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FACT SHEET | APRIL 2024

MEGA PESTS

Managing soil-borne diseases

TIPS FOR MANAGING SOIL-BORNE DISEASES

- Read the fact sheet: Mega Pests - The Basics of Protecting Your Crop
- Understand the pathogen survival mechanisms and the crop and environmental conditions that favour disease development
- Implement farm sanitation practices to remove or reduce pathogen carryover - in weeds, crop debris and volunteer hosts
- Consider your planting sequences. Rotation with non-host crops will limit the build-up of pathogen populations
- Test soils for specific pathogens to identify heavily infested blocks before planting susceptible crops
- Use clean planting material and resistant varieties (if available)
- Manage soils to increase organic matter and improve soil health, while disadvantaging soil-borne pathogens
- Monitor blocks and keep records on crop and disease history to aid decision-making
- Provide plants with optimum nutrition and water regimes
- Remove and destroy infected plants to reduce disease spread within a crop and carryover to the next crop; similarly remove or deep- bury crop residues and allow time for them to decompose.

Hort Innovation

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RMCG

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What are soil-borne disease organisms?

There are hundreds of soil-borne plant pathogens. The most common and important pathogens are fungi which often survive in the soil for long periods, even in the absence of their preferred weed and crop hosts. Most soil-borne fungal diseases have a wide host range while some, such as clubroot are more specific and only affect plants in the family Brassicaceae.

Many of these fungi may be present together in cultivated soils; some also in virgin soils. Once present on your farm they will remain an on-going concern for as long as you are growing susceptible crops. The fungi can infect roots, stems and other plant parts. There are many factors that influence how seriously pathogens in the soil will impact on plant health. They include the plant genetics, environmental conditions, cultural practices, and the types of other microbes present in the soil or root zone.

Some of these factors are more easily controlled than others and knowing how to best manage them to optimise plant health can be very powerful in the fight against soil-borne diseases.

Why is their control difficult?

Inconsistent results with chemicals to treat soil-borne fungi can be due to the development of resistance to the chemical in the pathogen population, a lack of effective chemistry, a build-up of bacteria that rapidly breakdown the chemical, and poor application (coverage, timing, placement). Despite inconsistent performance, fungicides and chemical fumigants have remained a common approach to managing these soil-borne fungi. They are expensive, however, and increasing awareness of their environmental impact, have motivated

Figure 1: Factors contributing to plant health and resilience to soil-borne diseases

many growers to explore alternatives and more sustainable and affordable, integrated crop protection (ICP) approaches. ICP when applied to pest and disease management considers the production system as a whole, and includes all pests, crop agronomy and soil health. ICP approaches aim to optimise chemical treatments and limit dependence on them.

A few alternative controls to chemicals, including biocontrol agents have been developed for controlling soil-borne pathogens in Australia and overseas. Cultural practices, such as rotation with non-host crops, biofumigation with green manure Brassica crops, and pre-plant soil treatment with composted organic matter or particular chemicals that stimulate sclerotial germination, can effectively reduce populations of some soil-borne fungal pathogens.

How can I protect my farm from these soil-borne fungi?

If you are raising crops susceptible to soil-borne pathogens, make sure you avoid inadvertent spread of the pathogens from infested to clean blocks. They may be introduced with water, on soil attached to equipment or vehicles, or on

planting material. Use pathogen–free planting material and compost/mulch from certified suppliers, and limit people and equipment movement around your property.

How can I manage these soil-borne pathogens if I grow susceptible crops?

By knowing your crop's stages of susceptibility to the fungi and understanding the conditions that influence the pathogens' long-term survival and pathogenicity, the on-farm activities required to manage the crop and the diseases, will become clearer.

Clubroot

If your farm is free of this organism, avoid its introduction! Be meticulous about nursery and farm hygiene, and accept only clean transplants in new trays/boxes.

Transplants received in re-used containers or with soil in the growing medium, are at greater risk than those grown according to 'best practice' guidelines. Restrict equipment, livestock, water and people movement around your production areas.

