

## Clubroot Disease of Canola and Mustard

Clubroot is a serious soil-borne disease of cruciferous crops (canola and cabbage family) worldwide and was first identified in Europe in the thirteenth century. This disease is a major problem in cole crops (cruciferous vegetables) in some areas of British Columbia, Quebec, Ontario and the Atlantic provinces.

There have been two previous reports of clubroot in cole crops in Alberta. So, clubroot is **not a new disease** in Canada or Alberta. However, in 2003, clubroot was confirmed in several canola fields near Edmonton, Alberta, which was the first report on canola in western Canada.

Clubroot has continued to spread in the Edmonton area, mainly in the counties of Sturgeon, Parkland, Leduc and Strathcona.

The disease can affect broccoli, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, kale, kohlrabi, radish, rutabaga and turnip. Canola/rapeseed and mustard are also susceptible to this disease. There are several weak, non-cruciferous hosts, but their contribution to disease development and carryover of the clubroot pathogen is not well known.

Clubroot was added as a declared pest to Alberta's *Agricultural Pests Act* (APA) in April 2007. The APA is the legislative authority for enforcement of control measures for declared pests in Alberta. The Minister of Alberta Agriculture and Food is responsible for this Act.

However, enforcement of pest control measures is the responsibility of the municipal authority, and Agricultural Fieldmen are responsible for enforcing pest control measures in their municipalities. Pest inspectors have the power to enter land at a reasonable hour, without permission, to inspect for clubroot and collect samples. The owner or occupant of the land has the responsibility for taking measures to prevent the establishment and spread of clubroot.

This factsheet contains current information about clubroot in canola and describes options

for Canadian canola growers to prevent this disease from being introduced and becoming well established in their fields.

### The disease cycle

The causal agent of clubroot is *Plasmodiophora brassicae* Woronin. In the past, this agent has been classified as a slime mould fungus (myxomycete), but more recently, it is regarded as a protist (an organism with plant, animal and fungal characteristics).

There are normally several different races or pathotypes in established infestations. *Plasmodiophora brassicae* is an obligate parasite, which means the pathogen cannot grow and multiply without a living host. The life cycle of *P. brassicae* is shown in Figure 1.

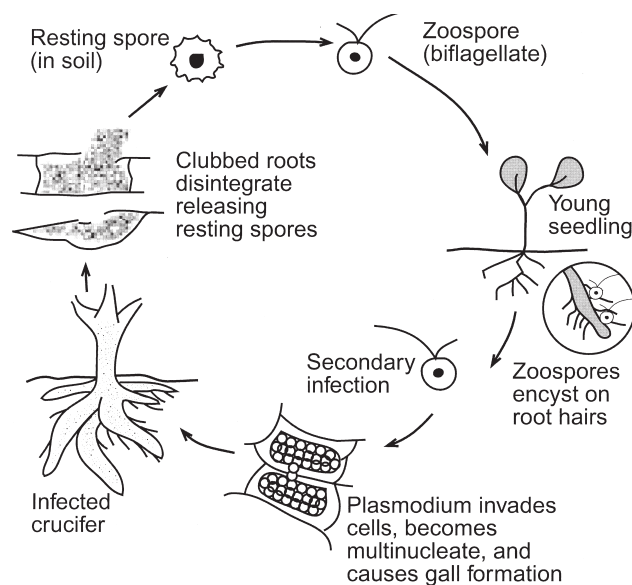


Figure 1. Life cycle of *Plasmodiophora brassicae*, the pathogen that causes clubroot (source: Ohio State University).

Resting spores germinate in the spring, producing zoospores that swim in soil water to root hairs. These resting spores are extremely long lived, with a half-life of about 4 years, but they can survive in soil for up to 20 years. For example, Swedish research in clubroot-infested spring rapeseed fields found that 17 years were needed to reduce the infestation to non-detectable limits.

The longevity of the resting spores is a key factor contributing to the seriousness of the disease. Resting spore germination is stimulated by exudates from the roots of host plants.

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

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. 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 Figures 2, 3 and 4).



Figure 2. Very severe clubroot on canola.

Kelly Turkington



Figure 3. Severe clubroot galls or “clubs” on canola root.

Kelly Turkington



Figure 4. Moderately infected canola root.

Valerie Sowiak

Some amoeba-like cells are able to move up and down roots in vascular tissue. After the secondary plasmodia mature, they divide into many resting spores. The galls are quickly decayed by soil microbes, leaving millions of resting spores in the soil.

Although there are no airborne spores released by this pathogen, the resting spores are capable of moving with infested soil transported by wind or water erosion and field machinery.

