economic on high value, high yielding crops where severe disease problems are anticipated. See the table on page 53 for more information on fungicide products.

Septoria Leaf and Glume Blotch *(Septoria tritici, Stagonospora nodorum, S. Avenae)*

Symptoms

Septoria leaf blotch symptoms include brown leaf spots that may expand to form elongated dark blotches. Leaf lesions have tiny dark specks (pycnidia). These are the fruiting structures of the fungus. Glume blotch starts as greyish tips on the glumes. Under severe disease pressure cultivars suffer severe kernel shrinkage and weight loss. The fungus can overwinter on seed, crop residue, and on winter wheat. Wet weather favours disease development and spread.

Control

- Rotate with non-cereal crops.
- Disease levels have been shown to be lower with reduced tillage than with conventional tillage.
- Resistant cultivars are not available, however cultivars differ in their resistance level to septoria.
- Foliar fungicide treatments are an option to protect plants from septoria diseases. See the table on page XX for more information on fungicide products.

Wheat Stem Rust *(Puccinia graminis* f. sp. *tritici)*

Cereal rusts are rare in the Peace River region, but may occur in other parts of British Columbia. Stem rust is known as the most destructive disease of wheat worldwide.

Symptoms

Symptoms include brick red pustules on stems and leaves. The pustules become black and powdery as the crop reaches maturity. Wheat stem rust also attacks barley.

Disease Cycle

Stem rust does not normally overwinter in Canada, unless barberry is present in a wheat-producing area. The disease overwinters in Mexico and the Southern United States, and spreads north via wind-borne spores every summer. The amount of stem rust developing in Canada is related to the timing and severity of the epidemic as it moves up the continent. Stem rust has an alternate host, barberry (Berberis spp.), which is present to some extent in Southern B.C. Teliospores produced on infected wheat in the fall can germinate to produce basidiospores in the spring, which can only infect barberry leaves (Berberis spp.). Aeciospores produced on barberry can then infect wheat. The presence of barberry in a wheat producing area can allow overwintering, earlier onset of epidemics, and more potential for yield losses. It also allows the fungus to complete its life cycle resulting in potentially new virulent strains. Barberry threatens the production of wheat, oats, rye, barley and various grasses in Canada. Susceptible barberry species are prohibited and may not be imported or transported within Canada. All bushes found should be eradicated.

Control

- Most hard red spring wheats have good resistance to stem rust, while most soft white and winter wheats do not. For more information on resistant varieties, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

- Foliar fungicide treatments are an option to protect plants from rust infection as well as other foliar diseases. Apply tebuconazole (Folicur), propiconazole (Bumper 418EC, Pivot 418EC, Tilt 250E) or propiconazole + trifloxystrobin (Stratego 250EC) according to label directions. Foliar fungicides are more likely to be economic on high value, high yielding crops where severe disease problems are anticipated. See the table on page 53 for more information on fungicide products.

Wheat Leaf Rust *(Puccinia triticina)*

Cereal rusts are rare in the Peace River region, but may occur in other parts of British Columbia. Wheat leaf rust appears as orange to yellow pustules on leaves and leaf sheaths. Pustules darken as the crop reaches maturity.

Disease Cycle

Wheat leaf rust also overwinters in the southern United States and Mexico, and spreads northward via wind-borne spores.

Control

- Resistant varieties are the best method of control. Please refer to the publication Disease resistance ratings of field crops grown in British Columbia at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

- Several fungicides are registered for control of leaf rust. See the table on page 53 for more information on fungicide products.

Stripe Rust *(Puccinia striiformis* f. sp. *tritici)*

Stripe rust is less common than leaf rust, but can be damaging on winter wheat and soft white spring wheat in Southern B.C. Stripe rust usually does not overwinter in B.C., although small amounts may survive mild winters. The rust usually blows in on southerly winds from Oregon where it overwinters on native grasses and winter wheat crops. This rust has no alternate host.

Symptoms

Symptoms appear as elongated, yellow pustules on leaves with stripe-like appearance.

Control

- Resistant varieties are available for soft white and common wheats. Please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm

- Several fungicides are registered for control of stripe rust. See the table on page 53 for more information on fungicide products.

Snow Molds of Fall Rye and Winter Wheat

After snowmelt in the spring, patches and occasionally whole fields appear dead, even with cold-hardy varieties. Partial recovery from sub-surface tillers may occur. Vigorous plants may lose only a few outer leaves. Cottony mold growth or small black fungal bodies, resembling mouse droppings, may be found inside dead leaves near their bases. In the Peace River snow mold losses are caused by a number of fungi. Of prime concern are cottony snow mold (low temperature basidiomycete), snow scald (Myrosclerotinia borealis) and grey snow mold (Typhula) spp. Whole fields may be killed in winters with prolonged snow cover.

Control

- Rotate winter cereals with 3 years of annual crops to reduce snow mold damage.
- Avoid growing winter grains in fields where snow tends to build up and remains in early spring.
- Avoid growing winter grains in fields immediately after grass sod breaking.
- Varieties of fall rye recommended for the Peace River region are very cold tolerant but only moderately tolerant to snow mold.

Loose and Covered Smuts of Oats *(Ustilago avenae, U. kolleri)*

Grain and much of the chaff is replaced by a powdery, black mass of smut spores.

Control

- Use seed from fields free of smut diseases.
- Resistant varieties are available. For more information please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm
- Apply a systemic fungicide seed treatment, or purchase treated seed. Seed treatments that control both loose and covered smut of oats include Charter, Dividend, Gemini, Raxil, Vitaflo-220 and Vitaflo-280. See the table on page 56 for more information on seed treatment products.

Rust Disease of Oats *(Puccinia coronata, Puccinia graminis* f. sp. *avenae)*

Oats are attacked by both stem rust and crown (leaf) rust. Stem rust overwinters on barberry (see wheat stem rust) and crown rust overwinters on European buckthorn (Rhamnus species).

Control

- Seeding early will usually decrease the level of rust damage.
- Eradication of European buckthorn near farm fields is important in the Kootenays.
- Grow resistant cultivars. For more information, please refer to the publication *Disease resistance ratings of field crops grown in British Columbia* at

  www.al.gov.bc.ca/cropprot/cerealratings.htm
- The fungicides propiconazole (Bumper, Pivot, Tilt) and propiconazole + trifloxystrobin (Stratego) are registered for control of crown rust on oats. See the table on page 53 for more information on fungicide products.

