Proactive approach reduces risk of soil-borne root diseases

Key facts

- **Growing non-cereal break crops reduces the inoculum levels of all four major cereal root diseases.**
- **Fungicides are available to reduce disease levels, but are expensive and can vary in their ability to control disease.**
- **Investing in effective summer weed control will pay dividends by reducing soil-borne root disease and conserving soil moisture.**

The cost of soil-borne cereal root diseases is most significant in the cereal-dominated rotations of the low-rainfall zone. Introducing a non-cereal break crop or pasture phase can reduce disease risk and provide other whole-system benefits.

Soil-borne root diseases are particularly severe on sandy soils due to suppressed root growth and fewer microsites to protect soil biota (organisms) — a consequence of low organic matter (OM) levels, low fertility and poor water-holding capacity. Under dry conditions, the activity of beneficial soil microbes also is reduced, which in turn enables the well-adapted pathogens to thrive and increase in numbers.

The most common soil-borne diseases affecting crops in the low-rainfall areas of south-eastern Australia include rhizoctonia bare patch (*Rhizoctonia solani AG-8*) cereal cyst nematode (CCN), take-all and crown rot.

Understanding the level and types of disease currently infecting individual paddocks is the first step to developing an effective disease-management strategy.

A Predicta-B® test is a DNA-based soil test that identifies which soil-borne pathogens pose a significant risk to broadacre crops leading up to sowing. This useful tool enables growers to assess and then plan and implement strategies to manage the risk of a range of root diseases.

Rhizoctonia bare patch (*Rhizoctonia solani AG-8*)

Rhizoctonia bare patch is a fungal pathogen that can affect plant roots at any stage of growth, increasing in severity under cool, dry conditions.

Plants affected by the *Rhizoctonia solani AG8* fungal pathogen are usually stunted and sometimes appear purple in colour. If plant roots are severely infected, the root cortex (core) will be eaten away and the stele (central root cylinder) will break, leaving characteristic brown 'spear tips'.

PREVIOUS PAGE: Clearly-defined bare patches or areas of stunted growth are a symptom of cereal root disease. (INSET): Plants severely infected with Rhizoctonia will show clear signs of roots damage. Photo: Sjaan Davey, SARDI

ABOVE: A crop rotation that introduces non-cereal crops can significantly reduce soil disease pathogen incidence. Photo: Alan McKay, SARDI

Bare patches appear in affected crops from an early growth stage and form sharply-defined areas of stunted plants, caused by the primary root infection.

The impact of Rhizoctonia has declined with the adoption of no-till farming, summer weed control and more timely sowing into warmer soils.

Crown root infection, from Rhizoctonia, tends to be seen more often, which can be more serious, as the crown roots play an important role in accessing moisture deep in the soil profile late during the season, driving grain filling.

Rhizoctonia can be particularly severe in sandy soils, in cereal-on-cereal rotations, or where there is poor grass weed control during break crops or pasture fallows. The disease also varies in its behaviour under different crop types, inoculum levels and summer rainfall conditions (Figure 10).

Canola and legume crops will reduce inoculum levels, with canola having the greatest beneficial impact. Inoculum levels will also decrease following all crops over summer, with levels dropping more following a wet summer.

Management options

There is a range of management options available to control Rhizoctonia, each with varying degrees of efficacy.

