Clubroot Management Plan
Developed by the Saskatchewan Clubroot Initiative
June 2014

Clubroot Overview

What is clubroot?

Clubroot is a soil-borne disease caused by the microbe *Plasmodiophora brassicae*. Clubroot affects the roots of cruciferous field crops such as canola, mustard, camelina, oilseed radish and taramira. It also affects cruciferous vegetables such as arugula, broccoli, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, kale, kohlrabi, radish, rutabaga and turnip. Cruciferous weeds (e.g. stinkweed, shepherd's purse, wild mustard) can also serve as hosts.

What are the symptoms of clubroot?

The invasion of the interior of host roots alters hormone balance and leads to increased cell division and growth, resulting in clubroot galls. These deformed roots have a reduced ability to absorb water and nutrients leading to stunting, wilting, yellowing, premature ripening and shrivelling of seeds. The cause of these above-ground symptoms can be confirmed by digging up suspected plants to check roots for gall formation. Clubroot affects canola yield and quality to a similar degree as other diseases affecting water and nutrient uptake. Its impact depends on soil conditions and the growth stage of the crop when infection occurs. Early infection of seedlings tends to result in great yield losses. Spore germination in *Plasmodiophora*, infection and disease development are favoured by warm soils, high soil moisture and low soil pH.

Is there surveillance in place for clubroot?

A canola disease survey is conducted annually in the province by a collaboration of plant pathologists, agronomists and crop specialists. They are from the Saskatchewan Ministry of Agriculture, Agriculture and Agri-Food Canada and private industry. The objective of the canola disease survey is to monitor the presence and severity of common canola diseases and to detect the appearance of new diseases such as clubroot.

Where has clubroot been found?

Clubroot affects crucifers worldwide. It was first identified in Europe in the thirteenth century. In Canada, clubroot is primarily established in the vegetable growing regions of British Columbia, Quebec, Ontario and the Atlantic provinces. It has also been found in canola in Quebec since 1997. After 45 years of large scale production of canola in Western Canada, the disease was reported for the first time in this crop near Edmonton, Alberta. Since then clubroot has been confirmed in more than 15 counties in Alberta and was added as a declared pest to Alberta's Agricultural Pests Act in 2007.
Clubroot symptoms have not been observed in any of the Saskatchewan canola crops randomly selected for canola disease surveys (1,315 surveyed between 2008 and 2013). In 2008, 30 soil samples were tested using DNA diagnostics to detect *Plasmodiophora brassicaceae* and a bioassay in which canola plants were grown in a sample of soil and observed for clubroot symptoms after six weeks.

One soil sample from west-central Saskatchewan was found to be positive for clubroot using these tests, despite the absence of symptoms in the crop. Clubroot was not detected in any additional soil surveys in 235 fields between 2009 and 2011. In 2011, clubroot was identified in two canola fields in north-central Saskatchewan in private canola industry research sites. In 2012, one soil sample from west-central Saskatchewan out of the 91 tested across the province was found to be positive for clubroot. Nevertheless, symptoms were absent in the crops.

**How does clubroot spread?**

Infected roots will eventually disintegrate and release resting spores into the soil. These are then be transported by wind, water erosion, animals/manure, shoes/clothing, vehicles/tires or an earth tag on agricultural or industrial field equipment. Resting spore numbers will decline over time when non-host crops are grown, but a small proportion can survive in the soil for up to 20 years. Clubroot is primarily a soil-borne disease; it does not infect seed but it may be found in soil attached to seed or other plant parts. Clubroot does not present any legal phytosanitary issues for trading.

**What is the oil and gas industry doing about clubroot?**

The Canadian Association of Petroleum Producers have developed a set of best-management practices. They are designed to promote the development of effective and achievable procedures to minimize the spread of clubroot pathogen spores where susceptible crops are grown.

**What are growers doing about clubroot?**

Producers growing susceptible host crops should follow the recommended best-management practices. These include proper crop rotation and sanitation for prevention and management of clubroot. Producers are advised to scout susceptible crops or weeds diligently and if clubroot is suspected, to contact the Saskatchewan Ministry of Agriculture. The Ministry will provide assistance with diagnosis and clubroot management.