Corn Diseases

Seed Rot and Seedling Blight *(Fusarium* spp.*, Rhizoctonia solani, Pythium* spp.*)*

Seed rot and seedling blight, or damping-off is favoured by cool, wet soils, deep seeding and other conditions that delay crop emergence.

Symptoms

Symptoms include poor stand establishment, uneven emergence, yellowing or browning of lower leaves, and root decay.

Control

- Plant high quality seed after the soil has warmed up to 14 °C or higher.
- Use a fungicide seed treatment. Seed treatment is an inexpensive insurance against crop failure. Seed treatments for corn include azoxystrobin (Dynasty), captan (Agrox, Captan Flowable), carbathiin + thiram (Vitaflo-280, Vitaflo-220), difenoconazole + metalaxyl (Dividend), fludioxonil (Maxim), metalaxyl (Apron, Allegiance) and thiram (Thiram 75). Additional treatment of the seed with insecticides may be helpful to give some protection against wireworms and seed maggots. Combinations of diazinon-captan (Agrox) seed treatment formulations are available for this purpose, as well as seed treatments containing thiamethoxam (Cruiser). Apply according to label directions, or purchase pre-treated corn seed. See the table on page 56 for more information on registered seed treatments.

Head and Common Smut *(Ustilago zeae, Sporisorium holci-sorghi)*

Two smut diseases occur on sweet and field corn. Common smut is more widespread while head smut occurs mainly on sweet corn in the Interior. The first symptoms of head smut are swellings on the tassels and ears that are covered with a papery membrane.

Eventually the interior of these galls turns into a mass of black spores that fall to the ground to infect subsequent corn crops. Common smut galls may appear on stems and leaves as well as ears and tassels.

Life Cycle

Common smut spores overwinter on crop residue and can survive in soil for several years. Initial infections occur from wind- or water-borne spores in the spring. Spores produced in galls can spread to cause further infection during the summer. Stress or injuries from herbicides, drought, hail, blowing sand or cultivation and high rates of nitrogen can increase common smut.

Head smut spores can survive in the soil for up to 10 years, and can spread by wind, contaminated machinery, and in manure. Seedlings are infected as they emerge from the soil under warm and dry conditions. The fungus grows internally in the plant as it develops and forms galls in the ears and tassels.

Control

1. Common Smut

- Follow a two-year minimum crop rotation.
- Avoid injuring plants during cultivation.
- Maintain balanced soil fertility; particularly avoid excessive nitrogen.
- Where practical, remove and destroy infected plants or plant parts as soon as possible after detection.
- Most field corn hybrids have adequate resistance to common smut.
- Seed treatment does not control common smut.

2. Head Smut

- Grow hybrids with resistance to head smut where the disease is a problem. Forage corn varieties generally show good tolerance to head smut.
- Where practical, remove and destroy infected plants as soon as possible to help prevent inoculum from building up in the soil.
- Harvest infected fields last and clean equipment thoroughly before entering a clean field.
- Treat seed with carbathiin + thiram (Vitaflo 220) to control seed-borne infection. Seed treatment will not control soil borne inoculum of smut. See the table on page 56 for more information on registered seed treatments.

Pea Diseases

Powdery Mildew *(Erysiphe pisi)*

Powdery mildew is the most common and widespread foliar disease of pea. It is more severe on late seeded or late maturing crops, and can cause significant yield reductions.

Symptoms

Symptoms appear as a fine powdery growth on the leaves, stems and pods. Brown to black fruiting bodies form on the leaf surface towards the end of the season.

Control

- Grow cultivars with resistance to powdery mildew.
- Early seeding and late maturing cultivars can reduce disease pressure.
- Rotate with non-legume crops.
- Foliar fungicide treatments are an option to protect plants from powdery mildew as well as other foliar diseases. Registered products include pyraclostrobin (Headline EC), sulphur (Kumulus DF), azoxystrobin (Quadris) or propiconazole (Tilt). See the table on page 53 for more information on fungicide products.

Seedling Blight, Root Rot and Wilt

A complex of fungi cause symptoms including poor emergence, seed rot, root and stem base decay and stunting. Fusarium wilt has been increasing in prevalence in Western Canada.

Symptoms

Plants turn yellow and wilt during the flowering to pod-filling stages, and eventually turn brown and die. An orange to red discolouration may be seen in the vascular tissue of the root and lower stem.

Control

- Practice a 4 to 5 year crop rotation with non-legumes to reduce the amount of disease in the soil.
- Treat seed with a fungicide seed dressing to protect against damping-off and seed decay. See the table on page 56 for more information on registered seed treatments.

Forage Legume Diseases

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Bacterial Wilt *(Clavibacter michiganensis* subsp. *insidiosus)*

This wilt disease is no longer common due to the widespread use of resistant cultivars.

Symptoms

Symptoms include stunting and yellowing with cup-like curling of leaflets. A yellow to brown ring forms just under the bark of the taproot. Yield and stand longevity are reduced in susceptible cultivars.

Control

- Plant cultivars with resistance to bacterial wilt. Most cultivars with verticillium wilt resistance also have resistance to bacterial wilt.
- Rotate with non-legumes.
- Clean and disinfect mowers when moving from a diseased to a healthy field. Harvest young stands before old ones. Avoid cutting when plants are wet.

Fungal Leaf Spots *(Phoma medicaginis, Leptotrochila medicaginis, Pseudopeziza medicaginis, Leptosphaerulina trifolii)*

There are several fungal diseases that commonly cause spotting of leaves and stems of alfalfa, including spring black stem, yellow leaf blotch, common leaf spot, and lepto leaf spot.

Symptoms

Symptoms include brown to black spots on lower leaves, sometimes spreading to the whole plant, girdling and death of older stems, and defoliation. Infection of flower stalks and seed pods can lead to reduced seed yields. In severe cases most of the lower leaves drop prematurely resulting in reduced hay quality. Disease development is favoured by cool, wet weather. The fungal pathogens overwinter on crop debris. Spring black stem can also survive in crown tissues and seed.

Control

- Early cutting will reduce leaf loss – harvest before defoliation becomes severe.
- Spring burning reduces overwintered inoculum, but may injure stand if growth has already begun.
- Rotate with non-legume crops.
- Turn under infected crop debris and destroy volunteer plants in waste areas.
- Thiram used as a seed treatment for the control of seed decay and seedling blight may reduce black stem in the early years of a stand.