Warm soil (20-24°C), high soil moisture and acid soil (pH less than 6.5) are environmental factors that favour infection and severe disease development. Unfortunately, these conditions exist in a significant portion of the traditional canola growing areas of Alberta.

High soil moisture areas of the field typically have the most severe infestations. These wet areas are found in depressions, spots with higher clay content or with subsoil horizons that cause poor water infiltration (such as Gray Wooded or solonchic soils).

## Clubroot symptoms on canola and mustard

Clubroot galls are a nutrient sink, so they tie up nutrients, and severely infected roots of canola cannot transport sufficient water and nutrients for aboveground plant parts. Symptoms will vary depending on the growth stage of the crop when infection occurs. Early infection at the seedling stage can result in **wilting, stunting and yellowing** of canola plants in the late rosette to early podding stage.

Such symptoms may be wrongly attributed to heat stress during periods with high temperatures or to other diseases such as blackleg or fusarium wilt. In such cases, proper diagnosis includes digging up wilted plants to check for gall formation on roots (see Figures 2, 3 and 4).

Infection that occurs at later crop stages may not show plant wilting, stunting or yellowing. However, infected plants will **ripen prematurely** and seeds will shrivel. Thus, yield and quality (oil content) are reduced.

Swedish researchers found that infestations nearing 100 per cent affected plants caused about 50 per cent yield loss, while infestations of 10 to 20 per cent led to 5 to 10 per cent yield loss. This result is similar to sclerotinia stem rot infection in canola in which, as a general rule of thumb, the yield loss estimate is half of the percentage of infected stems. This comparison is a reasonable one since both diseases restrict the flow of water and nutrients to developing seeds.

Patches of prematurely ripening canola due to clubroot infection (Figure 5) could be confused with other diseases such as sclerotinia, blackleg and fusarium wilt. In such cases, proper diagnosis should include digging up affected plants to check for gall formation on roots.



Figure 5. Patchy, premature ripening.

Stephen Strelton

If the suspected plants are not sampled until after swathing, the root galls may have decayed already, and typical whitish galls will no longer be present (see Figure 6). Instead, the decayed galls cause roots to have a brown peaty appearance rather than a healthy white colour, which should be a signal to carefully dig up more roots for closer inspection.



Kelly Turkington

Figure 6. Decayed clubroot galls and whitish stem appearance.

Hybridization nodules on canola roots (see Figure 7), although rare, could be confused with clubroot galls, but they 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. Furthermore, hybridization nodules will not decay rapidly to a peaty appearance like clubroot galls do.



Rob Dunn

Figure 7. Hybridization nodules on canola root.

For confirmation of suspected canola root galls, send samples to

Dr. Stephen Strelkov  
410 Agriculture/Forestry Centre  
Department of Agricultural, Food and Nutritional Science  
University of Alberta  
Edmonton, Alberta, T6G 2P5

## Prevention and management of clubroot in canola and mustard

Since clubroot infestations are still not widely distributed in Alberta, various precautionary measures should be taken by producers to curb the spread of this disease outside the known infested areas. Growers should be vigilant to prevent the introduction of clubroot to clean fields because few economic options currently exist to control infestations in canola.

Recommended preventative measures include the following:

- Use long rotations: canola every four years or more. Although this practice will not prevent the introduction of clubroot to clean fields, it will restrict this and other disease development within the field and probably avert a severe infestation.
- 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 resting spores are most likely to spread via contaminated soil and infected canola plant parts. Thus, **producers should follow the practice of cleaning soil and crop debris from field equipment before entering or leaving all fields.** The equipment cleaning procedure involves knocking or scraping off soil lumps and sweeping off loose soil.  
For risk-averse producers, the following additional cleaning steps may provide some extra benefit, but they involve considerably more work and expense:
  - After removing soil lumps, wash the equipment off with a power washer, preferably with hot water or steam.
  - Finish by misting equipment with a weak disinfectant (1-2% household bleach solution).
- Use direct seeding and other soil conservation practices to reduce erosion. Resting spores move readily in soil transported by wind or water erosion and by overland flow.
- Scout canola fields regularly and carefully. Identify causes of wilting, stunting, yellowing and premature ripening – do not assume anything!

- 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.
- Avoid common untreated seed (including canola, cereals and pulses). Earth-tag on seed from infested fields could introduce resting spores to clean fields. Certain seed treatment fungicide may control spores on contaminated seed, but this observation needs further research to confirm its validity. **Note: the risk of spreading clubroot by contaminated seed or straw is much less than by the transportation of contaminated field equipment.**

**Managing clubroot after establishment in a canola field is difficult.** There is no known clubroot resistance in current Canadian canola varieties. Partly resistant varieties in Europe have race-specific resistance that is not durable.

