



## Clubroot of cruciferous crops

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*This Agriculture Note describes clubroot, a persistent and devastating disease of cruciferous crops (ie. cabbage, cauliflower, chinese cabbage, broccoli, brussels sprouts, turnip and radish)*

### Caused by

A fungus that lives in the soil

### Scientific name

*Plasmodiophora brassicae*

### Introduction

Clubroot is a most persistent and devastating disease of cruciferous crops. This disease is widely distributed where these crops are grown and is particularly severe in older market garden areas.

### Symptoms

Infection occurs on roots at any stage of growth. Symptoms do not become obvious until knotted swellings form on the roots.

The first above ground symptom is usually wilting, particularly during hot-dry weather. Severely diseased plants are generally stunted, and the foliage may be different in colour from healthy plants.

Infected roots show characteristic swellings or knots. Normal root growth does not occur on severely infected taproots of young plants which form a single-clubbed root.



*Figure 1. Clubroot galls on broccoli roots.*



*Figure 2. Chinese cabbage affected by clubroot.*

### Biology

#### Survival

*P. brassicae* spores can remain viable in the soil for at least 20 years, even in the absence of a susceptible host.

Resting spores germinate under moist conditions and release swimming spores that infect tiny root hairs. The fungus multiplies rapidly in the root hair and releases more swimming spores which reinfest the roots. During the secondary stage of the lifecycle, the fungus continues to multiply within the root causing the root tissues to swell. This leads to the formation of galls which are characteristic of clubroot.

Infected root cells contain millions of fungal spores. After the roots decay, spores are released into the soil where they remain dormant until conditions are suitable for germination, eg when another cruciferous crop is grown.



*Figure 3. Numerous resting spores of clubroot in plant cells from a gall.*

### Dispersal

The fungus can be spread on or in anything that may carry contaminated soil from place to place. Farm machinery, boots, animals, the dung of animals that have eaten diseased roots, and compost containing remains of a diseased crop are some of the means of spreading clubroot.

The most important means of spread is on the roots of infected transplants, contaminated irrigation water and surface flood water. Reports indicate that dam water, especially water from dams receiving runoff from infected fields, can become contaminated with the fungus.

Spore dispersal by wind is also possible, especially under dry conditions. Seed may become contaminated, especially if it comes into contact with contaminated water or soil.

### Environmental conditions

Infection by *P. brassicae* depends on high soil moisture and disease development is favoured by soil temperatures between 20 to 25°C, although infection can also occur at temperatures as low as 12°C. Clubroot is more prevalent on poorly-drained soils, particularly low-lying areas.

Clubroot is more pronounced in acidic soils (pH<7.0), although at high spore concentration levels the disease can develop in alkaline soils (pH>7.0). Crop losses are most severe in warm-moist soils (generally between October to April) which are heavily infested with *P. brassicae*.

### Host range

The fungus infects a wide range of hosts, including some non-cruciferous plants (Table 2), however typical clubroot symptoms are only seen on members of the cabbage family.

In Victoria, clubroot has been recorded on cabbage, cauliflower, chinese cabbage, broccoli, brussels sprouts, turnip and radish. Clubroot has been recorded elsewhere on other crops, including rape, kale, swede and mustard, and also on cruciferous weeds and flower crops.

## Control

### Prevention

Management practices that can be used to reduce build up and spread of disease include:

### Seedlings

- Use only disease-free transplants obtained either as cell-grown seedlings in a pasteurised soil mix, or from an open seedbed which is disease-free or pretreated with appropriate soil fumigants.
- Isolate seedbed from other diseased areas and avoid contaminating the area with diseased soil or water.
- Ensure seed beds are maintained free of cruciferous weeds.