Damping-Off *(Aphanomyces euteiches, Rhizoctonia solani, Fusarium* spp.*, Pythium* spp.*)*

Seeds decay in soil or seedlings wilt and die, resulting in poor stand establishment.

Control

- Treat seed with thiram seed protectants or purchase treated seed. See the table on page 56 for more information on registered seed treatments.
- Avoid heavy irrigation prior to three to four-leaf stage.

Crown Rot Complex *(Phoma medicaginis, Rhizoctonia solani, Fusarium* spp., low temperature basidiomycete*)*

Crown rot is a disease complex that reduces stand longevity. Damage often becomes apparent as irregular patches of dead and unthrifty plants when the snow melts in the spring. This is a complex of winter and summer crown rots, which may be present in various combinations or singly. Damage can be increased by stresses on the crop such as frost, poor drainage, low fertility and frequent harvesting or grazing.

Summer crown rot pathogens grow into the crown from infected crown buds and stems, or following injury caused by freezing, insect damage or harvesting. Crown bud rot first appears as a brown spotting of the crown buds in the spring of the

second or third year. Later the rot extends into the crowns, the stand thins out, and weeds move in.

Snow mold or winter crown kill is a problem in areas with prolonged snow cover. Plants that appear sound in the fall are completely killed in the crown area by the following spring.

Control

- Avoid late cutting and overgrazing.
- Avoid tillage operations that damage the crown.
- Maintain good nutritional status by proper fertilization.
- Use varieties with recommended resistance to cold, bacterial wilt and alfalfa stem nematode.
- Rotate with cereals or grasses for at least two years before re-seeding with alfalfa. A three to four year rotation with annual crops may be necessary for minimize the impact of winter crown rot caused by snow mold.

Downy Mildew *(Peronospora trifoliorum)*

This disease is a widespread disease but seldom causes severe damage.

Symptoms

Infected leaves are twisted and curled and turn light green to yellow. Shoot tops are often dwarfed. A fine, grayish fungal growth can be seen on the underside of leaflets.

Control

- Use resistant cultivars
- Early cutting will reduce leaf loss – harvest before defoliation becomes severe.
- Rotate with non-legume crops.

Stem Nematode *(Ditylenchus dipsaci)*

The stem nematode has been found in the Cariboo and Southern Interior fields.

Symptoms

Symptoms include stunted and swollen crown buds, distorted leaves and shortened internodes. Severely infested plants are stunted. Lightly infested plants have fewer stems. Small white shoots may occur in regrowth after the first cut. In Alberta, significant damage has occurred on irrigated alfalfa in older stands.

Control

- Use resistant cultivars
- Rotate alfalfa with non-host crops such as grains and pulses for 2-3 years.

Verticillium Wilt *(Verticillium albo-atrum)*

Verticillium wilt is a common problem in most alfalfa growing areas in the Southern Interior of British Columbia.

Symptoms

Diseased plants are stunted; leaves turn yellow then brown. The stems remain green and upright but the leaves droop and curl. The alfalfa stand thins quickly and becomes weedy due to death of diseased plants. A few scattered diseased plants appear in the second year with heavier losses in the third year. In some cases yields are reduced so severely that fields are ploughed under after three cropping years. Diseased fields have been identified throughout British Columbia south of a line through Quesnel, Clearwater and Golden, including the lower Fraser Valley and Vancouver Island.

Verticillium wilt overwinters in infected plants, crop residue and seed. The pathogen is spread within and between fields on harvesting equipment. It can also be spread by hay, seed, insects, wind and running water.

Control

- Use of resistant varieties is recommended in infested areas.
- Use disease-free seed or treat seed with thiram to prevent introducing the disease to clean fields. All seed requires inoculation (Rhizobium) plus sticker just prior to planting. Thiram has no harmful effect on Rhizobium inoculum provided seed is sown soon after inoculum is applied.

- Do not feed hay from infested fields on disease free land.
- Harvest healthy fields first. Clean plant debris from harvesting equipment when moving from a diseased field to a healthy field.
- Prevent irrigation water run-off from diseased to healthy fields.
- Control insect vectors such as pea aphid, alfalfa weevil and grasshopper.
- Rotate to non-host crops (e.g. cereals, corn, grasses) for 2-3 years. Prevent growth of volunteer alfalfa plants on the whole field including borders during the rotation.
- Practice farm-wide weed control. Many common weeds including shepherd's-purse, lamb's-quarters, and dandelion are hosts for the fungus. Control of these weeds is important in all crops in the rotation.

CLOVER

Crown Rot Complex

See Alfalfa Crown Rot Complex. The same groups of symptoms are found on clovers although they progress somewhat faster.

Northern Anthracnose *(Aureobasidium caulivorum)*

This disease occurs principally on red clovers.

Symptoms

Stems and leaf stalks are blighted, turn dark brown and become shrunken. Leaves and flower heads are usually bent over, presenting a shepherd's crook appearance, after which they wilt and die, and may subsequently be broken off by wind. Cracking of stems may be pronounced. This disease kills individual plants, but usually occurs only sporadically in a field. It is accentuated by cool, humid weather.

Control

- Use resistant cultivars.
- Rotate with non-legume crops.

Powdery Mildew *(Erysiphe polygoni)*

This disease is common on red clover.

Symptoms

Leaves become covered with a light-grey powdery coating and eventually turn yellow and then brown. The second growth is often severely infected, reducing the quality of forage.

Control

- Resistant cultivars are available.
- Early harvest may reduce yield and quality losses.
- Rotate to non-legume crops to help to reduce disease incidence.

Sooty Blotch *(Cymadothea trifolii)*

This disease is common on alsike and white clover, but also affects red clover. Heavy infections of pastures and/or hay have been associated with sickness and mortality in sheep and horses. It is reputed to be a possible cause of "tryfoliosis", or mouth ulcers. "Mycotic stomatitis" and "non-infectious foot-and-mouth disease" are associated terms. Feet may become sore and swollen. Reproductive disorders, and liver and kidney damage are also involved.

Symptoms

Leaves develop sooty black spots that become so numerous that the leaves shrivel and die. Whole plants may be blighted and whole pastures affected in cool, moist locations. The fungus survives on crop debris.

