

APRIL 2016

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Clubroot in Canola – Overview, Identification, Prevention & Management Strategies

1 CEU IN PEST MANAGEMENT

CLUBROOT OVERVIEW

Clubroot is a serious soil-borne disease of cruciferous crops. In canola, it causes swellings or galls to form on the roots, which ultimately causes premature death of the plant. It is caused by a fungus-like protist called *Plasmodiophora brassicae*. Currently, there are no economical control measures that can remove this pathogen from a field once it has become infested. However, it is possible to curtail the spread of the pathogen and reduce the incidence and severity of the disease. Management of infested fields through the combination of scouting and record keeping, sanitation, crop rotation, soil amendments and the cropping of resistant varieties are the most effective methods of controlling this disease.

Clubroot had been seen before in cole crops across Canada; it has been recognized as a problem in *Brassica* vegetable crops (e.g. broccoli, cabbage, radish, rutabaga) in Ontario, Quebec, British Columbia, and Atlantic Canada for several years. However, the first report of this disease in a commercial canola field in western Canada occurred near Edmonton, AB in 2003. Since then, thousands more infested fields have been identified in Alberta. Alberta named the clubroot pathogen as a declared pest in the *Alberta Pests Act* in 2007 and released the *Alberta Clubroot Management Pla*n in 2008 (revised in 2010 and 2014). (http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex11519).

Manitoba has not yet declared clubroot a pest under *The Plant Pest and Disease Act* though it was found in soil tests as early as 2005, and in the field in 2013. Clubroot was declared a pest under The Pest Control Act in Saskatchewan in June 2009, and the disease was found in several fields in 2011 and 2012.

Since clubroot has continued to spread, particularly in Alberta in the Edmonton area, it has become a key disease for the canola industry. Preventing the spread of clubroot spores through contaminated soil movement is critical to managing this disease.

DISEASE CYCLE

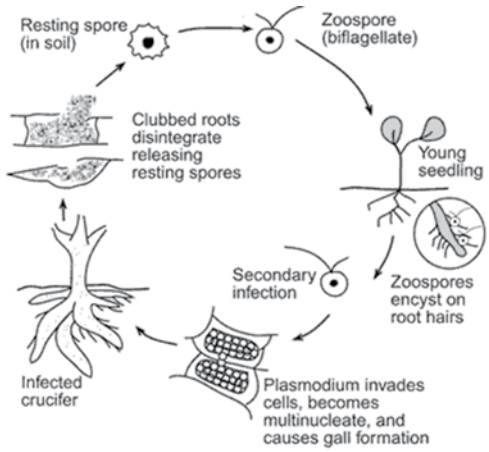

Figure 1. Life cycle of *Plasmodiophora brassicae*, the pathogen that causes clubroot [source: Ohio State University].

SOURCE: This article is adapted from the Canola Council of Canada Website. Summary reprinted with approval from the Canola Council of Canada.

Plasmodiophora brassicae is regarded as a protist, which means it is an organism with plant, animal, and fungal characteristics. *P. brassicae* is an obligate parasite, which means the pathogen can't grow and multiply without a living host, such as canola or other susceptible crops and weeds. The lifecycle of *P. brassicae* is shown in Figure 1.

The pathogen overwinters in the soil as very hardy resting spores. In the spring, the frequency of resting spore germination is stimulated by secretions from the roots of various plants. Resting spores then germinate and transform into zoospores, capable of swimming short distances in water, or water-films in the soil, seeking root hairs to infect. The mobility of these zoospores makes clubroot a very different disease from others in canola. This mobility actually allows the zoospore to "seek out" potential host plants instead of solely relying on random distribution methods like wind or rain (such as with sclerotinia or blackleg, for example). The swimming zoospore phase is short-lived.

After initial infection through root hairs or wounds, the zoospore forms an amoeba-like cell. This abnormal cell multiplies and joins with others to form a plasmodium (a naked mass of protoplasm with many nuclei). The plasmodium eventually divides to form many secondary zoospores that are released into the soil after the host root begins to decompose.

Figure 2. Severe clubroot galls or 'clubs' on canola root.
[Photo courtesy of T.K. Turkington, AAFC Lacombe]

These second generation zoospores re-infect the roots of the initial host or nearby plants and are able to invade the cortex (interior) of the root. Plants with genetic resistance to clubroot function by preventing this invasion from secondary zoospores.