Fungicides are not a practical solution for clubroot in canola and there are no foliar products or seed treatments registered for control of clubroot in canola in Canada. Many Canadian canola varieties are susceptible and currently available resistant varieties are not effective against all pathotypes of clubroot.
Producers are also funding clubroot research through their canola levy. Saskatchewan researchers at Agriculture and Agri-Food Canada in Saskatoon are working in collaboration with the University of Alberta (U of A), Alberta Agriculture and Rural Development (AARD), the University of Guelph, and Ibaraki University in Japan. They are working to isolate, screen and discover indigenous microorganisms for biological control of clubroot in canola. This research is part of an integrated disease management approach supported by provincial canola development commissions, grower associations and the Canola Council of Canada. Researchers at the U of A and AARD have also been studying pathogen and control options. Both public and private research programs have been screening Brassica germplasm and have been developing clubroot resistant (or tolerant) canola lines for Western Canada.

What are canola industry organizations doing about clubroot?

Industry organizations are assisting producers through education and awareness for the prevention and the spread of clubroot in Saskatchewan. The organizations help direct the canola levy to appropriate research initiatives such as the development of clubroot tolerant and resistant canola varieties. Canola industry organizations are also assisting the Saskatchewan Ministry of Agriculture through the Saskatchewan Clubroot Initiative.

What is the province doing about clubroot?

As part of the provincial clubroot management plan, the Saskatchewan Clubroot Initiative was established to promote awareness and identify priorities for clubroot prevention and management. In June 2009, the Saskatchewan Ministry of Agriculture declared clubroot a pest, giving municipalities powers to control clubroot under The Pest Control Act. These powers include the appointment of Pest Control Officers to enforce, enter land, perform inspections, collect specimens or issue orders to any person; the authority to pass bylaws to prevent, control or destroy clubroot; and the ability to require individuals to take actions to control or destroy clubroot on the land they own, occupy or control. Education and awareness continue to be a priority to help producers and industry members prevent the spread of clubroot into and within Saskatchewan.

Where can I get more information?

For more information on clubroot, please visit www.clubroot.ca or the Saskatchewan Ministry of Agriculture's website at www.agriculture.gov.sk.ca or contact the Agriculture Knowledge Centre at 1-866-457-2377.
Objective

To promote awareness and minimize the risk of clubroot in Saskatchewan.

Best Practices for Prevention and Management

1. Consider clubroot resistant varieties, particularly in fields where the pathogen has been detected.
2. Plant susceptible crops, including clubroot resistant canola varieties, no more than once every four years. Crop rotation will not prevent the introduction of clubroot to fields that are free of the pathogen, but it will restrict clubroot development by limiting the increase of clubroot resting spores. This will prevent the increase of clubroot inoculum, thereby reducing the risk of resistance breakdown and alleviating the impact of other plant pathogens.
3. Scout crops regularly and carefully.
   - Identify suspicious above-ground symptoms including wilting, stunting, yellowing and premature ripening of canola or other susceptible crops.
   - Wilting is more likely to be apparent in hot weather (usually in the afternoon).
   - Field entrances and approaches are likely to be contaminated with clubroot spores first; therefore, symptoms will often appear there first.
   - Confirm the cause of above ground symptoms by checking the roots for galls.
   - If clubroot is suspected, inform the Saskatchewan Ministry of Agriculture by contacting the Agriculture Knowledge Centre (1-866-457-2377) or your local Saskatchewan Ministry of Agriculture regional office.
4. Seed canola early. Early crop establishment has been shown to reduce the effects of clubroot if it is present in a field.
5. Restrict movement of potentially contaminated soil to non-contaminated regions.
   - For Saskatchewan producers this means restricting field entry for vehicles, field machinery or oil rig equipment with an earth tag from an infested region unless it has been properly sanitized. Ask questions about where the equipment is from and what sanitation measures have been taken before the equipment left the infested area, dealer or auction site.
   - Cleaning steps may include: removal of crop debris and soil, washing of equipment with a power washer using hot water or steam and misting with disinfectant (1-2 per cent bleach solution). This is to be followed by an additional rinse with water.
   - Zero-till practices are beneficial due to the reduction in soil erosion they provide.
   - The risk of spreading clubroot through contaminated plant material or manure is much lower than through transporting contaminated soil on field equipment and vehicles. However, clubroot spores can be found in soil particles on seed and may survive livestock digestion. Avoid the use of
seed with an earth tag, straw, hay, silage and manure from infested or suspected areas.

6. To minimize the risk of accidental release of P. brassicae, appropriate containment guidelines should be followed when conducting research involving P. brassicae in greenhouses, growth cabinets or laboratories. Because clubroot is not widespread in Saskatchewan, field plot research should not be conducted here. Preventative measures should also be taken when conducting disease surveys in Saskatchewan. Contact the Saskatchewan Clubroot Initiative for a copy of the current “Recommendations for Managing Risks associated with Clubroot Research in Saskatchewan”.

