

## CLUBROOT OF BRACCICAS

Clubroot, caused by *Plasmodiophora brassicae*, is an important disease of brassicas. The disease was first identified in the 1870s in St. Petersburg, Russia. Clubroot is a soilborne disease and is present in all brassica-producing countries, particularly in humid, temperate regions. The pathogen attacks the roots of cabbage, cauliflower, broccoli, Brussels sprouts, turnip, radish, mustard, oilseed rape, and rutabaga. Clubroot reduces yields, quality, and palatability of stock-feed brassicas. The pathogen can survive in the soil up to 20 years. Clubroot symptoms are specific to brassicas, but the pathogen also capable of invading root hairs of nonbrassica plants, including grasses and dicotyledons.



**Figure 1.** Localized area in a cauliflower field with clubroot pathogen. (Courtesy R. Smith and S. Koike).

### Symptoms

Typical clubroot symptoms are swelling and contusion of the host roots and hypocotyl. Fibrous-rooted cole and oilseed crops form a mass of coralloid galls when infested (Figures 1 and 2). Galls on hypocotyls of rutabaga and turnip may partially or completely cover the surface and also affect the taproot and secondary roots (Figure 3). The extent of galling varies with plant age, morphology of roots, and more importantly, the period over which the plant is exposed to infection and reinfection. Once clubs being forming, growth is almost entirely directed to the swelling galls. Only rarely are infected plants killed, but they have fewer, smaller leaves and blue-green foliage and show wilt symptoms under even light water stress. Early in the season, the galls are firm and white inside; later they turn brown and start to decay.



**Figure 2.** Clubbing of broccoli roots (Courtesy NCSU).

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## Disease cycle

The pathogen may survive for years as dormant mycelia in infected seeds. *P. brassicae* is an obligate parasite and can only reproduce in the root tissue of the host. The pathogen survives dormant in soil as thick-walled hyaline resting spores of various diameters up to 4  $\mu$ . Resting spores germinate to form thin-walled biflagellate, primary zoospores. The primary plasmodium formed in root hairs of the host, consists of naked, multinucleate masses of protoplasm containing 30-100 nuclei. These give rise to multinucleate zoosporangia, which release zoospores. The secondary zoospores invade the cortical tissue and give rise to secondary plasmodia. Each plasmodium is surrounded by a seven-layered envelope, the outer portion being of host origin.

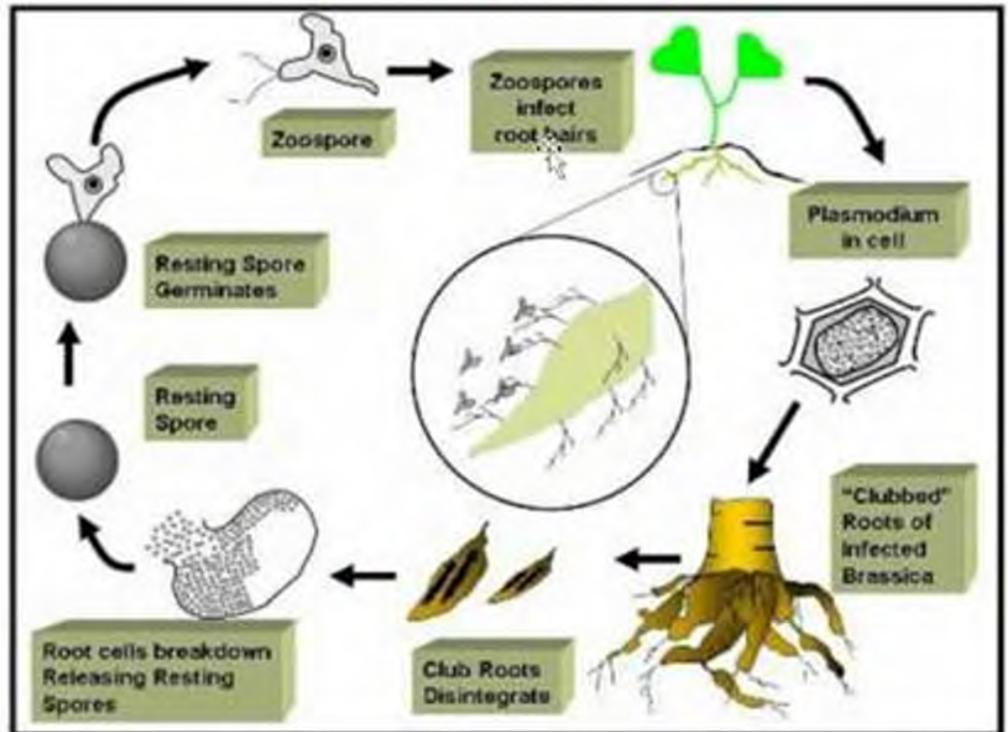
Many aspects of biology of *P. brassicae* remains unresolved, especially the link between development of primary plasmodia in root hair cells and the later production of secondary plasmodia with the root cortex. Most resting spores of the pathogen are concentrated in the upper soil profiles, the concentration decreasing with depth. Spore dissemination is via drainage and irrigation water, materials originating from infested roots, and wind-borne soil particles. Contaminated transplants are a major means of long-range spread. Resting spores can remain viable in soil for decades. In the presence of suitable hosts, resting spores germinate, forming primary zoospores.

## Disease management

- Prevent introduction of clubroot pathogen to the field. Once the pathogen is established in a field, eradication is improbable, and several management practices must be implemented to reduce levels of inoculum and viability of the pathogen.
- Use *P. brassicae*-free transplants.
- Sanitize infested tools and equipment. Disinfestation can be achieved by 1% bleach solution.



**Figure 3.** Club root of rutabaga (Courtesy OSU, A. L. Heinrich).



**Figure 4.** Life cycle of clubroot of brassicas (Courtesy YouTube).

- Use lime to increase soil pH above 7.0 (7.1-7.3). This is a traditional method of clubroot control over several centuries. However, this is not a totally reliable technique. The form of calcium influences efficacy against *P. brassicae*. Calcium cyanamide, for example, has been reported as an effective control agent.
- Consider crop rotation with nonhost crops for  $\geq 3$  years to reduce the clubroot infestation. Corn and alfalfa have been reported good nonhost crops for reducing clubroot infestation.
- Plant resistant or less susceptible cultivars, if available.
- Cultivate soil to reduce concentration of clubroot pathogen.
- Avoid poorly-drained soils with history of clubroot.
- Avoid water run-off.
- Eliminate weedy host and volunteer brassicas to reduce the incidence of the disease.
- Fungicides Blocker 4F (PCNB) and Omega 500F have been registered for managing clubroot of brassicas. For the up-to-date information on using chemicals for managing clubroot of brassicas, refer to the Midwest Vegetable Production Guide for Commercial Growers (<https://mwvegguide.org/uploads/pdfs/2022-Midwest-Veg-Guide-8.5-x-11-with-covers-no-bleeds-bookmarked-compressed.pdf>).