Once in the cortex, the amoeba-like cells multiply or join with others to form a secondary plasmodium. As this plasmodium develops, plant hormones are altered, which causes the infected cortical cells to swell. Clusters of these enlarged cells form clubs or galls (see Figure 2). Some amoeba-like cells are able to move up and down roots in vascular tissue, which is plant tissue that transports nutrients and water throughout a plant. After secondary plasmodia mature, they divide into many resting spores. When the galls are rapidly decayed by soil microbes, millions of long-lived resting spores are left in the soil.

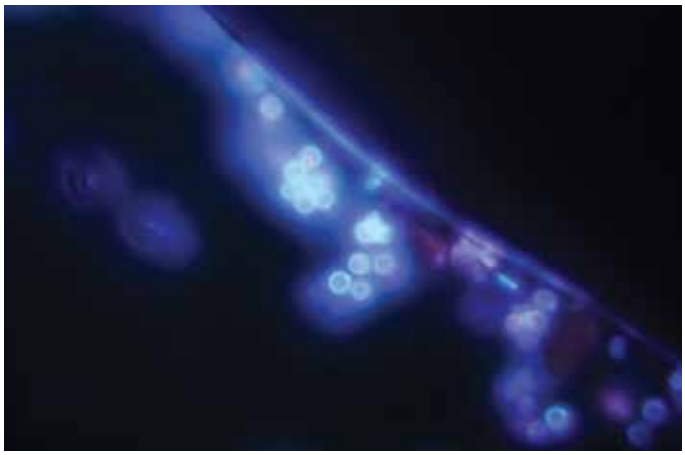

Figure 3: Clubroot resting spores inside a canola root

This longevity of the resting spores is a key reason why clubroot is known as a serious disease (Figure 3). The spores can survive in the soil for up to 20 years. However, many of the resting spores appear to become inactive or non-viable after a 2 year break from a host crop, indicating the importance of crop rotation, weed control and sanitation to help reduce spore loads in the soil. This represents a significant decline in inoculum in the field, but the more spores that start the infection, the more that will remain over time. This is why it is important to prevent major infestations from becoming established in a field using a crop rotation of 3 to 4 years out of a susceptible crop. Under severe infestations, which can occur quickly when a susceptible variety is grown on infested land, much longer periods will be required to reduce inoculum to manageable levels via natural population decline.

ENVIRONMENTAL FACTORS

Warm soil (20-24°C), high soil moisture and acid soil (pH less than 6.5) all favour infection and the severity of disease development. Soils with a pH over 7.2 tend to inhibit spore germination and disease development, although the disease can still develop. High pH soils will not prevent *P. brassicae* from arriving in a field, nor prevent the disease from infecting susceptible plants, and nor will it prevent yield loss from occurring. Liming fields to a pH>7 will be most successful under low levels of infestation and become less effective under high spore loads in the soil. So liming proactively or when soil infestations are **discovered early** will help reduce the severity and impact of the disease. This is another beneficial practice which **relies on intensive scouting and early detection of clubroot**.

Areas of a field with more soil moisture typically see the most severe infestations. These wet areas are found in depressions, spots with higher clay content, or with subsoil horizons that result in poor water infiltration (such as Gray Wooded or solonetzic soils).

YIELD LOSS

Yield loss is dependent on many factors including time of infection, soil moisture and temperature, spore load, soil pH, soil texture, host genotype, and pathogen pathotype. An early infection with favourable conditions and moderate to high spore loads can lead to 100% loss, while low spore loads with less favourable conditions may result in little or no yield loss.

IDENTIFICATION

Roots of infected plants become malformed due to increased cell division and growth, which leads to the development of galls. Clubroot galls tie up nutrients, and severely infected roots can't transport adequate water and nutrients to aboveground plant tissues.

Depending on local conditions and timing, clubroot infected canola may look very similar to canola suffering from other diseases or environmental stresses (Figure 4). Patches of prematurely ripening canola due to clubroot infection could be confused with other diseases such as sclerotinia, blackleg or fusarium wilt, or moisture stress (drought, waterlogging) if only viewed from a distance.

Figure 4. Clubroot causes drought-stress in canola plants.
[©Monsanto Canada Inc. Used with permission]

Symptoms in the field will vary depending on the growth stage of the crop when infection occurs, the level of infection and conditions after infection takes place. Early infection at the seedling stage can result in wilting, stunting, yellowing and even death of canola plants in the late rosette to early podding stage.