Control

- Rotate to non-legumes with good control of volunteers for 3 years.
- Spring burning reduces overwintered inoculum, but may injure stand if growth has already begun.
- Move livestock with symptoms promptly to uninfected pastures or hay.

Forage Grass Diseases

CREEPING RED FESCUE

Stem Eyespot or Blackstem *(Didymella festucae)*

Stem eyespot is a fungal disease of creeping red fescue capable of causing considerable yield reduction to seed crops.

Symptoms

Symptoms on flowering culms (stems) vary from solid brown or purple spots through streaks to clear eyespots with dark brown or purple margins and grey-white centres. In heavily infected crops, similar spots also occur on the flower parts and seeds and coalesce to form more or less continuous purplish-black girdling lesions on the stem. Spots on the blades of the leaves are rare.

Control

No effective control is currently available. In the Peace River Region burning is only feasible as part of rejuvenation. If the fire is hot enough to control stem eyespot, there will be no seed crop the following season. In rejuvenating stands apply a hot burn and then plow to completely turn under all plants and all remaining debris as soon after harvest as possible.

Manage the crop to maximize the yield of the first crop because it usually becomes infected too late to cause much yield loss. To do this, seed prior to mid-June at 10 to 12 kg/ha and fertilize in the late fall. Do not use a companion crop. The control of all weeds and volunteer crops early in the season is essential for the success of this management system.

Snow Mold

First-year plants may be killed outright over winter. In older stands individual clumps usually survive but foliage and tillers are killed, especially around the outside of the clump. Small black resting bodies of the fungus responsible may be found, mainly toward the base of dead leaves. Winter destruction of growing points destined to become seed heads represents an absolute, non-recoverable loss of seed. In severely affected fields as much as 80% of the seed production may be lost.

Control

Post-harvest burning destroys the fungus resting bodies (see above under Stem Eyespot for details of this procedure). Follow fertilization recommendations, especially for nitrogen, since vigorous plants are more resistant. Deep plough heavily affected fields to bury the resting fungal bodies, and rotate with non-grass, non-cereal crops.

Brown Stripe *(Cercosporidium graminis)*

This fungal disease affects timothy, bentgrass, meadow foxtail, fescues, orchard grass and bluegrass.

Symptoms

Symptoms start as water-soaked spots that turn gray in the centre with a brown or dark-purple margin. The spots occur between leaf veins and some spots may develop into stripes with golden-yellow, bronze, purple or chocolate margins. Infected leaves eventually wither. The fungus overwinters in leaf and sheath tissue. Although seedlings may be attacked it is usually the older leaves that are more severely infected.

Control

For seed crops, stubble burning where allowed should provide effective control (except for creeping red fescue in the Peace River).

BROMEGRASS

Scald

See Scald of Barley.

Brown Leaf Spot *(Pyrenophora bromi)*

Symptoms

Chocolate-brown spots appear in spring, become oval-elongate, purplish underneath, and develop a yellow halo. As the spots enlarge and join together, the tips of the leaves become yellow and then wither from the tip downwards.

This disease causes a reduction in hay quality and when extensive, yield losses occur. Although this disease is extremely common, it is not usually serious. Humid weather and poor nutrition increase losses. Since it is prevalent on wayside bromegrass, control is difficult; and it is only warranted in severe cases.

Control

- Cultivars with partial resistance are available.
- Post-harvest burning of crop residues is effective provided adjacent infection sources are also treated. However, seed yields can be reduced by burning.
- Apply a recommended fertilizer; the disease is more severe when soil fertility is low.
- Rotate with other crops.

Leaf and Culm Spot *(Pseudoseptoria bromigena)*

Symptoms

In early stages the leaf spots are similar to those of Brown Leaf Spot. Subsequently the spots develop grey centres with small black dots, containing fungus fruiting bodies. The spots are inter-veinal, more linear at maturity than those of brown leaf spot, and the yellow halo is marked only at the narrow ends. Severely infected leaves wither and die from the tip downward. There is a loss of hay quality and, in severe cases, yield losses occur. It is widespread but not usually severe except with prolonged humid weather.

Control

See Brown Leaf Spot.

Snow Mold

Snow mold and winter killing may be so severe that the stand survives only from underground rhizomes. Recovery can be fast but the resulting stand is sparse; large dead patches seldom occur. Since growing points are induced in the same season in which seeds mature, there is no absolute seed loss, but yields can be sharply reduced. In pastures, over-grazing accentuates snow mold killing.

Control

See fescue snow mold.

ORCHARDGRASS

Stripe Rust *(Puccinia striiformis)*

Stripe rust has been a problem on orchardgrass in the Fraser Valley. The fungus does not overwinter in B.C., although small amounts may survive mild winters. The rust usually blows in on southerly winds from the U.S. Pacific Northwest.

Symptoms

Yellow to orange pustules of the rust fungus develop in stripes down the leaves. Later in the season the pustules become a dark brown colour. Leaves wilt and die. Digestibility of forage is reduced.

Control

- Minimize disease severity by fertilizing at the recommended rates using a nitrate fertilizer.
- Early harvest may reduce yield and quality losses.
- Grow resistant cultivars. Seed dealers can provide information on the rust resistance of the varieties they sell.

Cocksfoot Mottle Virus

This virus is present in orchardgrass in the Fraser Valley, causing stand thinning and yield loss, particularly in older stands.

Symptoms

Infected fields have a general yellow appearance. Individual plants turn yellow, then brown from the tops down, and the entire plant may die. Symptoms seem to be most severe in the spring, and infected fields can look healthy in September.

The virus does not survive in the soil, and is not carried in the seed. It is spread between and within fields by harvesting equipment. Some insects (beetles) may also transmit the disease.

Control

- Harvest disease-free fields before infected fields. Harvest young fields before older fields.
- Clean harvesting equipment after cutting an infected field. Sterilizing equipment with bleach is recommended (caution – bleach my cause corrosion).
- Consider Renovating infected, thinning fields.
- Plant varieties with resistance to Cocksfoot mottle. Resistance ratings from most resistant to least resistant are as follows: Prairial, Pizza, DS7, Napier, Justus, Lidacta, Amba, Pro-File, Potomac, ProGress, Benchmark, Rapido, Dactus.