Confirmation of clubroot requires observation of disease symptoms in a susceptible plant in addition to the detection of the pathogen's DNA in a plant or soil sample. If DNA test results are positive for clubroot despite an absence of symptoms in the plant surveyed, a follow-up bioassay is required to dispel false-positives and prove pathogen viability. Bioassay is a process where susceptible plants are grown in a sample of the soil and observed for clubroot symptoms after six weeks. If either the DNA test results or the plant symptoms indicate the presence of clubroot without the combination of both, this is still deemed ‘unconfirmed’. In fields where clubroot has been confirmed through the observation of disease symptoms in susceptible crop and the detection of the pathogen’s DNA in a plant or soil sample, the following measures should be taken:

1. Plant susceptible crops, including clubroot resistant canola varieties, no more than once every four years and rotate sources of disease resistance. Resistance to clubroot does not mean full immunity to the disease. Tight rotations of resistant varieties may lead to propagation and spread of new clubroot pathotypes that the variety has no resistance to, thereby breaking down the effectiveness of the clubroot resistance. Although the signs and symptoms of clubroot may not be present, plants may still host the disease and propagate new spores. These spores increase the potential severity of the disease in the future; therefore, a minimum of four years is required between susceptible crops, including clubroot resistant canola varieties.

2. Minimize traffic to and from fields and practice good sanitation by restricting movement of soil from the contaminated field to other areas. Any individuals or companies who may be accessing the land should be informed that clubroot is present on the land so that they may limit traffic and/or ensure proper sanitation. Procedures for proper sanitation are outlined in point #3 of the previous section.

3. If infestation is only near the current field access, consider seeding perennial grass to that area and create a new access point as far from the contaminated area as possible.

4. Use direct seeding and other soil conservation practices to reduce erosion. Resting spores can be readily moved in soil transported by wind or water erosion. Reducing the amount of tillage will reduce the spread of the organism within the field and to other fields.
Sampling for Clubroot Testing

As clubroot may take six to eight weeks to develop, symptoms are most detectable later in the growing season (late July or August). Soil samples can be collected at any time but soil should be dried after collection. Do not drive into the field or field access, but park on the road whenever possible and follow sanitation procedures if visiting more than one field. Dispose of, or clean and disinfect, footwear and tools that come in contact with the soil. Keep records of all the fields visited.

In fields that have been confirmed for clubroot, sampling can be expanded in intervals of 150 metres from the field entrance or other location of the initial finding. This is done in order to confirm the extent of the infestation.

Plant Sample Procedure

1. Collect 20 plants each from five different sites in the field, for a total of 100 plants. Then observe them for disease symptoms. Each of these five sites needs to be at least 20 metres from each other and at least 20 metres from the field’s edge.
2. If patches of premature ripening are observed, particularly in field entrances or corners, dig or pull up the plants and shake off the excess soil to inspect the roots for the presence of galls. If clubroot is suspected, cut off the stems and collect root samples.
3. Air-dry root samples in a double paper bags or freeze them in a double Ziploc bag (samples must remain frozen if this option is chosen). Next, send them to the Ministry of Agriculture’s Crop Protection Laboratory at 346 McDonald Street, Regina SK, telephone: (306) 787-8130. You may mail, courier or drop off samples in person. There is a $20 fee for visual inspection.
4. If the visual diagnosis is positive, root samples will be forwarded to an accredited laboratory on behalf of the municipality for DNA testing. Cost of the DNA testing will depend on the current fee set by the accredited laboratory (approximately $100).

Soil Sample Survey Procedure

1. Soil samples should be comprised of a mixture of small scoops (approximately one cup each) of soil taken at each of the 5 sites visited in any one field. As clubroot is most likely to arrive on soil attached to vehicles and field equipment, if the entrance to the field is evident, these 5 sites should be located in the vicinity of the approach. Otherwise, keep each of these five sites at least 20 metres away from each other and at least 20 metres away from the field’s edge.
2. Clear away residue from the soil surface and scoop approximately 1 cup of the top 0 to 10 cm of soil at each site (total 1.5 litres from all 5 sites combined).
3. Air-dry soil samples in paper boxes and send them to the laboratory for DNA testing. The cost of the DNA testing will depend on the current fee set by the accredited laboratory (approximately $100).

