Clubroot Management Plan

Developed by the Saskatchewan Clubroot Initiative
Revised July 2018

Clubroot Overview

What is clubroot?

Clubroot is a soil-borne disease caused by a microbe, *Plasmodiophora brassicae* (*P. brassicae*). Clubroot affects the roots of host plants, which include cruciferous field crops such as canola, mustard, camelina, oilseed radish and taramira, and 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 for the clubroot pathogen.

Clubroot infected canola root with intact clubroot galls

What are the symptoms of clubroot?

Clubroot infection of host plant roots results in increases in cell size and cell number resulting in a swollen or club-like appearance (clubroot galls). These swollen and deformed roots have a reduced ability to absorb water and nutrients, leading to stunting, wilting, yellowing, premature ripening and shriveling of seeds. The cause of these above-ground symptoms can be confirmed by digging up suspect 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, and 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. Infection by the clubroot pathogen and disease development are favoured by warm soils, high soil moisture and low soil pH.

How does clubroot spread?

Infected roots will eventually disintegrate, releasing resting spores into the soil, which may then be transported by wind, water erosion, animals/manure, shoes/clothing, vehicles/tires, or earth tag on agricultural or industrial field equipment. The clubroot pathogen, in the form of resting spores in the soil, can be moved any way that soil can be moved. Activities that move large volumes of soil (such as on agricultural or industrial field equipment) between areas or regions are considered to have the highest risk.

Decomposing clubroot gall

The pathogen population (spore numbers) will decline over time when non-host crops are grown, but a small proportion can survive in 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 (including seed potatoes) or other plant parts. If you are growing potatoes, source your seed potatoes from regions where clubroot has not been confirmed or suspected. Clubroot does not present any legal phytosanitary issues for trade.

Where has clubroot been found in Saskatchewan?

In Saskatchewan, the Ministry of Agriculture monitors commercial canola fields for clubroot symptoms and for the presence of the clubroot pathogen through their annual canola disease survey. The presence of the clubroot pathogen can be detected through DNA-based soil testing, which may allow for the detection of the

pathogen at levels lower than those required to cause visible symptoms under field conditions. Confirmation of the disease requires visible symptoms on the roots of infected plants.

The clubroot pathogen was first detected through the Ministry's canola disease survey in 2008, when one soil sample collected from a commercial canola field in west-central Saskatchewan was found to be positive for the clubroot pathogen using DNA diagnostic techniques. The clubroot pathogen was detected in a second field located in west-central Saskatchewan in 2012. In both of these cases, there were no visible symptoms of clubroot in the field.

In 2011, clubroot symptoms were identified in two private canola industry research sites located in north-central Saskatchewan. Most recently, in 2017, clubroot symptoms were identified and clubroot was confirmed in crop districts 9A and 9B (northwest and north-central Saskatchewan) with fewer than 10 canola fields identified to have clubroot in each crop district.

Clubroot survey 2018

In order to gain a better understanding of the distribution and severity of clubroot in Saskatchewan, the Ministry of Agriculture and SaskCanola is conducting an extensive clubroot survey in 2018. This survey includes a total of 1,800 fields, with one field located in each township across the survey area. The survey area will cover the northern agricultural regions and a large area along the east side of the province. For more information about this survey, please contact the Agriculture Knowledge Centre at 1-866-457-2377.

How will clubroot be regulated?

In June 2009, the Saskatchewan Minister of Agriculture declared clubroot a pest, giving municipalities powers to handle clubroot under *The Pest Control Act*. These powers include:

- The appointment of Pest Control Officers (PCO) 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 growers and industry members prevent the spread of clubroot into and within Saskatchewan.

The Saskatchewan Ministry of Agriculture is committed to a farmer-driven approach to clubroot regulation and to working with rural municipalities (RMs) to develop effective and consistent management plans (Appendix A). This approach to clubroot management encourages the producer to take an active role in the management of any clubroot confirmed on their farm.

For the purpose of clubroot regulation, visible symptoms on the roots of a host plant are required for clubroot confirmation. When visible clubroot symptoms are not present, but the clubroot pathogen is detected in a soil sample using DNA-based diagnostics, the disease will not be considered confirmed. In these cases, regulation will not be recommended but the producer and/or landowner will be encouraged to implement proactive management strategies such as extended crop rotation, use of clubroot-resistant varieties and strategies focused on minimizing soil movement. These proactive management strategies will minimize the impact of clubroot on canola yields by keeping pathogen levels low while also minimizing the movement of the infested soil to prevent the spread of clubroot and the clubroot pathogen. If visible symptoms are identified and clubroot is confirmed through subsequent monitoring of the field in future years, the producer and/or landowner will be required to develop a clubroot management plan as described below.

