

ROOT ROT IN PEAS AND LENTILS

in Western Canada



Root rot in peas and lentils is caused by a complex of diseases that affect the belowground portion of the developing plant, leading to poor performing pulse crops. The organisms that cause the disease are seed or soil-borne and can infect the plant at any stage. Unfortunately once root rot has set in, there is nothing that can be done. Understanding the disease, identifying the risks for root rot infection, and thorough planning for prevention are the only current options.

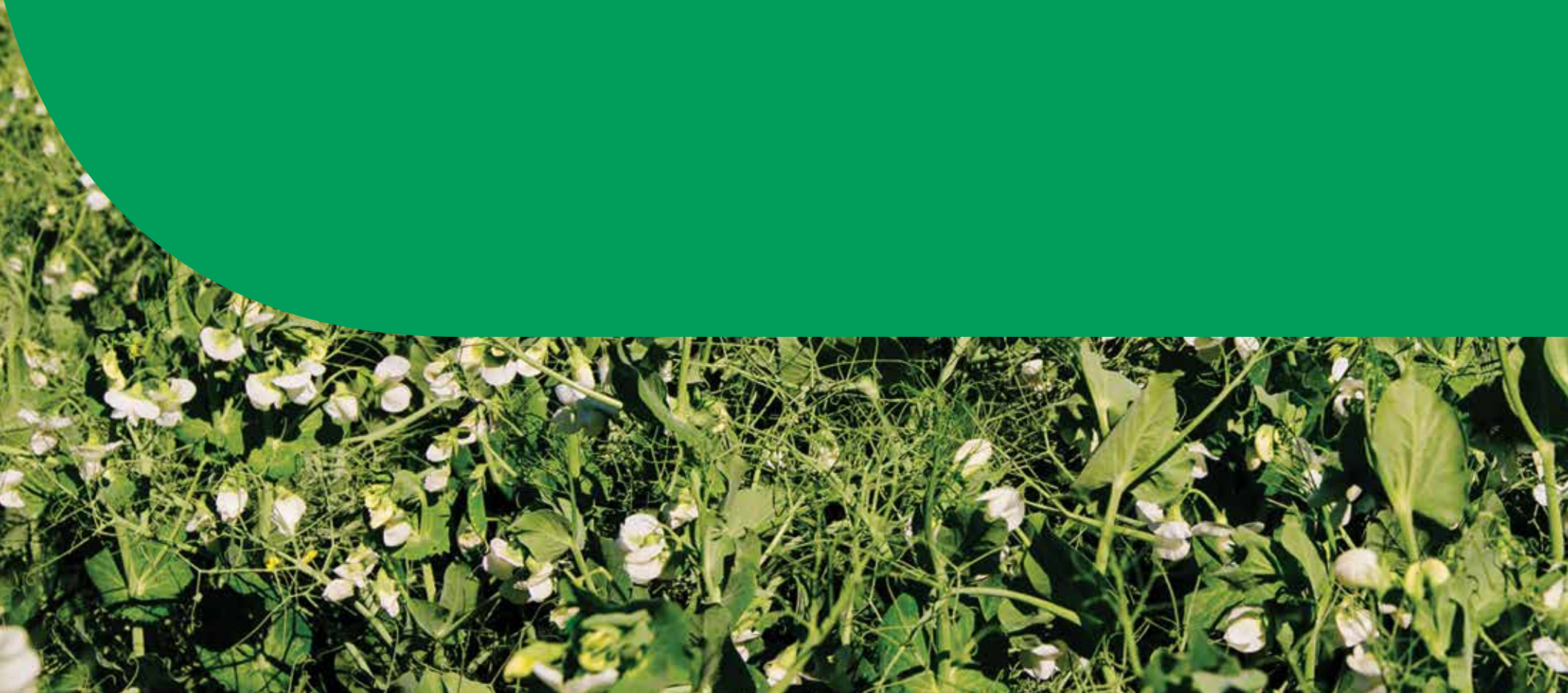
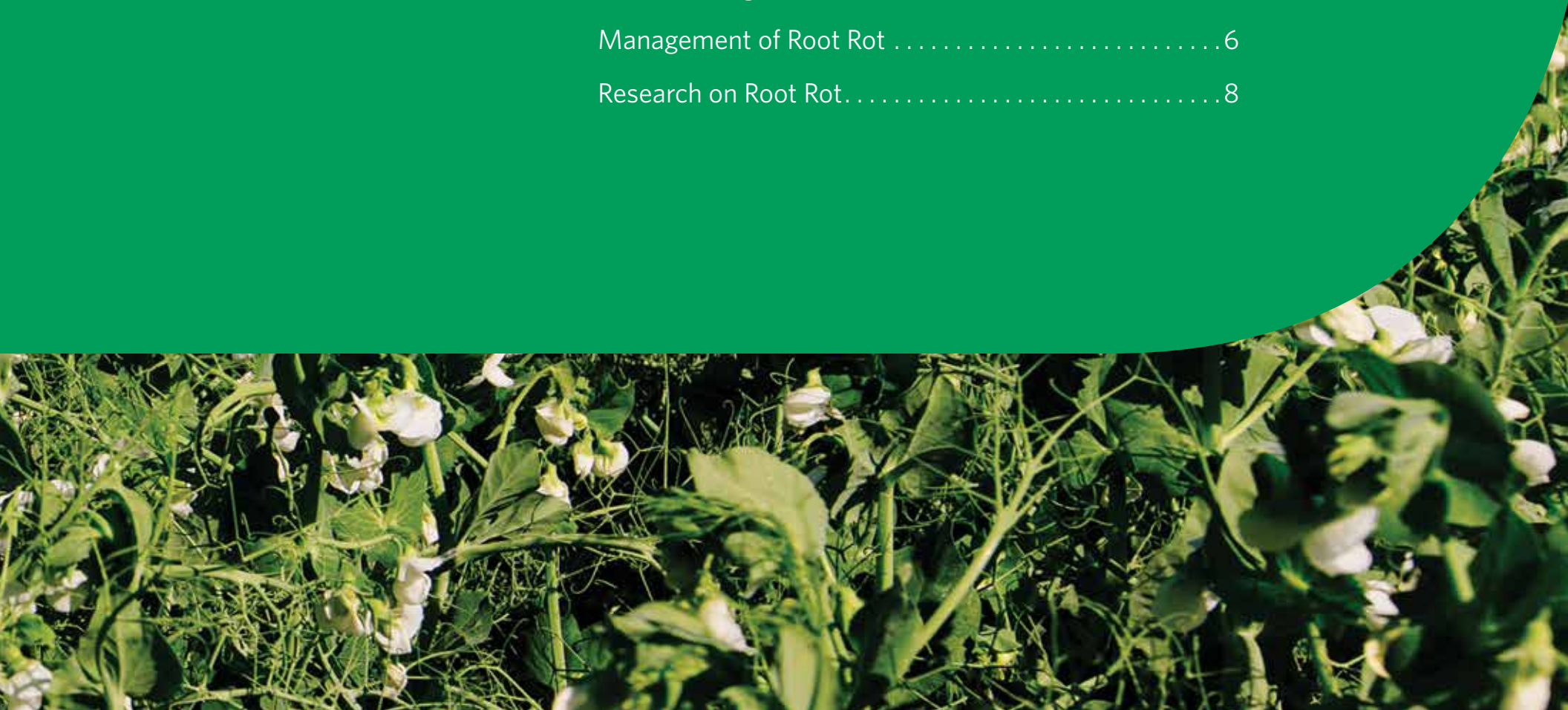