There are at least two prevalent clubroot races or pathotypes in the Alberta infestations, with one pathotype dominating. However, the characterization of single spore-derived isolates from the populations indicates that they may consist of mixtures of pathotypes.

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 unsuitable for canola field production.

Liming acid soils to above pH 7.2 has shown poor or erratic results for clubroot control in cole crops in British Columbia and eastern Canada. Given the inconsistency and high cost of the practice, liming is not a reliable option for clubroot control in canola.

Calcium cyanamide, an old form of nitrogen fertilizer with fungicidal properties, has shown promise for reducing clubroot in cole crops, but high application rates, significant cost and limited availability make it a poor option for canola.

**Long rotation out of canola is the only strategy to cope with clubroot infestations in Alberta at the present time.** Canola, mustard, kale and cole crops should not be grown **for at least four years in slightly infested fields and seven years in severely infested fields.**

A new molecular test (PCR) is being commercialized that may prove useful for measuring the remaining infestation in a field after a certain number of years. For example, testing soil samples after three years have elapsed in an infested field could indicate whether the infestation has declined to low enough levels such that canola could be re-seeded without economic yield losses.

Volunteer canola and susceptible weeds (mustard family, dock and hoary cress) must be controlled in the rotation crops. There is some evidence that a few non-cruciferous crops, such as orchardgrass and red clover, may be weak hosts for clubroot disease, but the rotational effect of such crops on clubroot incidence and severity is likely of little practical significance.

**In combination with the rotation strategy, sanitation and soil conservation measures should be practiced to keep contaminated soil and infected crop debris from being transported from infested fields.** Whenever practical, infested fields should not be worked in when wet since more mud will stick to equipment and then be transported to clean fields.

There has been one report from Norway of lower clubroot severity under reduced tillage. Thus, reduced tillage or direct seeding may help combat a clubroot infestation. Also, fewer tillage operations will help avoid the movement of contaminated soil. Similarly, all equipment traffic into infested fields should be minimized. For example, service and nurse trucks should remain on the road and field equipment should be brought to them.

## References

- Cao, T., Tewari, J.P., and Strelkov, S.E. 2007. Molecular detection of *Plasmodiophora brassicae*, causal agent of clubroot of crucifers, in plant and soil. *Plant Dis.* 91:80-87.
- Ekeberg, E. and Riley, H.C.F. 1997. Tillage intensity effects on soil properties and crop yields in a long-term trial on morainic loam soil in southeast Norway. *Soil & Tillage Res.* 42: 277-293.
- Friberg, H., Lagerlof, J., and Ramert, B. 2006. Usefulness of nonhost plants in managing *Plasmodiophora brassicae*. *Plant Pathol.* 55:690-695.
- McDonald, M.R., Kornatowska, B. and McKeown, A.W. 2002. Management of clubroot of Asian Brassica crops grown on organic soils. Abstract S08-0-11, XXVI<sup>th</sup> International Horticulture Congress, Toronto.
- Strelkov, S.E., Tewari, J.P., and Smith-Degenhardt, E. 2006. Characterization of *Plasmodiophora brassicae* populations from Alberta, Canada. *Can. J. Plant Pathol.* 28:467-474.
- Tewari, J.P., Strelkov, S. E., Orchard, D., Hartman, M., Lange, R., and Turkington, T.K. 2005. Identification of clubroot of crucifers on canola (*Brassica napus*) in Alberta. *Can. J. Plant Pathol.* 27:143-144.

Tremblay, N., Bélec, C., Lawrence, H., and Carisse, O. 1999. Clubroot of crucifers – control strategies. Agriculture and Agri-Food Canada. Saint-Jean-sur-Richelieu, PQ. 3 pp.

Wallenhammar, A.C. 1996. Prevalence of *Plasmodiophora brassicae* in a spring oilseed rape growing area in central Sweden and factors influencing soil infestation levels. *Plant Pathol.* 45:710-719.

Wallenhammar, A.C., Johnsson, L., and Gerhardson, B. 1999. Clubroot resistance and yield loss in spring oilseed turnip rape and spring oilseed rape. Proceedings of 10<sup>th</sup> International Rapeseed Congress, Australia.

### Prepared by

Murray Hartman  
Oilseed Specialist  
Alberta Agriculture and Food

### Contributions from plant pathologists

J.P. Tewari, Kelly Turkington, Ralph Lange, Stephen Strelkov, Ron Howard and Paul Laflamme.