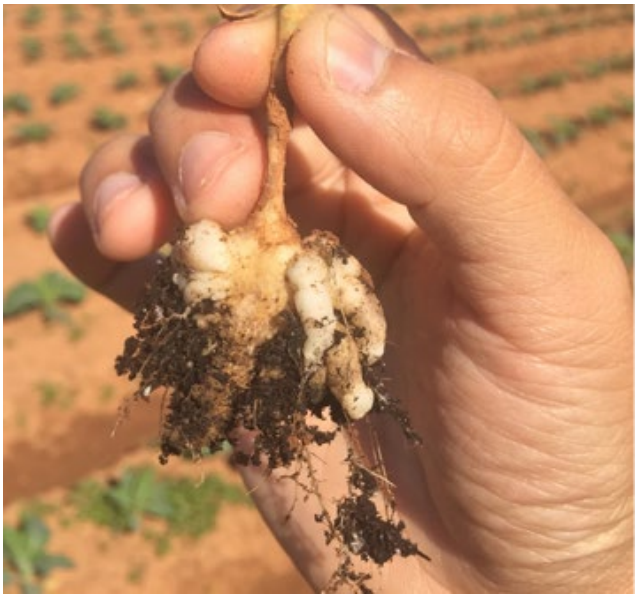

Figure 2: Knot-like swelling (galls) on the root system caused by Clubroot infection (S. Grigg, Ag Hort Consulting)

Do not plant susceptible varieties in infested soils, especially in summer, if the soil population of this fungus exceeds 1,000 spores per gram of soil. Clubroot, caused *by Plasmodiophora brassicae,* affects the roots of cruciferous vegetables and weeds like wild turnip and radish. The most susceptible crop is Chinese cabbage followed by cauliflower. Some broccoli varieties are tolerant to clubroot. A few varieties of Asian vegetables, cabbage and cauliflower are resistant and meet Australian market requirements.

If clubroot has occurred on your farm, start with cultural practices including crop rotation, controlling volunteer host plants and the addition of organic matter to boost beneficial microbes to minimise its spread and impact. Remove mustard weed and include non-brassicas in your crop rotation so that the disease carryover from crop to crop is minimised.

Site preparation – Before planting, make sure plants and roots from the previous crop have been removed and that areas that were infection 'hot spots' in the previous crop, are treated either by chemical fumigation or biofumigation through the selection of non-brassica crops, including biofumigant sorghum varieties.

Soil modifications – Before planting a susceptible crop, increase soil pH to 7.0 - 7.5 by adding lime. During the early production period, maintain higher calcium and boron levels as this appears to reduce the potential for gall formation on roots.

Water management – Ensure each block receives clean water rather than run-off from nearby infested blocks. Good drainage is essential because 'warm, acid soils with standing water' are the conditions that favour rapid growth of the fungus.

Pythium Root Rot

Pythium root rot is caused by *Pythium aphanidermatum.* Pythium can infect the seed causing brown, gelatinous rotting of the seedcoat. If seeds germinate, crop emergence is poor. Seedlings are stunted, chlorotic and start to collapse and die.

Site selection and irrigation management are particularly important in managing this fungus-like pathogen, which thrives in wet conditions. Irrigation water, whether it is sourced from bores, mains, rivers or a re-circulation system, should be tested regularly for Pythium species. When viable spores exist in water, every irrigation is a threat to young plants that may result in new infections and disease spread. It is important to minimise plant residues which can become infected with Pythium.

Because soil or water movement can spread this pathogen, use foot baths, and clean wheel wells and equipment. Good drainage is also important as saturated conditions and standing water increase the potential for infection by Pythium species.

Planting dates that promote quicker plant emergence from soil can minimise root rots due to some Pythium species. Chemical treatments (such as seed treatments, protectants or eradicants) are needed at times when soil conditions favour root infection.

Figure 3: Sunken dark lesions may occur on lower stems or a rot of the roots may develop (Penn State University, Bugwood.org)

Fusarium

Fusarium fungi is caused by *Fusarium oxysporum f. sp. conglutinans*. Fusarium is associated with general plant wilting and yellowing, leading to foliage necrosis. Roots and vascular tissues turn black.