Since above-ground symptoms of clubroot may be incorrectly attributed to moisture stress or to diseases such as blackleg, fusarium wilt or sclerotinia, proper diagnosis of clubroot should always include digging up plants to check for gall formation on roots (see Figure 5).

Typically, it takes six to eight weeks from initial infection to gall formation, but this depends on when the field receives rain. The best time to scout for clubroot symptoms on roots is late in the season, approximately two weeks before swathing, since root galls should be easy to identify at this time (see Figures 6 to 9).

Infection that occurs at later crop stages may not show plant wilting, stunting or yellowing. However, infected plants may ripen prematurely, resulting in shrivelled seeds, negatively impacting both yield and quality (oil content).

Another good option is to identify patches of concern while swathing and sample afterwards. Since the entire field is traversed during swathing, this will give the most detailed indication of the incidence in the field. If suspicious plants are not sampled until several weeks after swathing, the root galls may have decayed already, and typical whitish galls will no longer be present. Instead, the decayed galls give roots a brown, peaty appearance (See Figures 9 and 10) rather than the healthy white colour associated with normal roots.

Figure 5. Always dig up roots when scouting for clubroot
[Photo courtesy of Parkland County Agricultural Services, Alberta Canada]

Figure 6. Initial infection with small gall formed on a lateral root.
[©Monsanto Canada Inc. Used with permission]

Figure 7. The small galls begin to expand as the infection progresses
[©Monsanto Canada Inc. Used with permission]

Figure 8. At later stages as the plant begins to die, the galls become "woody" in appearance. [©Monsanto Canada Inc. Used with permission]

Figure 9. As galls decay, they become "peaty" in appearance. [©Monsanto Canada Inc. Used with permission]

Clubroot infects all species of plants in the Crucifer (Brassicaecea) family. Weeds such as Shepherd's purse, stinkweed, flixweed, wild mustard and many others in this family will carry and increase this disease.

Hybridization nodules on canola roots (see Figure 10), although rare, could be confused with clubroot galls although these appear as small, round nodules located at root nodes. The interior texture of a clubroot gall is spongy or marbled, while hybridization nodules are uniformly dense inside, like healthy roots. Also, hybridization nodules will not decay rapidly to a peaty appearance like clubroot galls.

Figure 10. Hybridization nodules on canola root [Photo courtesy of Alvin Eyolfson, Battle River Research Group].

PREVENTION STRATEGIES

Since the clubroot pathogen and primary disease symptoms all occur underground, it is crucial to scout fields throughout the season and pull up roots to look for symptoms. Clubroot is spread by the movement of soil containing soil-borne resting spores. Soil transport occurs mainly on farm machinery. Clubroot surveys in Alberta have found that almost all new infestations begin near the field access, which indicates that contaminated equipment is the predominant spread mechanism. Any vector that moves soil will move this disease. Wind and water erosion, recreational vehicles, livestock, manure, hay, seed potatoes, common (uncleaned and untreated) seed, exploration/construction equipment, and even footwear may also move this pathogen. The amount of soil required to initiate infection in a new field depends on the number of spores in the soil being moved. Heavily infested soil requires significantly less soil to initiate infection than lightly infested soil. But in general, those vectors that move the greatest amount of soil are the greatest risk. Therefore, any soil transfer from an infested field should be viewed as a risk.

Figure 11. Cleaning farm equipment

The best approach to managing clubroot is to be proactive. If you are a visiting grower or landowner, ask before coming onto their land about the sanitation measures they use to prevent the spread of clubroot.

Any individual who contacts agricultural soil should consider the risks of moving *P. brassicae*. These are some strategies that may help prevent the movement of this pathogen:

1. **Practice good sanitation** to restrict the movement of possibly contaminated material (this approach will help reduce the spread of other diseases, weeds and insects too). The equipment cleaning procedure (Figure 11) involves knocking or scraping off soil lumps and sweeping off loose soil. The level of sanitation should be based on the level of perceived risk. Equipment moving from infested fields to non-infested fields is high risk and should be sanitized to the highest degree.
2. **Restrict access to fields** if a risk of transfer of infested soil is perceived.
3. **Avoid common untreated seed.** Earth-tag on seed from infested fields could introduce resting spores to clean fields.
4. **Avoid the use of straw bales and manure from infested or suspicious areas.** Clubroot spores are reported to survive through the digestive tracts of livestock.