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2016 ROOT ROT SURVEY RESULTS

Researchers in Alberta, Manitoba, and Saskatchewan have been conducting surveys to assess presence of root rot and levels of severity.

Percentage of Fields Testing Positive for Specific Root Rot Pathogens in 2016 Using DNA Testing

Location	Crop	Number of Fields Tested ¹	<i>Aphanomyces euteiches</i> ²	<i>Pythium ultimum</i>	<i>Pythium irregulare</i>	<i>Fusarium avenaceum</i>	<i>Fusarium solani</i>	<i>Fusarium redolens</i>	<i>Fusarium culmorum</i>	<i>Fusarium graminearum</i>
Alberta	Peas	62	61	18	41	88	82	82	23	2
	Lentils	21	29	30	65	91	74	87	39	13
Saskatchewan	Peas	66	44	33	41	97	94	91	38	27
	Lentils	62	32	33	57	95	70	87	43	22
Manitoba	Peas	26	58	28	20	100	88	96	12	4

¹ Only fields that showed a disease severity > 3 in the surveys were tested for pathogen composition.

² These tests are being repeated, results only show fields that had a strong positive reaction to *Aphanomyces euteiches*. Number may be higher when considering fields with lower inoculum levels that gave a weak positive result.

Source: Syama Chatterton, Agriculture and Agri-Food Canada

ROOT ROT SYMPTOMS

- Poor emergence, stunting, yellowing of leaf tissue, a less well-developed root system, decay, and brown discoloration of roots.
- Nodules are often reduced in size and number, are pale in colour, or have not developed.
- Typically occur in patches and may expand if conditions are favourable for the pathogens over several growing seasons. Symptoms are often associated with areas of flooding or waterlogging.
- Difficult to identify root pathogens once plants are heavily damaged or dead, due to the presence of other organisms that feed on decaying tissue.
- Pathogens associated with root rot often appear as a complex, where more than one pathogen is present, making identification of the primary causal agent difficult.



Browning of belowground portion of pea plants
Source: Agriculture and Agri-Food Canada



Peas damaged by *Aphanomyces*
Source: Saskatchewan Pulse Growers

ROOT ROT PATHOGENS

Various fungal and fungus-like organisms make up the complex that contributes to root rot. Other factors can also contribute to root rots, including abiotic conditions such as flooding and soil oxygen depletion which can result in root cell death. Abiotic factors can produce symptoms that are similar to root rots, as well as facilitate infection by root rot pathogens.

Fusarium Root Rot

Fusarium species isolated from pulses in the Prairies include *F. avenaceum*, *F. solani*, *F. redolens*, *F. oxysporum*, *F. graminearum*, *F. equiseti*, *F. culmorum*, and *F. poae*. These pathogens are also able to infect cereals and other rotational crops.



Red discolouration from *Fusarium* root rot
Source: Alberta Agriculture and Forestry



Blackened roots as a result of *Fusarium* root rot
Source: Saskatchewan Ministry of Agriculture

Aphanomyces and Pythium Root Rots

Pythium and *Aphanomyces* are organisms that belong to a group of fungus-like root pathogens commonly referred to as "water moulds." As the name indicates, they are particularly adapted to wet, waterlogged soils. *Pythium* can be controlled with certain seed treatments, and there is one seed treatment registered for early-season suppression of *Aphanomyces* (Intego™ Solo, currently only registered for use on lentils). Because *Aphanomyces* can infect at any time in the growing season and spores can persist for many years in the soil, *Aphanomyces* is the most difficult to manage, and therefore the most serious pathogen among the root rot pathogens.



Caramel coloured roots are a key symptom of *Aphanomyces* root rot
L: diseased plants, R: healthy plants
Source: Crop Development Centre



L: Seedlings grown in normally watered field soil. The two plants on the left do not have *Aphanomyces* present. The two plants on the right do have *Aphanomyces* present
R: Seedlings grown in field soil where *Aphanomyces* is present. The two left plants were in normally watered soil. The two plants on the right were in flooded soil. Even when watered normally, *Aphanomyces* was able to cause disease in peas, but symptoms were more severe when the soil was flooded
Source: Crop Development Centre

RISK FACTORS FOR ROOT ROT

Stress factors that delay germination and slow emergence and growth of plants contribute to an increased risk of root rot infection.

STRESS FACTORS	WHY?
Wet Conditions	Wet feet stress plants and reduce rhizobial activity. Some root rot organisms need water to germinate and infect roots
Cool Temperatures Early in the Season	Slows plant growth and slows nitrogen availability from organic matter
Shortened Rotations	Favours pathogen multiplication in soil
Heavy Textured Soils	More prone to waterlogging and compaction
Soil Compaction	Root growth impeded, reduced aeration, and poor water drainage
Nutrient Deficiency	Slows seedling growth and weakens plant

Key Facts

- Plant roots and nitrogen fixing bacteria need oxygen. When the soil is saturated, roots function poorly, and Rhizobia activity is reduced, resulting in yellow growth.
- Cool conditions slow seedling metabolism and root growth. This also slows mineralization of nitrogen from organic matter.
- Plants that are stressed or have low vigour are more susceptible to seedling diseases.
- Seed treatments are ineffective past the seedling stage and foliar fungicides will not work on root diseases.
- Root rots tend to be more severe under waterlogged conditions. However, root rots can occur even under ideal or drier moisture conditions.
- Crops can also appear yellow and stunted due to wet feet regardless of pathogen pressure.

Heavy Disease Pressure

When a pathogen is able to build up in the soil due to conditions favourable for its development in consecutive seasons (such as waterlogging and tight rotations), the pathogen may continue to cause issues even when conditions return to "normal" or ideal for crop production.