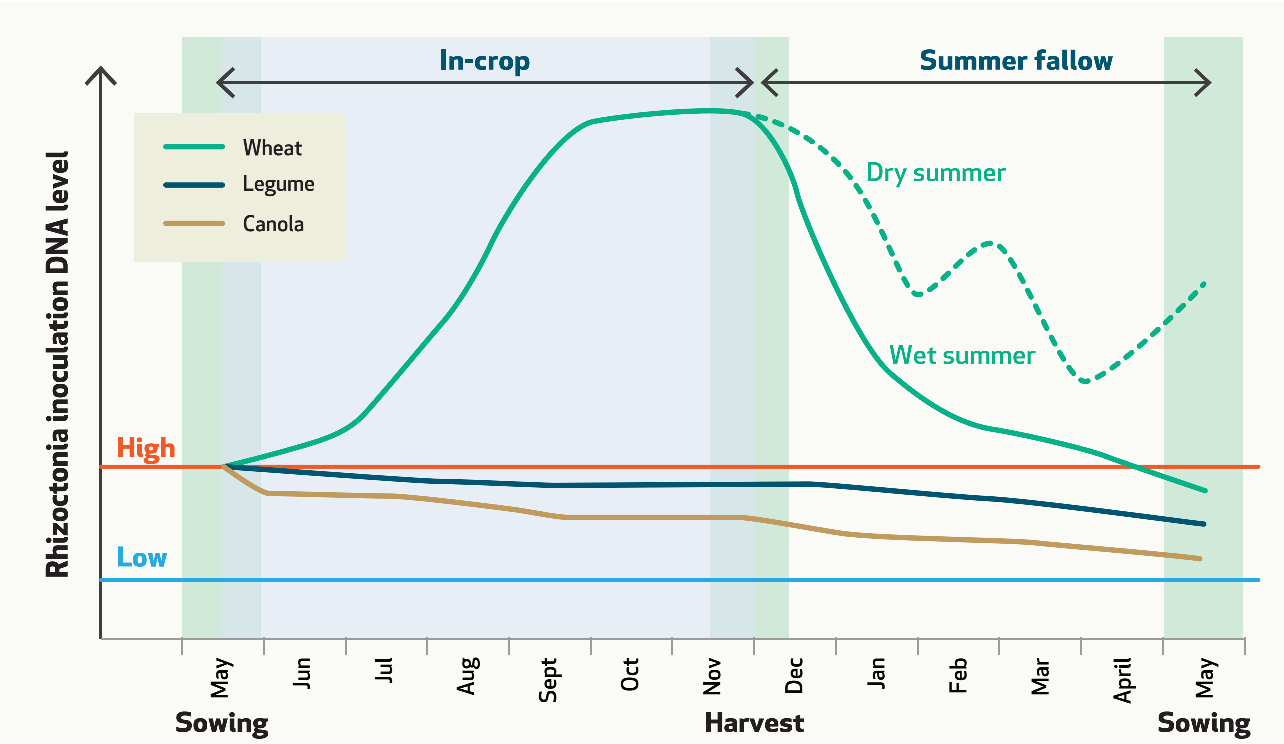
Non-host break crop

The best and most reliable way to control Rhizoctonia is to include non-cereal break crops in the rotation. However, the number of reliable and profitable break crop options that can adequately protect the sandy soils in low-rainfall environments from erosion is limited.

Canola, chickpeas, field peas, vetch and legume pasture breaks can increase wheat yields by 9–47% compared with cereals or other grassy phases.

Canola usually provides a one-year disease break and is by far the best option for reducing Rhizoctonia inoculum, due to its biofumigation properties. Legumes also provide a disease break and can provide a number of additional benefits, including a supply of organic nitrogen (N). Legumes are not as efficient at extracting moisture from the soil profile compared with canola and cereals, and therefore residual soil moisture is often left in the profile for subsequent crops.

Figure 10. The impact of crop type and summer rainfall on Rhizoctonia inoculum levels



Source: *Tips and tactics Rhizonctonia, Southern Region* (GRDC)

CASE STUDY

Serradella break crop offers multiple benefits

Colin and Anna Butcher, Brookton, Western Australia

Colin and Anna Butcher have been growing Margurita French serradella (*Ornithopus sativus*) for a number of years, to reduce soil-borne diseases, increase soil nitrogen levels and fill feed gaps in their livestock operation. The inclusion of this hardy annual legume has enhanced the profitability and sustainability of their farming system through lower input costs (fertiliser and fodder) and increased soil fertility and feed.

The Butchers achieve additional savings by harvesting their serradella crop, saving the seed and sowing again during February the following year. The semi-hard-seeded nature of the seed reduces the risk of germination with summer rainfall, but breaks down sufficiently to allow germination following the autumn break.

"Serradella suits our acidic sands and fits in well with our livestock operation," Anna explained. "We often are short of feed during autumn and our summer-sowing approach allows us to fill feed gaps and avoid supplementary feeding."