When clubroot has been confirmed in a field (including fields identified through the Ministry's clubroot surveillance program, and fields reported to or identified by an RM or an appointed PCO), the producer and/or landowner will be contacted by a PCO to inform them of the clubroot confirmation and to provide them with information on clubroot management. After the initial conversation with the PCO, the producer and/

or landowner will have 30 business days to work with a professional agrologist (any agrologist licensed to practice with the Saskatchewan Institute of Agrologists) to develop a clubroot management plan for the clubroot infected field(s). If the developed clubroot management plan meets a minimum set of science-based standards (below), it will become the formal agreement between the landowner and/or producer and the PCO. When a formal agreement cannot be reached or when a producer and/or landowner fails to carry out the measures outlined in the clubroot management plan formal agreement, the PCO may write an order indicating how clubroot will be managed in the clubroot-infected field(s) as per section 19 of *The Pest Control Act*.

The objective of this approach is to ensure that clubroot is managed in a consistent and science-based manner while not putting any unnecessary restriction on a producer's production practices. A flow chart describing this process can be found in Appendix A.

To become a formal agreement, the clubroot management plan must include the following:

- Minimum of a three year rotation (two-year break) between host crops such as canola, camelina, mustard and brassica vegetables (including resistant varieties).
- Use of only clubroot-resistant varieties in clubroot-infested fields.
- Control of canola volunteers and related brassica weeds throughout the crop rotation.
- Management measures to be followed by the producer, field staff and all others working on the clubroot-infested land to prevent the spread of clubroot (e.g.: cleaning of equipment, restricting entry of vehicles into fields unless they have been properly cleaned, and creation of a separate exit as for as possible from the field entrance).
- Use of soil conservation practices, such as direct seeding or zero-tillage, to minimize the spread of clubroot through soil movement via wind and water erosion.
- Notification of all occupants and easement holders who have access to the land that clubroot has been confirmed to enable biosecurity actions to prevent the spread of clubroot.
- Intent to disclose that clubroot has been confirmed if the land is sold or rented.
- Signatures of the producer and/or landowner and the Pest Control Officer.

This list represents the minimum requirements that need to be included in a clubroot management plan in order for it to become the formal agreement between the producer and/or landowner and the PCO. Producers are encouraged to consider implementing additional clubroot management and prevention actions. A complete list of best practices for clubroot management and prevention can be found below.

Best Practices for Prevention and Management

1. Extend your crop rotation. Aim for a four year rotation (three-year break between host crops), even when clubroot-resistant varieties are used. A minimum of a three-year rotation (two-year break between host crops including clubroot-resistant varieties) should be followed. Longer crop rotations are encouraged for fields with high disease severity and high pathogen levels (resting spore concentrations) and for those wishing to further reduce the impact of clubroot.
   - Crop rotation will not prevent the introduction of the clubroot pathogen to fields that are free of the pathogen, but it will restrict clubroot development by limiting the increase of clubroot pathogen population (resting spores) in the field, maintaining the effectiveness of clubroot-resistant varieties while also alleviating the impact of other plant pathogens.
2. Use clubroot-resistant varieties when clubroot has been identified on your farm or within your community.
   - 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 pathogen pathotypes that the variety has no resistance to, thus breaking down the effectiveness of the variety's resistance to clubroot. To prevent this from happening, clubroot varieties should be grown in extended rotations with a minimum of two years

between host crops.