More than One Susceptible Crop

The root rot pathogen can infect various crops in the rotation, or survive as a saprophyte (feeding on dead plant material) until the next susceptible crop is grown, and/or conditions are favourable for disease.



Root rot identified in left field in 2014. Field on the left had peas in 2010. The field on the right had canola in 2010, with no peas for previous eight years

Source: Saskatchewan Pulse Growers

ROOT ROT DIAGNOSIS

An accurate diagnosis of root rot aids future crop management decisions. Results may reveal trends among varieties, crop rotations, and management practices that affect the soil or other inputs and stresses.

Send Samples to a Lab

Diagnostic laboratories are able to examine freshly infected roots for spores, plate samples for fungal identification, or confirm disease using DNA testing. The following labs offer analysis for root rot pathogens:

BDS Laboratoires - Qu'Appelle, SK

306-699-2679
bdslabs.com

BioVision Seed Labs - Sherwood Park, AB*

1-800-952-5407
biovision.ca

Discovery Seed Labs Ltd. - Saskatoon, SK*

306-249-4484
seedtesting.com

20/20 Seed Labs Inc. - Nisku, AB & Winnipeg, MB*

1-877-420-2099
2020seedlabs.ca

Individual labs may differ in testing methods and sample requirements. Please check with the lab prior to sending samples.

*Lab offers DNA test for *Aphanomyces*

Information to Gather for Diagnosis and Discussions

Field History	Crop rotation, last year in pulses
Herbicide History	Herbicides used throughout the year and past history
Environment	Moisture situation leading up to the problem including previous year(s)
Soil Information	Texture, organic matter, pH, signs of compaction, flooding, or water runs
Seeding Information	Variety, seeding date, seeding depth, seed treatments, inoculant, fertilizer amount, and placement as applicable
Field Information and Maps	Legal land location, map of good and bad areas, notes on topography, and patterns in the field where symptoms are present and not present. Mark waterways, side hill seeps, heavier soil, etc.
Patterns in Field	Note any patterns that may be visible. Patterns may relate to equipment such as misses, overlap areas, swath and chaff rows from harvest, and compacted areas. Note seeding and sprayer direction. Patterns may also relate to other factors such as field edges (see picture below)
Photo and Samples	Good photos are critical. Aerial photos are great for identifying patterns. Collect plant and soil samples from both good and bad areas for analysis



Better peas along field edge where grass helps reduce excess water
Source: Saskatchewan Pulse Growers



Aerial shows entire pea field in Alberta affected by root rot
Source: Alberta Pulse Growers

MANAGEMENT OF ROOT ROT

Following best management practices can help get crops off to a good start, ensuring they are better able to handle stress and tolerate disease pressure. The two most critical factors to disease development are environment (moisture) and presence of pathogen (rotation). Field choice is key but other factors may play a role.

In the case of *Aphanomyces*, it is important not to grow a susceptible host for a **minimum** of six years. *Aphanomyces* can infect peas, lentils, alfalfa, dry beans, and possibly some of the native weedy legume species. Faba bean and chickpea varieties with partial resistance can be used to maintain pulse crops in rotation. Soybeans are another option for a nitrogen fixing crop that is resistant to *Aphanomyces*.

Peas and lentils fix their own nitrogen but until the nodules form, the crop relies on soil nitrogen. Starter nitrogen is not usually recommended with peas and lentils, as extra nitrogen can delay nodulation and maturity. However, under conditions where soils are low in nitrogen (less than 15 lb/acre in the top 12 inches) at the start of the season, an application of 10-20 lbs of nitrogen may be beneficial. As a rule of thumb, if soil tests indicate more than 20 lbs/acre of nitrate nitrogen, then no additional nitrogen is needed. If below 15 lb/acre, then consider starter nitrogen.

Phosphorous is important for good root development and to support the nitrogen fixation process. Good phosphorus levels are important for early growth, especially under cool conditions associated with early seeding. Maximum safe rates of seed placed phosphorus are 20-25 lbs/acre for lentils and 15-20 lbs/acre for peas based on narrow opener (15 per cent seedbed utilization), and good moisture conditions. If higher phosphorus rates are required, banding fertilizer away from the seed is the best strategy.