5. **Plant clubroot-resistant varieties on fields with no history of this disease if clubroot is in your community.** This strategy relies on the genetic resistance to greatly reduce disease development/establishment compared to susceptible varieties if clubroot is inadvertently introduced to the field.
6. **Use direct seeding and other soil conservation practices to reduce erosion.** Resting spores move readily in soil transported by wind or water erosion and overland flow.
7. **Use clubroot resistant varieties in long rotations.** While a long canola rotation will not prevent *P. brassicae* from being introduced to your farm, nor prevent this pathogen from being spread around the field and to other fields, long rotations will help prevent the build-up of clubroot resting spores. Growers in clubroot-infested areas should grow resistant varieties, and preferably only once every four years in order to reduce soil inoculum levels and preserve existing clubroot resistance for their farms for as long as possible.

MANAGEMENT STRATEGIES

Managing clubroot after establishment in a canola field is difficult. Canola growers are encouraged to use multiple tools (rotation, sanitation, amendments, etc.) to manage clubroot as this will give the best long-term control.

GENETIC RESISTANCE

Genetic resistance to clubroot is available in a number of canola cultivars. The resistance is very effective and can reduce disease loss to zero. However, the resistance is not durable when used in short rotation situations in heavily infested areas. The pathogen has many naturally-occurring pathotypes in each soil population, and will commonly have at least one pathotype capable of causing disease on the resistant canola plants. These rare pathotypes start out at very low, almost non-detectable, levels in the soil population, but quickly multiply when resistant canola is grown repeatedly. The loss of disease control can be detected after two or three exposures to the resistant cultivar. In order to prevent or postpone loss of control, the following principles should be used:

1. Scout for clubroot, even in resistant canola cultivars
2. Avoid growing canola more than once every 4 years in the same field
3. Do not plant canola in heavily infested fields
4. When scouting, if one finds infection rates of greater than 10% of seeded plants (do not count volunteers) then that may indicate that the clubroot resistance is no longer functional against the pathogen population in the field. These infected plants may be restricted to a small patch which indicates a recent pathogen change.

ROTATION

Long canola rotations will help to prevent the build-up of clubroot resting spores when used in conjunction with clubroot resistant varieties, and will help preserve the effectiveness of our resistance. Growers in clubroot-infested areas should grow canola only once every four years in order to reduce soil inoculum levels and preserve existing clubroot resistance for their farms for as long as possible.

But it is important to understand what a long canola rotation will not accomplish:

- it will not eliminate *P. brassicae* from an infested field,
- it will not prevent clubroot from being introduced to a field,
- it will not prevent clubroot from being spread throughout a field,
- nor will it prevent clubroot from being spread to another field.

There has been one report from Norway of lower clubroot severity under reduced tillage. Reduced tillage or direct seeding also may help combat a clubroot infestation in Canada. Fewer tillage operations will help prevent movement of contaminated soil within a field and between fields.

FUNGICIDES

Currently there are no registered fungicides for clubroot control or suppression in canola. Although there are fungicides registered for clubroot control in cole crops around the world, the relatively high cost and application method (transplant bed drench or broadcast incorporation) make them uneconomical for canola on a field scale.

The effectiveness of seed treatments for managing traces of clubroot on seed surfaces is currently being explored.

LIMING

Liming acid soils to above pH 7.2 has shown erratic results for clubroot control in cole crops in British Columbia and eastern Canada. Other countries have had moderate success with liming lightly infested fields or liming prior to infection. Canadian researchers are continuing work with soil amendments.

BAIT CROPS

Recently completed research at two highly infested field sites in Alberta found that bait crops had no effect on clubroot severity. In a bait crop situation, plants that are sensitive to clubroot are allowed to grow for approximately four to five weeks to stimulate germination of the clubroot resting spores. The sensitive crop is ploughed down before the clubroot pathogen completes its lifecycle, which prevents the addition of more resting spores to the soil. This strategy helps draw down the population of resting spores in that field, which may shorten the time needed between plantings of a commercial canola crop. Although the Alberta research indicates that bait crops are not useful in severe infestations, they might be useful in light infestations.

MORE INFORMATION

More information about clubroot identification, prevention and control strategies can be found through the Canola Council of Canada at www.clubroot.ca.

You may also wish to view this video provided by Canola Council of Canada as supplemental viewing. This is not required for the Examination. https://www.youtube.com/watch?v=3dyQhsqIu0o