According to Colin and Anna, serradella grows relatively well on sand, and the loamy soils across their farm, although regeneration appears to be better on their heavier soil types.

"Originally we grew serradella to provide nitrogen for our cropping phase, but livestock love it, and we have been able to increase our stocking rates and grow our sheep enterprise as a result," Anna said.

ABOVE: Summer-sown Margurita French serradella, 25 February, 2013 (left) compared with autumn-sown serradella, sown on 31 May, 2013 (right). Photo: Colin and Anna Butcher.

Establishment program

Colin and Anna establish their serradella with a sowing rate of 20kg/ha during February.

"The seed is grown on-farm and harvested with a conventional header," Anna explained. "We use the canola settings on our air-seeder to sow the crop and sow at the same depth as canola.

"It takes time for the dormancy of the seed to break down, so it doesn't germinate until about March.

"We avoid sowing into weedy paddocks, which can compete with the serradella — if we do have a weed infestation during the growing season, we treat the serradella as a brown manure crop.

"We fertilise the paddock in autumn with a pasture/ potash fertiliser, and before germination, or as close as possible, we apply imazethapyr (i.e. Spinnaker®) to suppress broadleaf weeds."

Challenging old habits

Colin and Anna have found it difficult to get out of the mind set of applying additional nitrogen fertiliser to their subsequent crops.

"Because the nitrogen supplied by the serradella is in an organic form, it becomes available when it rains, meeting the crop demand," Anna said.

"The other challenge has been adjusting to the summer sowing of serradella, although it allows us to get our grain crops sown on time."

In the lead-up to sowing Anna warns other growers not to apply sulfonylurea (SU) herbicides (e.g. Ally®) or clopyralid (e.g. Lontrel®) herbicides as they severely affect the ability of the serradella to grow and nodulate.

*Note: Serradella is well suited to the Butcher's acid sands, however growers with more alkaline soils could achieve similar benefits with a range of clovers, such as bladder clover (*Trifolium spumosum*), which are more suited to alkaline conditions.*

Further information — Serradella

- Butchers back summer-sown serradella (GRDC Ground Cover, December 2014): http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-113-NovDec-2014/Butchers-back-summer-sown-serradella
- Summer-sown serradellas deliver nitrogen benefits (GRDC, November 2014): http://www.grdc.com.au/Media-Centre/Media-News/West/2014/11/Summer-sown-serradellas-deliver-nitrogen-benefits

Fallow

A well-managed 12-month weed-free fallow can reduce Rhizoctonia innoculum levels in the soil. However, Rhizoctonia can survive on dead plant material and levels are likely to spike quickly when sown back to a cereal. Ensure the paddock is adequately covered and not over-grazed to reduce the erosion risk.

Mitigation options

Adequate nitrogen, phosphorous (P) and zinc (Zn) nutrition and reducing the use of SU herbicides, which prune root growth, can reduce the impact of Rhizoctonia.

In a direct-drilled system, a depth-modified seeder, which disturbs the soil 50mm beneath the seedbed while sowing at the correct depth, will provide sufficient soil disturbance to reduce damage caused by this disease. Low soil disturbance sowing systems, such as disc systems, can increase the risk of Rhizoctonia due to reduced disturbance of the Rhizoctonia hyphae (branching filaments) network.

Summer weed control

Research has previously shown that $5.57 is returned for every $1 invested in summer weed control per hectare through conserved moisture, improved water use efficiency (WUE) and reduced soil disease. NSW DPI research and development cropping agronomist Colin McMaster suggests this figure is more likely to be $8 in return for every $1 spent per hectare on summer weed control, and goes on to suggest the practice essentially 'buys you a spring'. Research carried out by CSIRO has shown that if summer weeds are not controlled, Rhizoctonia can reduce grain yield of barley by up to 40%.

Timely sowing

Rapid early root growth can significantly reduce the severity of Rhizoctonia — the impact on cereals is greater for slow-growing roots. In dry, cold seasons, and particularly where subsoils are compacted, root development slows and Rhizoctonia is likely to be a greater problem. A trial carried out near Lameroo, SA in 2015 showed that earlier sowing (into warmer soils) was more effective than fungicide treatments for improved crop growth.