3. Control canola volunteers and brassica weeds, such as wild mustard, stinkweed and shepherd's purse, throughout the crop rotation.
4. Minimize the movement of contaminated or potentially contaminated soil to non-contaminated regions by:
   - Restricting entry of vehicles, machinery or industrial equipment with adhering soil from another area (earth tag) into fields unless they have been properly sanitized. Ask questions about where the equipment is from and what sanitation measures have been used before the equipment left the infested area, dealer or auction site (prior to entering the field or farm).
     - 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 a disinfectant (two per cent sodium hypochlorite solution) for 20 to 30 minutes, followed by an optional additional rinse with water.
       - Sodium hypochlorite is the active ingredient in bleach that is used as a disinfectant for clubroot. Bleach products range in the concentration of sodium hypochlorite and typically contain between approximately four and eight per cent. As a result, different dilutions will be needed for different bleach products to create a two per cent sodium hypochlorite disinfectant solution. For example, Clorox disinfecting bleach contains six per cent sodium hypochlorite. To make 750 mL of a two percent sodium hypochlorite, you would need to add 250 mL of the Clorox disinfecting bleach and 500 mL of water.
       - The concentration of sodium hypochlorite will decrease during storage. Purchase bleach in small quantities and use it relatively quickly (within a few months). If you are storing bleach, store it in a cool, dry location.
       - Organic matter will inactivate the sodium hypochlorite. If using a two per cent sodium hypochlorite solution to disinfect foot wear or other equipment, refresh the solution frequently or as it becomes dirty to maintain a two per cent solution.
     - The level of sanitation used should be representative of the risk associated with the particular activity
   - When possible, consider creating a separate exit as far as possible from the field entrance to reduce the movement of the pathogen inoculum out of an infected field. If possible, create the exit on higher ground to further reduce the amount of soil leaving the field. Testing the new exit to ensure that clubroot or the clubroot pathogen is not present is also a good idea.
   - Consider restricting unwanted vehicles entering your field by posting with "no trespassing" and "no hunting" signs.
   - Use direct seeding, zero-tillage and other soil conservation practices to reduce erosion.
     - Resting spores can be 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.
   - Clubroot spores can be found in soil particles on seed and may survive livestock digestion. Avoid use of seed or seed potatoes with earth tag, straw, hay, silage and/or manure from infested or potentially infested areas. The risk of spreading clubroot through contaminated plant material or manure is much lower than through transporting contaminated soil on field equipment and vehicles.
5. Scout crops, including both susceptible and resistant varieties, regularly and carefully. Early detection is important for clubroot management. Symptoms can be quite severe below ground while remaining healthy above ground. As a result, randomly pulling plants at the field entrance is suggested, even if the plants look healthy
   - Scouting should include full plant assessment at field entrances, low areas or areas with above-ground symptoms including wilting (will be more apparent in hot weather), stunting, yellowing and premature ripening. Plants should be dug and pulled up and the roots examined for the presence of clubroot galls.
   - Field entrances and approaches are likely to be contaminated with clubroot pathogen first. Therefore,

symptoms will often appear there first.

6. If the clubroot infestation is only near the current field access or a limited area of the field, consider seeding that area to a perennial grass and create a new access point as far as possible from the contaminated area.
   - This will allow time for the pathogen levels to decrease while also minimizing the movement of contaminated soil on equipment and via wind or water erosion
7. Seed canola early. Early crop establishment has been shown to reduce the effects of clubroot if it is present in a field.

If clubroot is suspected, inform the Saskatchewan Ministry of Agriculture by contacting the Agriculture Knowledge Centre at 1-866-457-2377 or your local Saskatchewan Ministry of Agriculture regional office.

Precautions to take when conducting research

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, this particular kind of field plot research should not be conducted in the province. Preventative measures should also be followed when conducting disease surveys in Saskatchewan.

Contact the Saskatchewan Clubroot Initiative Chair (contact information below) for a copy of the current Recommendations for Managing Risks associated with Clubroot Research in Saskatchewan.

Clubroot surveillance and testing

The best time to scout for clubroot is later in the growing season, around late July or August, since clubroot symptoms take approximately six to eight weeks to develop. The best places to scout for clubroot include the field entrance, low spots or areas with premature ripening.

DNA-based testing (at an accredited laboratory) can be used to detect the clubroot pathogen in soil collected from the field. It is important to note that the occurrence of the clubroot pathogen can be variable throughout a field. Therefore, a negative DNA test only reflects that the pathogen could not be detected (within the detection limit of the test) in the area sampled. This method of testing can provide early detection of the clubroot pathogen at levels lower than those required for obvious disease symptoms to develop under field conditions. Soil samples can be submitted for DNA-based testing at an accredited laboratory to detect the clubroot pathogen at low levels. Soil samples can be collected at any time, but soil should be dried after collection. A list of laboratories that conduct clubroot testing can be found at clubroot.ca.

When sampling or scouting for clubroot, do not drive into the field or field entrance, but park on the road whenever possible, and follow sanitation procedures if visiting more than one field. Dispose of or clean and disinfest footwear and tools that come in contact with the soil. Keep records for all 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, in order to ascertain the extent of infestation.

Plant sampling and field scouting procedure

1. Collect 20 plants at each of five sites in the field, for a total of 100 plants, and observe 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 edge.
2. If patches of premature ripening are observed, particularly in field entrances or corners, dig or pull up plants, shake off excess soil and inspect roots for the presence of galls. If clubroot is suspected, cut off stems and collect root samples.