Management of fusarium has been successful in many crops with the breeding of resistant varieties. Cultural practices that assist in management of these fungi include rotation with non-host crops, roguing (i.e. removing and destroying) infected plants and minimisation of plant stress (environmental, nutritional or due to other pests or pathogens like sciarid flies (fungus gnats), nematodes*, Rhizoctonia spp., Fusarium spp.* or *Pythium spp.).* Careful irrigation management (shorter and more frequent irrigation) and use of nitrate forms of nitrogen fertilisers have been shown to reduce disease severity.

Figure 4: Lower leaves appear stunted, wilt and turn yellow more on one side of the plant which may be confused with water stress or nutrient efficiency (L. Tesoriero, Crop Doc Consulting)

Rhizoctonia

Rhizoctonia solani is a fungal pathogen comprised of many species and strains that can cause diseases across a wide host range of vegetable crops. Some diseases caused by *Rhizoctonia spp.* include damping off, root and stem rots and sometimes leaf blights or leaf spots. *Rhizoctonia spp.* causes dry, sunken cankers with a sharply defined margin that develop near the soil junction soon after seedlings emerge. Plants wilt and collapse. More advanced seedlings may send out new

shoots from below the diseased area.

The fungi produce survival structures (sclerotia) that can also survive well in soil in the absence of a host plant. Clean transplants (also tubers, stolons, runners), seed treatments, site selection and planting times are important considerations in the management of *Rhizoctonia spp*.

In particular, organic matter such as ploughed-in weeds or residues from previous crops should be completely degraded before planting new crops because these fungi use them as a food source from which they can quickly grow and infect roots and stems. Long periods of moisture on, or near the soil surface favours the growth of fungal threads that attack roots and the stem collar.

Sclerotinia and Sclerotium

These fungal genera mostly have wide host ranges. *Sclerotinia minor, S. sclerotiorum and Sclerotium rolfsii* attack many plants, while *Sclerotium cepivorum* only infects onions, garlic and related Alliums. Leaves of infected plants show yellowing, leaf dieback, and wilting. Leaf decay begins at the base and water-soaked lesions, or dry lesions appear on the stems and leaves of the plant. Roots also rot and as a result, the plant can be pulled from the ground easily. At later stages, white fluffy mycelium of fungal hyphae and black sclerotia appear.

These fungi have sclerotia that may remain viable in soil for long periods (10 – 15 years). *S. sclerotiorum* is spread by soil and water movement from infested soil paddocks as well as airborne spores. The disease is most active in moist soil when the temperature is 9 – 25°C with an optimum of 15 – 18°C. Management of these diseases must include consideration of site selection, cropping sequences and rotations with the use of alternate cropping, and minimisation of sclerotia formation and survival by practicing farm hygiene to prevent the movement of contaminated soil, water, plants and equipment.

Pre-plant soil tests, crop histories, and monitoring of disease in previous crops should guide site selection and crop choices. Soil inversion and deep burial of sclerotia, and rotation with non-host green manure or biofumigant crops have shown some benefit in reducing the number of sclerotia and the potential threat to the next crop.

Other cropping and cultural practices that may reduce the severity of infection and losses include variety selection to minimise leaf contact with the soil, planting density to reduce contact between plants and duration of leaf wetness. Roguing of diseased plants, removal of weeds and improved soil health can reduce the impact of Sclerotinia and Sclerotium species and of other soil-borne pathogens.

Figure 5: Sclerotes in lettuce, characteristic white fluffy growth with black fruiting bodies (sclerotia) as seen on a lettuce head

Case study: Damping off in spinach

What causes damping off?

Usually, one or several of the following soil-borne fungal pathogens cause damping off in spinach: *Pythium* spp, *Phytophthora* spp, *Fusarium* spp and *Rhizoctonia* spp. If more than one pathogen is involved, pathologists talk about a “damping off complex”.

Other fungi such as *Verticillium* spp can cause spinach to wilt and die off, but generally only in older plants such as in seed crops.