Fungicides

During recent times penflufen-based products (e.g. EverGol Prime®) have been released as seed treatments, and were recently registered as in-furrow treatments.

Seed treatment has failed to produce consistent results, although a significant improvement (5%) in barley yields has been observed in numerous trials carried out by SARDI when fungicide was applied in-furrow during 2013.

Sedaxane-containing products (e.g. Vibrance® seed treatment, and fertiliser treatments and in-furrow products containing azosystrobin and metalaxyl-M (e.g. Uniform®) are also available to control Rhizoctonia.

In-furrow applications have produced the best, and most consistent results in trials over a number of seasons. An initial trial conducted by SARDI at Geranium, SA during 2010 found a combination of fungicides applied via split streams on the soil surface and in-furrow below the seed produced a 0.51t/ha yield response in a knife point and rippled coulter sown treatment.

Data from 2011–13 trials found that Vibrance in wheat, and EverGol Prime in barley produced an average yield increase of 5%, but yield responses were variable and dependent on spring rainfall. Yield increased when the seed treatment was used in conjunction with Uniform® in-furrow, at a cost of approximately $24/ha.

The cost of machinery modifications to include a liquid delivery system and the cost of these fungicide products require additional investment and need to be carefully considered in low-rainfall environments.

ABOVE: CCN cysts attached to a cereal root system at flowering. Photo: John Fisher, University of Adelaide

Cereal cyst nematode/eelworm (*Heterodera avenae*)

Cereal cyst nematodes (CCN) — also referred to as eel worms — are tiny parasitic worms, which infect the roots of cereal crops, causing plants to produce a mass of small lateral roots at the feeding site. Root expansion is reduced, limiting nutrient and water uptake.

Symptoms of CCN infestation include plant stunting and yellowing, which often gives the crop a 'patchy' appearance. The presence of CCN can be established by inspecting the primary roots and looking for abnormal branching and knotting. Symptoms can be confirmed at flowering by the presence of small (1–2 mm in diameter) white 'cysts' attached to the roots.

Cereal cyst nematodes survive between susceptible cereal crops as eggs inside the protective cysts. Each year approximately 85% of cysts hatch after the autumn break, while the remaining 15% remain dormant until the following season. This dormancy mechanism means it takes at least two years of break crops (this includes resistant varieties, non-cereals or fallow) to control CCN.

Cereal cyst nematodes have a narrow host range, limited to cereals and some grass weeds. Susceptible cereals and wild oats are the most important hosts. Annual ryegrass, brome and barley grass are poor hosts. Wheat and barley varieties differ in their susceptibility to CCN.

Management options

The impact of CCN has reduced in recent years, due to newer varieties having adequate resistance to these soil-borne parasites. Continued management will ensure this disease is kept at relatively low levels.

The most effective tool available to manage CCN is to grow resistant cereal varieties or other non-host crops (e.g. legumes and canola). Refer to crop variety guides to determine the resistance of individual cereal varieties.

ABOVE LEFT: Take-all causes premature maturation of susceptible cereal crops. Photo: Marg Evans, SARDI

ABOVE RIGHT: Blackening symptoms of take-all may extend to the stem sheath Photo: Marg Evans, SARDI

ABOVE: The take-all fungus infects the roots of the crop, restricting water and nutrient up-take. Photo: David Roget, SARDI

Take-all (*Gaeumannomyces graminis*)

Take-all is a disease caused by the fungal pathogen, that affects a plant's ability to transport nutrients, by blocking the water-conducting tissue in the plant, restricting water uptake and causing premature maturation.

One of the most characteristic symptoms of take-all is blackening of the crop roots. The take-all fungus infects the centre of the root. In severely infected plants the blackening may extend to the stem base under the leaf sheath.

The second-most characteristic symptom of take-all is 'white heads' occurring in patches within a crop. In a severe outbreak the entire crop may be affected. The white heads contain pinched grains or no grains at all. Low soil moisture during October and November increases the occurrence of deadheads.

The host range of take-all is confined to grass species and includes wheat, barley, triticale, barley grass, brome grass, silver grass and annual ryegrass. Oats are generally not considered a host, however there is a strain of take-all that can affect oats and other cereals.