### In the field

- Include several non-cruciferous crops in the rotation.
- Avoid cropping crucifers more than once every two years in infested sites.
- Add lime to responsive soils to increase pH above 7.0. In some soils, large amounts of lime may be required. Be careful, because such applications may result in nutritional problems or encourage diseases such as common scab in potatoes and white rot in onions.
- Practice weed control, especially in infested sites, to reduce build up of clubroot spores on weed hosts. See Table 1 and 2 for examples of alternate hosts.
- Clean machinery thoroughly before moving cultivation and planting equipment from infested fields to non-infested fields.
- Avoid over-watering the soil and using practices that flood the soil, such as furrow irrigation. Do not use water from dams receiving run-off from infested soils.
- Improve drainage in poorly drained soils and low-lying areas.
- Dispose of or burn diseased material. Do not throw infested seedlings near waterways or dams; use waste dumps and other industrial waste facilities.
- Do not use manure as a fertiliser if animals have been fed diseased roots because some spores can remain viable after passing through animals' guts.
- Increase soil concentrations of beneficial plant nutrients (calcium, boron and magnesium).
- Use high-analysis fertilisers.

### Chemical control

**Warning: These compounds are toxic; seek advice on their use from your local supplier or professional fumigation contractor.**

#### Fungicides

Fungicides currently registered for clubroot control in Victoria include PCNB (Terraclor, Barmac Chloroturf, Barmac Chloroturf DG, and Purasoil), and Fluzinam (Shirlan).

#### Fumigants

Fumigate seedbeds especially if there is a likelihood of contamination with *P. brassicae*.

Fumigants currently registered for clubroot control in seedbeds and/or the field include Dazomet (Basamid granular), and Metham sodium (Metham).

### Solarisation

Solarisation is a safe, non-chemical method for controlling clubroot, particularly for treating seedbeds (this treatment is more effective when combined with low doses of fumigants). If the fumigant is applied in bands two weeks before transplanting, then this technique may be adapted to large-scale field production.

Solarisation is only economic to use on heavily-infested fields during periods of high temperature (January and February).

**Table 1. Common cruciferous weeds susceptible to infection by *P. brassicae*. \***

Common name	Botanical name
Bird rape	<i>Brassica campestris</i> L.
Wild turnip	<i>B. tournefortii</i> . Gouan
Shepherd's purse	<i>Capsella bursa-pastoris</i> (L.)Medikus
	<i>Conringia orientalis</i> (L.) Dumort
Wild cabbage	<i>Diplotaxis tenuifolia</i> (L.) DC
Sand mustard	<i>Lepidium campestre</i> (L.) R.Br.
Field cress	<i>Myagrum perfoliatum</i> L.
Musk weed	<i>Raphanus raphanistrum</i> L.
Wild radish	<i>Raphanus rugosum</i> (L.) All
Turnip weed	<i>Sinapsis arvensis</i> L.
Charlock	<i>Sisymbrium officinale</i> (L.) Scop.
Hedge mustard	<i>Vella annua</i> L.
Wards weed	

**Table 2. Non-cruciferous plants susceptible to infection by *P. brassicae*. \***

Common name	Botanical name
Creeping bent grass	<i>Agrostis alba</i> (L.) var stolonifera
Cocksfoot	<i>Dactylis glomerata</i> L.
Strawberry	<i>Fragaria</i> sp.
Yorkshire fog grass	<i>Holcus lanatus</i> L.
	<i>Lolium perenne</i> L.
Perennial rye grass	<i>Matthiola incana</i>
	<i>Papaver rhoeas</i>
Stock	<i>Reseda odorata</i> L.
Flanders poppy	<i>Rumex</i> sp.
Common mignonette	<i>Tropaeolum majus</i> L.
Dock	
Nasturtium	

\*Infected plants may show atypical symptoms or none at all.

**Table 3. Non-susceptible cruciferous weeds.**

Common name	Botanical name
Hoary cress	<i>Cardaria draba</i> (L.) Desv.
Lesser swine cress	<i>Coronopus didymus</i> (L.) Sm



Figure 4. Clubroot galls on a cruciferous weed species.

### Acknowledgement

Information in this Agriculture Note is based on work carried out by Ian Porter at the DPI PIRVic Knoxfield Centre.

**Correct diagnosis is essential for effective pest and disease control. A commercial diagnostic service is available at the DPI PIRVic Knoxfield Centre.**

**For further information, phone Crop Health Services on (03) 9210 9222 or fax (03) 9800 3521.**

**For further information on registered chemicals, phone DPI Chemical Information Service.**

*The previous version of this note was published in November 2001.*

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