Symptoms and causes

Symptoms include poor growth, stunted, yellowing plants, death of seedlings (Figure 6 and Figure 7), wilting of older plants, poor germination and brown or black, rotted roots and crowns. Symptoms can depend on which pathogens are involved, whether it be Pythium, Phytophthora, Fusarium or Rhizoctonia.

Conditions which favour pathogens causing damping off

Variation in moisture, temperature, tillage and soil health can all provide conditions that favour pathogens that cause damping off, as shown below.

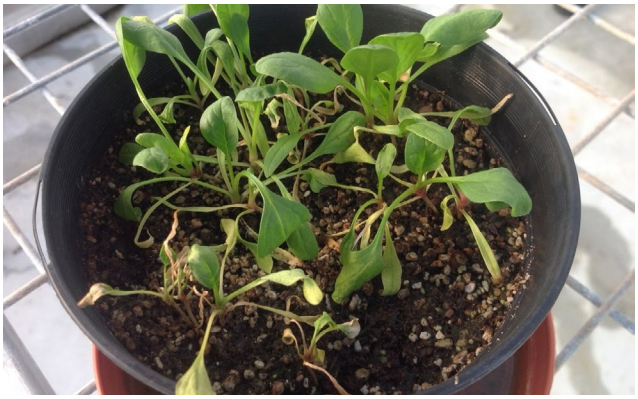

Figure 6: Symptoms of damping off in a spinach plant

Figure 7: Bare patches in spinach, typical of damping off (D. Lucas, RMCG)

Table 1: Conditions that favour pathogens causing damping off

	Pythium spp	*Phytophthora* spp	*Rhizoctonia solani*	*Fusarium* spp
Wet soil conditions above field capacity for extended periods or periodic wetness	✓	✓	✓	
Wet and **cool soils**	✓	✓		
Wet and **warm soils**	✓			
Moist and **warm soils** e.g. above 15oC			✓	✓
Poor air circulation preventing soil and plant surfaces to dry off	✓	✓	✓	✓
Reduced tillage			✓	
Acidic soils **low in organic matter**				✓
Physical damage at soil level e.g. wind, transplanting or insect damage – when combined with wet soil conditions			✓	

Diagnosing damping off

Each disease has unique symptoms on the roots and root tips, however generally typical symptoms are plants collapsing. The most accurate diagnosis is by sending fresh samples to a pathologist, as knowing the causal pathogen can aid the selection of effective management and control strategies.

How to manage damping off

1. Get site specific advice
2. Susceptibility is related to soil and environmental conditions. Damping off is favoured by wet, compacted and poorly drained soil. Therefore:
   a. Sow in well-drained soil
   b. Avoid risky paddocks (e.g. a known history of damping off, poorly drained soils, poor soil condition) especially for crops grown during high-risk periods.
3. Monitor and manage crop nutrition. Stressed or slow growing crops (especially during establishment) are more susceptible to damping off
4. Use nitrate forms of nitrogen fertiliser for management of Fusarium. Ammonium-based nitrogen fertilisers can foster Fusarium
5. Keep soil pH above 6.5 for Pythium and a pH of 7 or above for clubroot
6. Optimise irrigation scheduling. Avoid over-watering, and prevent flooding and saturated soil – particularly for Pythium
7. Rotate cash crops with cover crops to break the disease cycle
8. Plant biofumigants that release enzymes into the soil when cultivated to help kill the pathogen.
9. Consider solarisation or microwave treatment
10. Use good quality organic soil amendments, such as compost, to build organic matter.

A SELECTION OF HELPFUL RESOURCES

In addition to the other Mega Pest fact sheets in this series, there are many useful resources that can be accessed on the Soil Wealth ICP website.

1. Soil-borne diseases in vegetable crops – A practical guide to identification and control
2. Clubroot management in brassica vegetables
3. Managing fusarium diseases in vegetable crops
4. How to manage sclerotinia in vegetable crops with Dr Len Tesoriero (webinar recording)
5. How to control Pythium in vegetable crops with Dr Len Tesoriero
6. *Rhizoctonia Solani* anastomosis groups and their hosts
7. Better managing soil-borne diseases with pathogen DNA testing
8. Biofumigation guide
9. Disease Management Features at International Spinach Conference, Spain