Management options

Managing take-all effectively is imperative to avoid late-season losses.

Non-host break crops

Grow crops that do not host CCN (oilseeds, legumes and oats). Barley is the preferred cereal option given it is less susceptible to take-all than wheat

Inter-row sowing

Take-all can only survive in the root and tiller bases of previously-infected crops. Inter-row sowing will reduce the risk of infection in the following crop.

Fungicides

The use of flutriafol (i.e. Impact®) either in furrow or with fertiliser can reduce the level of infection of take-all, but is generally only effective in severe circumstances (i.e. where there has been a long history of growing continuous cereals). Products containing fluquinconazole (Jockey Stayer® or Quantum Pro®) at the higher label rates will provide some suppression of this disease.

Burning

A strategic burn of badly-infected paddocks can reduce inoculum levels, however it is important to consider the consequences of a burn (e.g. increased risk of erosion).

ABOVE LEFT: Scattered 'dead heads' caused by crown rot.
ABOVE: Honey-brown and pink colouring caused by crown rot infection
Photos: Marg Evans, SARDI

Crown rot (*Fusarium pseudograminearum*)

Crown rot is similar to take-all, whereby water uptake in affected plants is poorly transported from the roots to the growing tips. A honey-brown discoloration of the crown, lower leaf sheaths and tillers at the base of the plant is a classic symptom of crown rot. Affected plants are frequently stunted and produce fewer tillers, and symptoms can extend up the stem, where the fungus may form pink spore masses at the nodes. By comparison, plant roots and crowns infected with take-all are distinctly black in colour.

Severe infections will cause plants to die prematurely and deadheads or whiteheads are produced. The deadheads are either empty or partially filled with pinched grain. Affected plants may be scattered across a paddock or occur in patches.

Yield losses are greatest during dry years, especially when moisture stress occurs after flowering. The fungus can survive for up to two years on infected cereal stubble, from previous cereal plants, volunteer plants or grass weeds. Crown rot can cause serious yield losses in durum wheat varieties, and to a lesser extent in bread wheats, barley, and oats. Other host plants include wild oats, canary grass (phalaris), wheat grass, brome grass, barley grass, winter grass and annual ryegrass.

Management options

Non-host break crops

Rotations that include non-susceptible crops will reduce the severity of crown rot. A two-year break with a pulse, oilseed crop or fallow will reduce crown rot in the following wheat or barley crop.

Disease-tolerant varieties

A number of cereal varieties offer some tolerance to crown rot — check current variety guidelines.

Burning

Stubble retention, or slower decomposition of stubble, can increase the severity of crown rot. Burning infected crowns reduce the amount on inoculum and therefore the risk of future infection.

Inter-row sowing

Similar to take-all, inter-row sowing will provide spatial separation from infected stubbles.

Further information

- The Rhizoctonia Risk Tool http://eparf.com.au/research-project/rhizoctonia-risk-tool/
- Upper North Farming Systems Stubble Management guidelines: Break crop options (UNFS, 2106)
- Upper North Farming Systems Stubble Management guidelines: Crown rot (UNFS, 2106)
- Upper North Farming Systems Stubble Management guidelines: Inter-row sowing (UNFS, 2106)
- Tips and Tactics: Rhizoctonia: Western Region, (2016), GRDC GrowNote https://grdc.com.au/Resources/Factsheets/2016/02/Rhizoctonia
- Unkovich M (2014) A review of the potential constraints to crop production on sandy soils in low rainfall south-eastern Australia and priorities for research: A report for the GRDC Low Rainfall Zone Regional Cropping Solutions Network http://www.msfp.org.au/wp-content/uploads/A-review-of-the-potential-constraints-to-crop-production-on-sandy-soils-in-low-rainfall-SA.pdf
- Gupta V, Kroker S, Davoren B, McBeath T, McKay A, Ophel-Keller K, Llewellyn R and Roget D (2013) *Summer weed control benefits Rhizoctonia disease management in cereal crops*. In 'Research Compendium 2012, Mallee Sustainable Farming Project'. http://www.msfp.org.au