TIMOTHY

Purple Spot *(Cladosporium phlei)*

Symptoms

Symptoms include small, tan leaf spots with a purple border. Severely affected leaves wither and die from the tip downwards. This disease is most severe in prolonged cool, humid weather. It is widespread but only occasionally severe. Impacts include reduction in hay yield and quality, and reduction in yield of seed crops. The disease overwinters on crop residue.

Control

Same as for brown leaf spot of bromegrass. The varieties 'Climax' and 'Bounty' are slightly more resistant than 'Champ'. North American varieties are generally more resistant than those from elsewhere.

Leaf Streak *(Drechslera phlei)*

Symptoms

Symptoms include longitudinal light brown streaks on leaves, often along the margins. Leaves wither and die from the tip downward causing loss of hay quality and, in severe cases, of seed yield.

Control

Same as for brown leaf spot of bromegrass.

Snow mold

Same as for snow mold of bromegrass.

Table 4: Field Crop Foliar Fungicides

The following table summarizes fungicide products available for use in British Columbia on field crops, as of December 2007. Information provided includes the diseases and crops the products are registered for, the pre-harvest interval, the active ingredient and the fungicide resistance group. Rotate products with different group numbers for resistance management purposes. Always refer to the product label for complete use instructions, precautions and limitations. Labels are available on the PMRA website at:

http://pr-rp.pmra-arla.gc.ca/portal/page?_pageid=34,17551&_dad=portal&_schema=PORTAL

Fungicide	Active Ingredients	Crops	Diseases	PHI*	Comments
Bumper 418 EC	propiconazole 418 g/L Group 3 Fungicide	Wheat	Septoria leaf spot, septoria glume blotch, powdery mildew, leaf and stem rust, tan spot; stripe rust	45 days	1-2 applications. Apply at the first sign of disease, usually at the beginning of stem elongation, 2nd application before head is half emerged
		Barley	Net blotch, spot blotch, scald, powdery mildew, septoria leaf spot, leaf and stem rust	45 days	
		Oats	Septoria leaf blotch, crown (leaf) rust	45 days	
		Canola	Blackleg	60 days	Apply during the rosette stage; between 2nd true leaf and bolting
		Corn	Rusts, northern and southern corn leaf blight, helminthosporium leaf spot, eye spot, grey leaf spot	14 days	1-2 applications (field or sweet corn); 1-3 applications (seed corn)
Dithane DG	mancozeb 75% Group M Fungicide	Wheat	Tan spot, septoria leaf blotch, leaf rust	40 days	1-2 applications: apply when the crop is in the 3 leaf to tillering stage, and/or when the head is fully emerged but prior to flowering.
Folicur 432 F	tebuconazole 432 g/L Group 3 Fungicide	Wheat	Suppression of fusarium head blight (scab), control of septoria glume blotch, rusts (leaf, stem and stripe), septoria leaf blotch, tan spot, powdery mildew	36 days	1 application/season. For fusarium head blight or glume blotch, apply when 75% of heads have emerged to when 50% of heads are in flower. For foliar diseases, apply at the first sign of disease.
Headline EC	pyraclostrobin 250 g/L Group 11 Fungicide	Wheat	Leaf rust, tan spot, septoria leaf spot, spot blotch, stripe rust, powdery mildew	Apply no later than the end of flowering	1-2 applications. Apply immediately after flag leaf emergence and repeat 10-14 days later if necessary.
		Barley	Net blotch, spot blotch, stripe rust, scald		
		Rye	Leaf rust, powdery mildew		
		Field Pea	Mycosphaerella blight, powdery mildew, Asian soybean rust	30 days	1-2 applications. Apply at the beginning of flowering or at the onset of symptoms for the more aggressive diseases.
		Corn	Common rust, grey leaf spot	7 days	1-2 applications. Apply prior to disease development and repeat 10-14 days later if necessary.
		Bluegrass, fescue, ryegrass grown for seed	Leaf and stem rust, powdery mildew suppression	14 days	1-2 applications. Apply prior to disease development and repeat 14-21 days later if necessary.
		Alfalfa grown for seed	Common leaf spot (*Pseudopeziza medicaginis*)		1 application/year at 10-30% bloom, or the onset of disease. Do not feed treated alfalfa hay or forage to livestock.

Table 4: Field Crop Foliar Fungicides *Continued*

Kumulus DF	sulphur 80% Group M Fungicide	Peas	Powdery mildew	1 day	Spray at first appearance of disease and repeat at 7-10 day intervals as necessary.
Lance WDG	boscalid 70% Group 7 Fungicide	Canola	Sclerotinia stem rot, alternaria black spot	21 days	1-2 applications. Apply at 20-50% flowering to control sclerotinia stem rot; late flowering to early green pod to control black spot.
		Dry peas	Ascochyta blight, grey mold, mycosphaerella blight	21 days	1-2 applications. Apply at beginning of flowering. Repeat 7-14 days later if necessary.
		Alfalfa grown for seed	Blossom blight (*Sclerotinia sclerotiorum / Botrytis cinerea*), common (*Pseudopeziza*) leaf spot, spring black stem, *Leptosphaerulina* leaf spot	n/a	1-3 applications/season. Apply at 20-50% flowering; repeat at 7-14 day intervals if necessary.
Manzate DF	mancozeb 75% Group M Fungicide	Wheat	Tan spot, septoria leaf blotch, and leaf rust	40 days	1-2 applications: apply when the crop is in the 3 leaf to tillering stage, and/or when the head is fully emerged but prior to flowering.
Penncozeb 75DF	mancozeb 75% Group M Fungicide	Wheat	Tan spot, septoria leaf blotch, leaf rust	40 days	1-2 applications: apply when the crop is in the 3 leaf to tillering stage, and/or when the head is fully emerged but prior to flowering.
Pivot 418 EC	propiconazole 418 g/L Group 3 Fungicide	Wheat	Septoria leaf spot, septoria glume blotch, powdery mildew, leaf and stem rust, tan spot, stripe rust	45 days	1-2 applications. Apply at the first sign of disease, usually at the beginning of stem elongation, 2nd application before head is half emerged
		Barley	Net blotch, spot blotch, scald, powdery mildew, septoria leaf spot, leaf rust, stem rust	45 days	
		Oats	Septoria leaf blotch; crown (leaf) rust	45 days	
		Canola	Blackleg	60 days	Apply during the rosette stage; between 2nd true leaf and bolting
		Corn	Rusts, northern and southern corn leaf blight, helminthosporium leaf spot, eye spot, grey leaf spot	14 days	1-2 applications (field or sweet corn); 1-3 applications (seed corn)
Quadris	azoxystrobin 800 g/kg Group 11 Fungicide	Canola	Blackleg, *Sclerotinia* stem rot, *Alternaria* black spot	30 days	1-2 applications/season. To control blackleg, apply once at the 2- to 6-leaf stage; for sclerotinia stem rot apply at the early bloom stage (prior to 30% bloom); for alternaria black spot apply at the pod stage (90% petal fall).
Quadris Flowable	azoxystrobin 250 g/L Group 11 Fungicide	Canola	Blackleg, *Sclerotinia* stem rot, *Alternaria* black spot	30 days	1-2 applications/season. To control blackleg, apply once at the 2- to 6-leaf stage; for sclerotinia stem rot apply at the early bloom stage (prior to 30% bloom); for alternaria black spot apply at the pod stage (90% petal fall).