Air-dry root samples in double paper bags OR freeze the samples in a double Ziploc bag (samples must remain frozen if this option is chosen) and 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 $50 fee for visual inspection. If the visual diagnosis is positive, root samples will be forwarded to an accredited laboratory on behalf of the municipality or the person who submitted the samples for DNA testing. Cost of the DNA testing will depend on the current fee set by the accredited laboratory (approximately $100).

Soil Sampling Procedure

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

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, as well as provide information to the oil and gas industries, environmental companies, landscaping companies, equipment dealers and auction companies and custom applicators, seeders, and harvesters.
- If clubroot is confirmed through disease surveys or reported to the Ministry by an individual or company, the Ministry will first assess whether the report satisfies the requirements of clubroot confirmation. All locations confirmed to have clubroot and/or the clubroot pathogen will be reported to the RM where the field is located. The Ministry will work with the RM, the division Plant Health Officer, and the producer and/or landowner to develop a clubroot management plan that is effective in minimizing the spread of the pathogen to neighboring fields and the severity of clubroot in the infected field(s).
- The Ministry will ensure the grower(s) are informed 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, and advise them what the next steps will be by the Ministry, SaskCanola and RM.
- The Ministry can assist growers in the development of a clubroot management plan for their farm.

Producers and Producer Groups

- Scout canola crops for clubroot symptoms and implement best management practices that adhere to the Saskatchewan Clubroot Management Plan.
- Producer groups including SaskCanola, the Saskatchewan Mustard Development Commission, the Saskatchewan Vegetable Growers Association and the Saskatchewan Seed Potato Growers' Association assist in educating Saskatchewan producers about clubroot prevention and management.
- If clubroot is confirmed, SaskCanola will be informed through the Saskatchewan Clubroot Initiative and may provide a news release following grower notification. The news release will disclose the general area of the clubroot finding, but not the specific area. The RM will determine how and when more specific information will become public information.

Saskatchewan Association of Rural Municipalities (SARM) and RMs

- Help educate Saskatchewan producers about clubroot prevention and management.
- RMs 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 (through the Saskatchewan Clubroot Initiative) and the affected RM will be notified.
- The Ministry will work with the RM and Plant Health Officers through the Plant Health Network to develop a consistent clubroot strategy and management plan, in reference to any relevant bylaws, extension materials and clubroot policies provided by SARM.

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.

Equipment Dealers, Auctioneers and Custom Applicators

- Help educate those purchasing equipment from infested areas (destined for Saskatchewan), as well as the custom application, seeding and harvesting industries about clubroot.
- Take measures such as equipment cleaning to prevent the introduction and minimize the spread of clubroot from infested areas.

Oilfield, Gas, Road Construction and Other Companies Operating on Agricultural Land

- Help educate the Saskatchewan oil, gas and other field operators about clubroot.
- Take measures such as equipment cleaning to prevent the introduction and minimize the spread of clubroot from infested areas.

Saskatchewan Clubroot Initiative

- Provide a forum to represent the interests and views of Saskatchewan's agricultural research and production sectors, producer and other industry groups and municipal government 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 required.
- Help educate the Saskatchewan agriculture, equipment, oil, gas and other industries about clubroot and the economic and agronomic impacts the disease poses.
- The Saskatchewan Clubroot Initiative will be informed of the general location of all confirmed clubroot findings and will determine what extension materials should be developed to inform Saskatchewan producers of the clubroot situation in Saskatchewan.

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 situation. 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 B. Ziesman or E. Willenborg.

Saskatchewan Clubroot Initiative

The Saskatchewan Clubroot Initiative was developed as part of a provincial clubroot management plan to promote awareness and identify priorities for clubroot prevention and management. The membership

includes representatives from the Saskatchewan Ministry of Agriculture, Saskatchewan Crop Insurance Corporation (SCIC), Saskatchewan Canola Development Commission (SaskCanola), SARM, Agricultural Producers Association of Saskatchewan (APAS), Canola Council of Canada, Agriculture and Agri-Food Canada (AAFC), crown corporations and Industry organizations.

Regular communication with and representation to the Saskatchewan Clubroot Initiative also includes Saskatchewan Ministry of Highways, Saskatchewan Ministry of Energy and Resources, Saskatchewan Auctioneers Association, Canadian Association of Agri-Retailers, and private labs and agriculture companies. If you would like to participate in the Saskatchewan Clubroot Initiative, please contact the Saskatchewan Clubroot Initiative Chair.