- For a list of laboratories providing clubroot testing, please visit: www.clubroot.ca (click on Identify Clubroot) or contact the Crop Protection Laboratory in Regina.
Responsibilities

1. Saskatchewan Ministry of Agriculture
   - Co-ordinate efforts to monitor crops in the province for clubroot.
   - Compile and distribute the Saskatchewan Clubroot Management Plan.
   - Manage legislation and regulations pertaining to clubroot as a declared pest.
   - Extend clubroot education to the agriculture industry and the general public. Provide information to the oil and gas industries, environmental companies, landscaping companies, equipment dealers, auction companies, custom applicators, seeders and harvesters.
   - If clubroot is confirmed through disease surveys or reported to the Ministry by an individual, company, or RM, the Ministry will first assess whether the report satisfies the requirements of clubroot confirmation. The report will be considered confidential and communication will not proceed until clubroot is confirmed.
   - The Ministry will ensure the producer(s) is/are informed that they have clubroot (if they are not already aware) and are provided copies of the Saskatchewan Clubroot Management Plan, Clubroot Factsheet, and information on The Pest Control Act. They will also be advised of the next steps to be carried out by the Ministry, SaskCanola, and the Municipality.

2. Producers and Producer Groups
   - Implement best-management practices which adhere to the Saskatchewan Clubroot Management Plan.
   - Producer groups such as SaskCanola, SaskMustard, the Saskatchewan Vegetable Growers Association and the Saskatchewan Seed Potato Growers' Association will assist in educating Saskatchewan producers about clubroot prevention and management.
   - If clubroot is confirmed, SaskCanola will be informed and provide a news release following producer notification. The news release will disclose the region but not the specific area. The RM will determine how and when more specific information beyond the region will become public information.

3. Saskatchewan Association of Rural Municipalities (SARM).
   - Help educate Saskatchewan producers about clubroot prevention and management.
   - Rural municipalities have the authority under The Pest Control Act to undertake prevention and enforcement measures related to the spread and control of clubroot disease.
   - If clubroot is confirmed, SARM & the affected RM will be notified following producer notification. The Ministry will work with the RM to develop a clubroot strategy and appropriate management plan in reference to any relevant bylaws, extension materials and clubroot policies provided by SARM.
4. **Agricultural Retail Industry**
   - Help educate the Saskatchewan agriculture industry about clubroot.
   - Take measures such as equipment cleaning to prevent the introduction and minimize the spread of clubroot from infested areas.

5. **Equipment Dealers, Auctioneers and Custom Applicators**
   - Help educate those from the seeding and harvesting industries, the custom application industries and those purchasing equipment from infested areas (designated for Saskatchewan) about clubroot.
   - Take measures such as equipment cleaning to prevent the introduction and minimize the spread of clubroot from infested areas.

6. **Oilfield, Gas, Road Construction and Other Companies Operating on Agricultural Land**
   - Help educate Saskatchewan’s oil, gas and other field operators about clubroot.
   - Take measures such as equipment cleaning in order to prevent the introduction and minimize the spread of clubroot from infested areas.

7. **Saskatchewan Clubroot Initiative**
   - Provide a forum to represent the interests and views of Saskatchewan's agricultural research and production sectors, producers, industry groups and municipal governments regarding the management of clubroot.
   - Provide consultation in the development of the Saskatchewan Clubroot Management Plan as well as evaluation and revision of the recommendations as is necessary.
   - Help educate Saskatchewan’s agriculture, equipment, oil, gas and other industries about clubroot and the economic and agronomic impacts the disease poses.

8. **Researchers and Funding Agencies**
   - Researchers should familiarize themselves with the Recommendations for Managing Risks Associated with Clubroot Research in Saskatchewan and use them to develop suitable measures for their unique research. Funding agencies should also be aware of these recommendations and may wish to consider the importance of containment protocols in research proposals when considering supporting clubroot projects in Saskatchewan. For a copy of these guidelines contact F. Dokken-Bouchard; her contact information is on the next page.
Regular communication with and representation to the SCI also includes Saskatchewan Ministry of Highways, Saskatchewan Ministry of Energy and Resources, Saskatchewan Auctioneers Association, Canadian Association of Agri-Retailers, private labs and agriculture companies. Contact information for these parties can be provided by SCI.

If you would like to participate in the Saskatchewan Clubroot Initiative, please contact the SCI Chair.
For more information on clubroot or this management plan, contact:
Saskatchewan Ministry of Agriculture
Agriculture Knowledge Centre
Toll Free: 1-866-457-2377
Email: aginfo@gov.sk.ca

References


Best Management Practices: Clubroot Disease Management, Canadian Association of Petroleum Producers (July 2008)