Table 4: Field Crop Foliar Fungicides *Continued*

		Dry Peas	Powdery mildew, Asian soybean rust, ascochyta blight, mycosphaerella blight	30 days	1-2 applications/season.
		Corn (seed , field and sweet)	Rust	7 days	1-2 applications. Apply prior to disease development.
Ronilan EG	vinclozolin 50% Group 2 Fungicide	Canola	Sclerotinia stem rot		Apply split treatment at early bloom (20-30%) with a second application 7 days later at late bloom, or a single treatment at 20-50% flower.
Rovral Flo	iprodione 240 g/L Group 2 Fungicide	Canola	Sclerotinia stem rot, alternaria black spot	38 days.	1-2 applications. For Sclerotinia, apply at the 20 - 30% bloom stage, or in a split application at 20% and 50% bloom. For black spot, apply at early green pod stage.
		Alfalfa grown for seed (Peace River area only)	Sclerotinia	38 days	Apply when the crop is in the 20 - 50% bloom stage. Do not feed treated alfalfa to livestock.
Serenade MAX	*Bacillus subtilis* 14.6% Biofungicide	Peas	Botrytis pod rot (suppression)	0 days	Begin applications at the first sign of disease. Repeat as necessary on a 7-10 day interval.
Stratego 250EC	propiconazole 125 g/L + trifloxystrobin125 g/L	Wheat	Septoria leaf blotch, tan spot, powdery mildew, leaf and stem rust, stripe rust	45 days	1-2 applications. Apply at early stages of disease development. Typically, 1 application between tillering and flag leaf emergence is required. A second application may be made if needed.
		Barley	Net blotch, scald, septoria leaf blotch; spot blotch	45 days	
	Groups 3 & 11 Fungicides	Oats	Septoria leaf blotch, crown (leaf) rust	45 days	
Tilt 250E	propiconazole 250 g/L Group 3 Fungicide	Wheat	Septoria leaf spot, septoria glume blotch, powdery mildew, leaf and stem rust, tan spot, stripe rust	45 days	1-2 applications. Apply at the first sign of disease, usually at the beginning of stem elongation, 2nd application before head is half emerged
		Barley	Net blotch, spot blotch, scald, powdery mildew, septoria leaf spot, leaf rust, stem rust	45 days	
		Oats	Septoria leaf blotch, crown (leaf) rust	45 days	
		Canola	Blackleg	60 days	Apply during the rosette stage; between 2nd true leaf and bolting
		Corn	Rusts, northern and southern corn leaf blight, helminthosporium leaf spot, eye spot, grey leaf spot	14 days	1-2 applications (field or sweet corn); 1-3 applications (seed corn)
		Dry Peas	Asian soybean rust (*Phakopsora* spp.), powdery mildew	30 days	1-2 applications

*PHI = pre-harvest interval, or days to harvest. Indicates the minimum number of days between final application and harvest date as specified on the pesticide label.

Table 5: Field Crop Seed Treatments

The following table summarizes the fungicide and insecticide seed treatment products registered in Canada for use on cereals, canola, pulse crops, peas, corn and forage crops, as of December 2007. Always refer to the product label for complete use instructions, precautions and limitations. Labels are available on the PMRA website at:

http://pr-rp.pmra-arla.gc.ca/portal/page?_pageid=34,17551&_dad=portal&_schema=PORTAL

Fungicide and Insecticide Seed Treatments - Canola

Product	Active Ingredients	Crops	Diseases and Pests	Commercial[1]	Group Number[2]
Apron FL or Allegiance FL	metalaxyl 317 g/L	canola	seedling blights and seed rots caused by *Pythium* spp.	C	Group 4 Fungicide
Foundation Lite	iprodione 132 g/L thiram 88 g/L	canola	damping off and root rot caused by *Rhizoctonia solani*, seed borne blackleg and seed borne alternaria black spot		Groups 2 & M Fungicides
Gaucho 480 FL	imidacloprid 480 g/L	canola, rapeseed	flea beetles	C	Group 4 Insecticide
Gaucho CS FL	imidacloprid 285.7 g/L carbathiin 47.6 g/L thiram 95.3 g/L	canola, rapeseed	flea beetle, seed rot, damping off, seedling blight and early season root rot caused by *Pythium, Rhizoctonia* and *Alternaria*, seed-borne blackleg	C	Groups 7 & M Fungicides; Group 4 Insecticide
Helix Liquid Seed Treatment	thiamethoxam 10.3% difenoconazole 1.24% metalaxyl 0.39% fludioxonil 0.13%	canola	early season control of flea beetles (for areas with low to moderate flea beetle pressure), seed-borne blackleg, seed-borne *Alternaria*, and the seedling disease complex caused by *Pythium*, *Fusarium* and *Rhizoctonia* spp.	C	Groups 3, 4 and 12 Fungicides; Group 4 Insecticide.
Helix XTra Seed Treatment	thiamethoxam 20.70% difenoconazole 1.25% metalaxyl 0.39% fludioxonil 0.13%	canola	early season control of flea beetles (for areas with high flea beetle pressure), seed-borne blackleg, seed-borne *Alternaria*, and the seedling disease complex caused by *Pythium*, *Fusarium* and *Rhizoctonia* spp.	C	Groups 3, 4 and 12 Fungicides; Group 4 Insecticide.
Maxim 480FS	fludioxonil 40.3%	canola, rapeseed	seed-borne and soil-borne diseases caused by *Fusarium, Rhizoctonia, Aspergillus* and *Penicillium* spp.	C	Group 12 Fungicide
Prosper FL	clothianidin 120 g/L carbathiin 56 g/L thiram 120 g/L metalaxyl 4 g/L	canola, rapeseed	flea beetles, seed rot, damping off, seedling blight and early season root rot caused by *Pythium, Rhizoctonia, Fusarium*, seed borne *Alternaria* spp., seed borne blackleg.	C	Groups 4, 7, & M Fungicides; Group 4 Insecticide.
Poncho 600 FS or Poncho TM 600	clothianidin 48%	canola, rapeseed	flea beetles	C	Group 4 Insecticide.
Vitavax RS	carbathiin 5.97% thiram 11.94%	canola, rapeseed	seed rot, damping-off, seedling blight and early season root rot caused by *Pythium*, *Rhizoctonia* and *Alternaria*; seed borne blackleg		Groups 7 & M Fungicides