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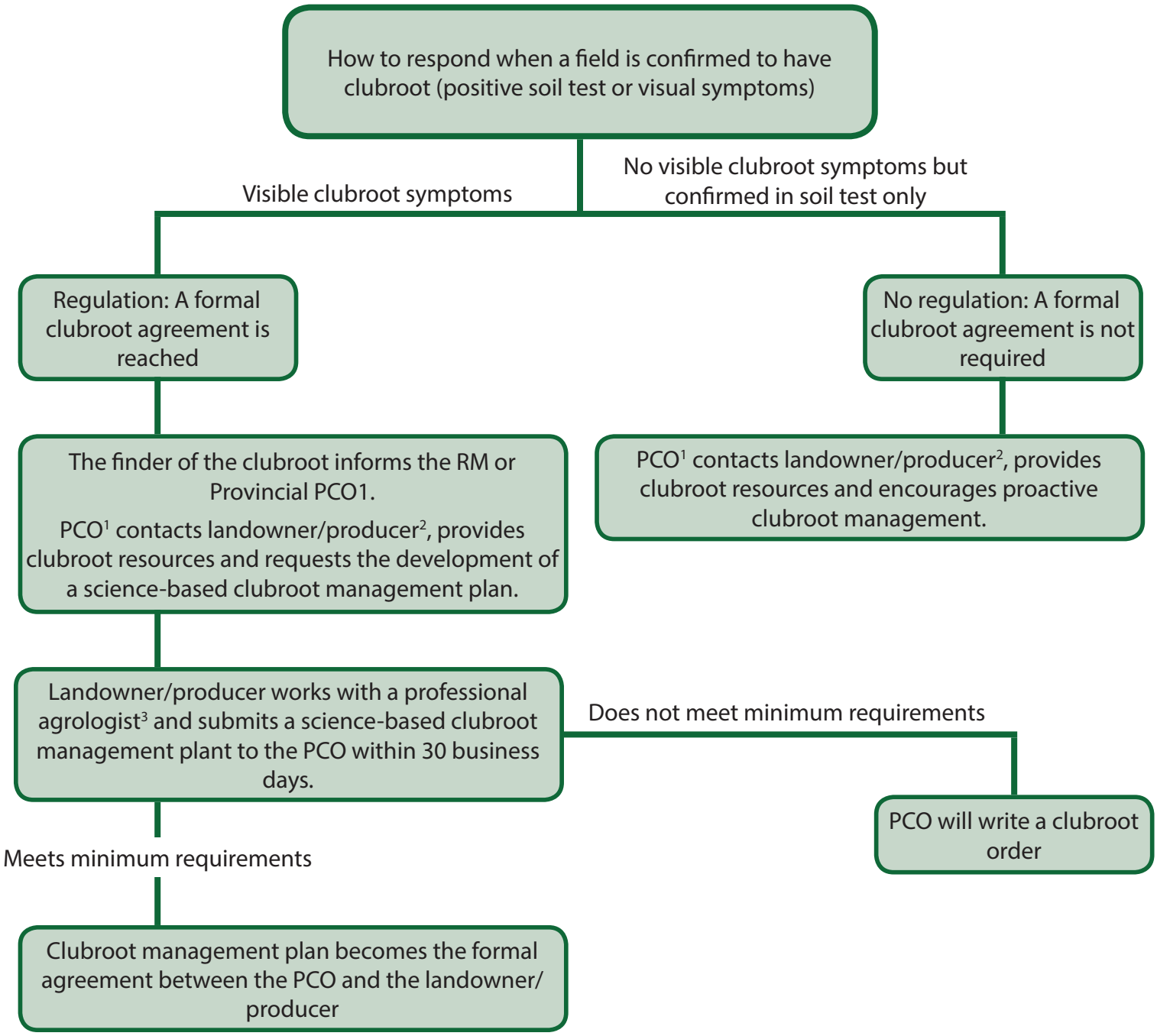
For more information on clubroot, please visit www.clubroot.ca or the Saskatchewan Ministry of Agriculture's website at saskatchewan.ca/crops, or contact the Agriculture Knowledge Centre, toll-free, at 1-866-457-2377 or email aginfo@gov.sk.ca.

Appendix A - The Saskatchewan Ministry of Agriculture's recommended farmer-driven approach to clubroot regulation



Where:

[1] A pest control officer appointed by an RM; a Ministry-appointed pest control officer.
[2] The landowner will be contacted initially. If the landowner rents the land out, preference will be given to a management plan developed by the renter with the assistance of a professional agrologist.
[3] Any agrologist registered with the Saskatchewan Institute of Agrologists (SIA) as a professional or articling agrologist. Includes Ministry staff, Canola Council of Canada, private agrologists or an agrologist hired by an RM.