CHOICES	OPTIONS FOR REDUCING RISK OF ROOT ROT
Field Choice	<ul style="list-style-type: none"> Lighter textured soils (sandier) with good drainage No peas/lentils for at least three years (four year rotation) and maybe up to six years if <i>Aphanomyces</i> positively identified Manage or avoid compacted fields or areas
Soil Testing and Fertility	<ul style="list-style-type: none"> Apply nutrients as needed Starter nitrogen if soils <15 lbs/acre available nitrogen in top 12 inches Phosphorous if seeding early into cool soils Other nutrients as required Know the safe rates of nutrients that can be safely applied
Seed Testing	<ul style="list-style-type: none"> Plant good quality seed Apply seed treatments as warranted for seed-borne disease or if planting early into cool soils
Seeding Decisions	<ul style="list-style-type: none"> Use appropriate inoculant and good application methods Choose more resistant pulse crop options – faba bean, chickpea, and soybean (only for <i>Aphanomyces</i>) Minimize seed damage and watch airspeed of seeder Seed into warm moist soil – the quicker the emergence the more vigorous the seedlings
After Seeding	<ul style="list-style-type: none"> Monitor crop for signs of stress Follow herbicide labels – increased injury can occur when plants are stressed

Seed Treatments for Peas and Lentils

Root rot pathogens can be controlled to a certain degree using seed treatments. However, fungicidal effects will only last two to three weeks against early season disease pressure. Making informed decisions before root rot symptoms appear is the best option. Once the seed is in the ground, it is important to monitor plant health by checking above and belowground portions of the plant throughout the season. When determining the economic threshold for utilizing a seed treatment, consider conducting a soil test if the field has a disease history.

DISEASE (PATHOGEN)	SEED TREATMENTS
<p>Pythium (seed rot and damping off)</p> <ul style="list-style-type: none"> Use seed treatment if field has a history of disease and/or seeding under cool/wet condition 	<ul style="list-style-type: none"> Metalaxyl Intego™ Solo (ethaboxam)¹
<p>Root Rot Complex Including: Botrytis, Fusarium, Pythium, Rhizoctonia solani (Seed rot and seedling blight)</p> <ul style="list-style-type: none"> Use seed treatment if levels of botrytis or <i>Fusarium</i> on seed total 10% or more Use seed treatment if field has a history of disease and/or seeding under cool/wet conditions 	<ul style="list-style-type: none"> Agrox FL (captan) Apron® Advance (fludioxonil, metalaxyl, thiabendazole) Apron® Maxx RTA/RFC (fludioxonil, metalaxyl) Cruiser Maxx® Pulses (thiamethoxam, fludioxonil, metalaxyl) EverGol® Energy (penflufen, prothiconazole, and metalaxyl) Insure® Pulse (metalaxyl, fluxapyroxad, pyraclostrobin) Thiram (thiram)² Trilex® AL (trifloxystrobin, metalaxyl) Trilex® EverGol (penflufen, trifloxy strobil, metalaxyl) Vibrance® Maxx (fludioxonil, metalaxyl, sedaxane) Vitaflo® products (carbathiin, thiram)³
<p>Aphanomyces</p>	<ul style="list-style-type: none"> Intego™ Solo (ethaboxam)¹

¹Intego™ Solo is registered for lentil but not registered for pea

²Thiram is registered for pea but not registered for lentil

³Includes Vitaflo® 280, Vitaflo® Fungicide, and Vitaflo® SP

Always refer to product labels before application. Review the most recent Guide to Crop Protection for more information on seed treatments.

RESEARCH ON ROOT ROT

Developing rapid generation technology involving wild lentil crosses in order to produce *Aphanomyces*-resistant lentil varieties – proof of concept

S. Banniza, M. Lulsdorf, and B. Vandenberg

Funded by Saskatchewan Pulse Growers (2015-2017)

- **Objective:** To shorten seed-to-seed life cycle duration of wild species such as *Lens ervoides* that have partial resistance to *Aphanomyces*.

Marker-assisted selection for *Aphanomyces* resistance in pea for rapid development of adapted pea varieties with improved *Aphanomyces* resistance

S. Banniza, T. Warkentin, and K. Gali

Funded by Saskatchewan Pulse Growers (2016-2019)

- **Objective:** To implement marker-assisted selection for rapid development of resistant pea varieties.

Integration of *Aphanomyces* resistance screening into rapid generation technology of lentil and pea

S. Banniza, T. Warkentin, and B. Vandenberg

Funded by Saskatchewan Pulse Growers (2015-2018)

- **Objectives:**
 1. To identify pathotypes of Saskatchewan *Aphanomyces* isolates.
 2. To identify germplasm with high *Aphanomyces* resistance through screening under controlled conditions and develop adapted germplasm.
 3. To develop a screening technique that integrates *Aphanomyces* resistance screening with Rapid Generation Technology for peas and lentils to speed up variety development.