[1] C: For use in commercial seed treatment facilities only.
[2] Fungicide and Insecticide Group Numbers for resistance management.

Fungicide and Insecticide Seed Treatments - Cereals

Product	Active Ingredients	Crops	Diseases and Pests	Commercial[1]	Group Number[2]
Apron FL or Allegiance FL	metalaxyl 317 g/L	wheat, barley, oats, rye	seedling blights and seed rots caused by *Pythium* spp.	C	Group 4 Fungicide
Maxim 480FS	fludioxonil 40.3%	barley, oats, rye, triticale, wheat	seed-borne and soil-borne diseases caused by *Fusarium* spp. (including seedling diseases due to *F. graminearum*) and *Rhizoctonia* spp.	C	Group 12 Fungicide
Vitaflo-280	carbathiin 15.59%	wheat, barley, oats,	BARLEY: false loose, covered and true		Groups 7 &

Table 5: Field Crop Seed Treatments *Continued*

	thiram 13.25%	rye, triticale	loose smut, leaf stripe, suppression of net blotch; WHEAT: loose smut, common bunt. seed-borne dwarf bunt, seed-borne *Septoria*; OATS: loose and covered smut. RYE: stem smut; ALL CEREALS: damping-off, seedling blight and seed decay (*Pythium* spp., *Penicillium* spp., *Fusarium* spp. and *Cochliobolus sativus*); suppression of root rot.		M Fungicides
Baytan 30	triadimenol 317 g/L	wheat, barley	BARLEY: false loose smut, covered smut, true loose smut and leaf stripe, suppression of common root rot, scald and net blotch; SPRING WHEAT: loose smut, common bunt, powdery mildew; WINTER WHEAT: loose smut, common bunt, powdery mildew, suppression of take-all.		Group 3 Fungicide
Charter Seed Treatment	triticonazole 25 g/L	wheat, barley, oats	WHEAT: seed rot and seedling blight caused by *Fusarium* spp., loose smut, common bunt, suppression of fusarium crown and root rot and common root rot; BARLEY: Seed rot and seedling blight caused by *Fusarium* spp., loose smut, covered smut, false loose smut, suppression of fusarium crown and root rot and common root rot; OATS: loose smut, covered smut.		Group 3 Fungicide
Cruiser 5FS Seed Treatment	thiamethoxam 47.6 %	wheat, barley	wireworms	C	Group 4 Insecticide
Cruiser 350FS Seed Treatment	thiamethoxam 29.9%	wheat, barley	wireworms	C	Group 4 Insecticide
DB-Red L	maneb 323 g/L	wheat, barley, oats, rye	WHEAT: common bunt, root rot, and seedling blight (including *Fusarium*); BARLEY: covered smut, false loose smut, root rot, and seedling blight; OATS: covered smut, root rot, and seedling blight; RYE: common bunt, root rot, and seedling blight.		Group M Fungicide
Dividend XL RTA	difenoconazole 3.37 % metalaxyl-M 0.27 %	barley, oats, rye, triticale, wheat	BARLEY: seed-borne *Septoria,* covered smut, false loose smut; OATS: covered smut, loose smut; RYE: seed-borne *Septoria,* common bunt, dwarf bunt; TRITICALE: loose smut; SPRING WHEAT: seed-borne *Septoria*, common bunt, loose smut; WINTER WHEAT: seed-borne *Septoria*, dwarf bunt, common bunt, loose smut; *Septoria* leaf blotch; ALL CEREALS: seedling blight, damping-off and seedling root rot caused by seed- and soil-borne *Fusarium* and soil-borne *Pythium,* suppression of common root rot, *Fusarium* crown & foot rot, and take-all.		Groups 3 & 4 Fungicides
Gemini Seed Treatment	triticonazole 1.25% thiram 12.5%	wheat, barley, oats	WHEAT: seed rot and seedling blight caused by *Fusarium* spp., loose smut, common bunt, *Pythium* damping off, suppression of *Fusarium* crown and root rot, *Cochliobolus* root rot and seedling blight; BARLEY: seed rot and seedling blight caused by *Fusarium* sp., true loose smut, covered smut, false loose smut, *Pythium*		Groups 3 & M Fungicides

Table 5: Field Crop Seed Treatments *Continued*

			damping off, suppression of *Fusarium* crown and root rot, *Cochliobolus* root rot and seedling blight; OATS: loose smut, covered smut.		
Raxil T	tebuconazole 6.7 g/L thiram 222 g/L	wheat, barley, oats	WHEAT: seed borne *Septoria,* common bunt, loose smut, seed rot caused by *Penicillium*, *Aspergillus* and *Alternaria,* suppression of *Fusarium* root rot and *Fusarium* crown rot; BARLEY: false loose and covered smut, loose smut, seed rot caused by *Penicillium*, *Aspergillus* and *Alternaria,* suppression of *Fusarium* root rot and *Fusarium* crown rot; OATS: loose smut; ALL CEREALS: seed rot caused by seed- and soil-borne *Fusarium,* seedling blight caused by seed-borne *Fusarium,* seed rot and seedling blight caused by *Cochliobolus sativus, Pythium* seed rot, suppression of common root rot.		Groups 3 & M Fungicides
Raxil 250 FL Flowable	tebuconazole 6 g/Litre	wheat, barley, oats	WHEAT: loose smut, common bunt, seed rots, seedling blights, suppression of common root rot and fusarium crown rot and root rot; BARLEY: false loose, covered and true loose smuts, barley leaf stripe, seed rots, seedling blight, suppression of fusarium crown rot and root rot; OATS: loose smut.		Group 3 Fungicide
Vitaflo 220	carbathiin 220 g/L thiram 200 g/L	wheat, barley, oats, rye	BARLEY: false loose, covered and true loose smut; suppression of net blotch; WHEAT: loose smut, common bunt; OATS: loose and covered smut; RYE: stem smut; ALL CEREALS: seed-borne seed rots and seedling blights.		Groups 7 & M Fungicides

[1] C: For use in commercial seed treatment facilities only.
[2] Fungicide and Insecticide Group Numbers for resistance management.

Fungicide and Insecticide Seed Treatments – Peas and Corn

Product	Active Ingredients	Crops	Diseases and Pests	Comm-ercial[1]	Group Number[2]
Apron FL or Allegiance FL	metalaxyl 317 g/L	peas, corn	seedling blights and seed rots caused by *Pythium* spp.	C	Group 4 Fungicide
Maxim 480FS	fludioxonil 40.3%	peas, corn	seed-borne and soil-borne diseases caused by *Fusarium* spp. and *Rhizoctonia* spp., seed rot and seedling blight in soybeans caused by seed-borne *Phomopsis* spp., *Aspergillus* and *Penicillium* on corn.	C	Group 12 Fungicide
Poncho 600 FS or Poncho TM 600	clothianidin 48%	corn	flea beetle, corn rootworm, corn flea beetle, cutworm, black, seedcorn maggot, wireworm, white grub	C	Group 4 Insecticide.
Vitaflo-280	carbathiin 15.59% thiram 13.25%	peas, corn	BEANS: early season seed rot, root rot and seedling blight caused by *Rhizoctonia solani*, seedborne anthracnose; PEAS: seed rot and seedling blight caused by *Mycosphaerella* (Ascochyta) *Fusarium* spp.; *Rhizoctonia solani* and *Pythium*. LENTILS: control of seed rot, early season root rot and seedling blight caused by *Botrytis cinerea*, *Fusarium*, *Pythium* spp. and *Rhizoctonia solani;* SOYBEANS: seed rot and seedling blight		Groups 7 & M Fungicides

Table 5: Field Crop Seed Treatments *Continued*

			caused by *Phomopsis* spp., *Rhizoctonia solani* and *Fusarium* spp.; CORN: damping-off, seed decay.		
Agrox B-2	diazinon 11.0% captan 33.5%	corn, peas	seed and root maggots, seed rots, seedling blights, and damping-off diseases		Group 1B Insecticide; Group M Fungicide
Agrox CD	diazinon 15% captan 15%	corn, peas	seed corn maggots and to supplement previous fungicidal treatment for seedling blight and seed rot.		Group 1B Insecticide; Group M Fungicide
Apron Maxx RTA	fludioxonil 0.73% metalaxyl 1.10%	peas (including field peas)	ALL CROPS: Control of seed rot, pre- and post-emergence damping-off caused by *Fusarium, Pythium* and *Rhizoctonia* spp.; PEAS: seed-borne ascochyta blight and foot rot*;* BEANS: anthracnose caused by seed-borne *Colletotrichum* spp.*;* CHICKPEA: Seed-borne ascochyta blight, seed-borne *Botrytis* spp.; LENTIL: Seed-borne ascochyta blight, seed-borne *Botrytis* spp.		Groups 4 & 12 Fungicides
Captan Flowable Seed Treatment	captan 30%	corn, pea,	seed decay, root rot, damping-off and seedling blights.		Group M Fungicide
Cruiser 5FS Seed Treatment	thiamethoxam 47.6 %	corn, peas,	CORN: wireworms, European chafer, seed corn maggot, corn flea beetle; BEAN: potato leafhopper, seed corn maggot, wireworms; PEAS: pea leaf weevil; SOYBEAN: seed corn maggot, bean leaf beetle, wireworms, European chafer, soybean aphid	C	Group 4 Insecticide
Cruiser 350FS Seed Treatment	thiamethoxam 29.9%	corn	CORN: wireworms, European chafer, seed corn maggot, corn flea beetle; BEAN: potato leafhopper, seed corn maggot, wireworms; SOYBEAN: seed corn maggot, bean leaf beetle, wireworms, European chafer, soybean aphid	C	Group 4 Insecticide
Dividend XL RTA®	difenoconazole 3.37 % metalaxyl-M 0.27 %	corn	seedling blight, damping-off and seedling root rot caused by seed- and soil-borne *Fusarium* and soil-borne *Pythium.*		Groups 3 & 4 Fungicides
Dynasty 100FS	azoxystrobin 100 g/L	corn	seed decay, damping-off and seedling blight caused by *Pythium* spp. Seed decay and damping-off caused by *Rhizoctonia*	C	Group 11 Fungicide
Thiram 75WP	thiram 75%	peas, field corn	seed decay, seedling blight and damping-off		Group M Fungicide
Vitaflo 220	carbathiin 220 g/L thiram 200 g/L	corn	damping-off and seed decay, seed borne corn head smut		Groups 7 & M Fungicides

[1] C: For use in commercial seed treatment facilities only.
[2] Fungicide and Insecticide Group Numbers for resistance management.

Fungicide Seed Treatments – Forage Grasses and Forage Legumes

Product	Active Ingredients	Crops	Diseases and Pests	Commercial[1]	Group Number[2]
Apron FL or Allegiance FL	metalaxyl 317 g/L	alfalfa, birdsfoot trefoil, clover, grasses, sainfoin	seedling blights and seed rots caused by *Pythium* spp.	C	Group 4 Fungicide
Maxim 480FS	fludioxonil 40.3%	all pasture and range grasses, grasses grown for hay or silage, alfalfa, clover, sainfoin, trefoil	seed-borne and soil-borne fungi which cause seed decay, damping-off and seedling blights	C	Group 12 Fungicide
Thiram 320 flowable	thiram 32.4%	alfalfa	verticillium wilt		Group M Fungicide
Thiram 75WP	thiram 75%	alfalfa, grasses	verticillium wilt , seed decay, seedling blight and damping-off		Group M Fungicide

[1] C: For use in commercial seed treatment facilities only.
[2] Fungicide and Insecticide Group Numbers for resistance management.