Infectivity model for *Aphanomyces euteiches* in Saskatchewan soils

S. Chatterton and S. Banniza

Funded by Saskatchewan Pulse Growers (2015-2018)

- **Objective:** To determine oospore inoculum levels in the Saskatchewan soil types that cause severe root rot, development of a risk assessment tool for Saskatchewan soils based on DNA quantification of oospore levels in soil, and determine the vertical and horizontal spread of *Aphanomyces* in the soil zone to recommend best soil sampling practices.

Distribution of *Aphanomyces euteiches* in pulse and forage crops in Alberta

S. Chatterton, M. Harding, and R. Bowness

Funded by the Alberta Crop Industry Development Fund and Alberta Pulse Growers (2015-2017)

- **Objective:** To determine distribution of *Aphanomyces* in pea, lentil, dry bean, faba bean, and alfalfa crops in Alberta.

Characterizing the *Fusarium* species that affect major crops in Manitoba

F. Daayf

Funded by Manitoba Pulse and Soybean Growers and Manitoba Wheat and Barley Growers Association (2016-2017)

Objectives:

1. To investigate the cross-pathogenicity between the *Fusarium* strains infecting soybean and those infecting wheat, barley, and oats.
2. To investigate the competitiveness of *Fusarium* species isolated from both peas/soybeans and cereals.
3. To investigate toxin producing potential of the *F. graminearum* isolates from soybean versus those from cereals.
4. To investigate genetic diversity of selected *Fusarium* species infecting these crops.

Pea root rot: distribution, genetic variability, resistance, and management

Funded by Manitoba Pulse and Soybean Growers,

Saskatchewan Pulse Growers, and Agriculture and Agri-Food Canada under the Growing Forward 2 Pulse Science Cluster (2013-2018)

Sub-activity 1:

D. McLaren, R. Conner, S.F. Hwang, K.F. Chang, and B. Gossen

- **Objective:** To improve screening for disease resistance in field pea lines based on the identification of the prevalent root rot pathogens in the prairie regions through molecular diagnostic procedures.

Sub-activity 2:

R. Conner, D. McLaren, S.F. Hwang, K.F. Chang, S. Strelkov and B. Gossen

- **Objective:** Identify new sources of resistance to the prevalent root rot pathogens and develop molecular markers that are closely linked to resistance genes for *Aphanomyces* root rot.

Sub-activity 3:

S. Chatterton, D. McLaren, S.F. Hwang, and B. Gossen

- **Objective:** To develop a risk assessment tool for *Fusarium* root rot by collecting quantitative data using molecular tools on soil and root rot pathogen levels to correlate with root rot severity data.

Sub-activity 4:

B. Gossen and S. Strelkov

- **Objective:** Conduct and coordinate field surveys and field trials to develop and assess best management practices for new and emerging pea root rot pathogens.

Development of an immuno-PCR for the detection of pea root rot causal agent, *Aphanomyces euteiches*

C. Sheedy

Funded by Alberta Pulse Growers and Western Grains Research Foundation (2016-2018)

- **Objective:** To develop a sensitive and specific antibody based detection method for *Aphanomyces euteiches*.

Evaluation of beneficial rhizosphere and endorhizosphere microorganisms as bioinoculants for the control of soil-borne root pathogens

F. Walley and J. Germida

Funded by Saskatchewan Pulse Growers (2015-2017)

To develop microbial inoculants for managing fungal root pathogens in peas.

Cover cropping as part of a rotation strategy to reduce pea root rot

S. Chatterton, S. Shirtliffe, S. Banniza, F. Larney, L. Hrapovic, R. Bowness, H. de Gooijer, N. Lupwayi, B. Beres, and J. Larsen

Funded by Alberta Pulse Growers, Saskatchewan Pulse Growers, and Alberta Funding Consortium (2017-2021)

• **Objectives:**

1. To evaluate the impact of fall-seeded cover crops in combination with rotation crops on *Aphanomyces* root rot of pea, rotational crop yield, and soil health parameters.
2. To determine the rate of decay of *Aphanomyces* and *Fusarium* inoculum under standard rotations in Prairie soils, with and without cover crops, and susceptible hosts.
3. To assess whether there are any benefits or detriments of cover crops to canola and winter wheat crops when Brassica or cereals are used as cover crops.





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