Management of soilborne Rhizoctonia disease risk in cropping systems

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Background

Rhizoctonia continues to be an important (average annual cost $59 million with potential costs $165 million, Brennan and Murray, 2009) but complex disease in the southern agricultural region, especially lower rainfall region. The fungus *Rhizoctonia solani* AG8 is present in Australian soils as part of the microbial community. This pathogenic fungus is a good saprophyte (grows on crop residues and soil organic matter), adapted to dry conditions and lower fertility soils. The aim of this research was to improve our understanding of the interactions between pathogen inoculum levels and natural soil biological activity for long term control of Rhizoctonia and to improve the prediction and management of the disease. A series of multi-year field trials were conducted at sites in SA, Victoria and NSW to determine key soil, environment and management factors influencing the pathogen dynamics and disease impact in cereal crops. These trials were complemented with annual field experiments to investigate the effect of specific management practices including fungicide evaluation.

Field experiments and Methods

1. Multi-year field experiments with crop rotation and tillage treatments were conducted at Waikerie (2008-12), Streaky Bay (2008-13), Karoonda (2009-2012) and Galong (2008-11). All treatments had four replicates. All plots were monitored for *R. solani* AG8 inoculum levels, disease development and incidence, soil water and nutrition, soil biological activity and populations of different microbial communities, plant growth (dry matter production) and yield. Data for environmental factors such as rainfall and temperature were recorded locally at the experimental site or obtained from the Australian climate database at http://www.longpaddock.qld.gov.au/silo/ for the nearby station. Field experiments were generally sown during the second fortnight of May every year.
2. One year field experiments were conducted at Karoonda and Wynarka in the Mallee to quantify the effect of summer weed control in continuous cropping systems on *R. solani* AG8 inoculum, microbial activity, plant performance and yield.
3. The influence of non-cereal crop rotation options on the build-up of Rhizoctonia inoculum levels was also monitored in field experiments conducted by the Regional crop sequencing-low rainfall group (Nigel Wilhelm, SARDI) at Minnipa and Appila in SA, Millewa and Chinkapook (BCG) in Victoria and Condobolin in NSW.
4. Surface 0-10 cm soil samples collected during off-season and within the crop were used for microbial and pathogen (*R. solani* AG8 DNA level) properties, root disease incidence, dry matter production, microbial activity, grain yield and quality. Disease incidence was monitored 7 weeks after sowing and after anthesis.

Results

In Australian soils, most of the *Rhizoctonia solani* AG8 DNA inoculum (60-75%) is present in the top 5 cm of soil; this has implications to the design of tillage / sowing equipment and seed and fungicide placement that can minimize disease impacts. Management practices and environmental changes, that either alter the physico-chemical environment or affect plant-pathogen interactions, are likely to influence the rhizoctonia disease occurrence in various ways. Therefore, effective management of rhizoctonia disease in rainfed cropping systems requires both the management of inoculum and the infection process.

A. Management of inoculum: Rhizoctonia inoculum build-up in one year's crop is the major determinant of disease risk in the following year

1. Wheat crop increased Rhizoctonia inoculum from seedling stage to maturity in all seasons. This was also observed with barley and cereal rye at all sites and in all regions in Southern Australia (SA and Vic) and NSW. Similar results were observed in Western Australia.
2. Non-cereal crops can be infected by Rhizoctonia however most do not allow the build-up of inoculum. Grass free canola and medic pastures reduce Rhizoctonia inoculum level resulting in significant increases in subsequent cereal yield. Other legumes such as field peas, chickpeas and vetch also showed limited or no inoculum build-up. Importantly, the effect of rotations generally lasted for one crop season only.

Table 1. Effect of crop type and fallowing on *R. solani* AG8 inoculum levels in soils[§].

Crop / Treatment	# Sites (soil types)	# Seasons	Inoculum levels at harvest compared to that at sowing
Wheat	8 (5)	5	Increased ***
Barley	3 (3)	3	Increased ***
Cereal Rye	1 (3)	3	Increased ***
Canola	8 (5)	5	Decreased ***
Mustard	1 (2)	1	Decreased ***
Peas	5 (3)	3	Decreased *
Lupins	2 (3)	2	Increased (V) **
Medic Pasture[$]	8 (5)	5	Decreased ***
Volunteer Pasture[$]	3 (2)	2	Decreased *
Vetch	3 (3)	1	Decreased **
Chickpeas	1	1	Decreased **
Fallow[$]	5 (4)	5	Decreased *
Oats	2 (2)	2	Decreased (V) *

[§] based on multi-year field experiments in SA (Waikerie, Karoonda and Streaky Bay) and NSW (Galong and Condobolin) as part of GRDC Rhizoctonia projects (CSE0048 and CSP00150) and Cropping system experiments by the Regional Cropping solutions Low rainfall group.

V = Variable; [$] = does not apply to grass-legume pastures including summer active perennial grasses

3. Crown root infection late into the crop season resulted in the build-up of *Rhizoctonia solani* AG8 inoculum in cereal crops. Therefore, observation of infected crown roots late in the season (spring) would provide a visual indication of inoculum build-up which could impact the following crop.
4. In cereals, Rhizoctonia inoculum builds-up from sowing to crop maturity (in all environments) and inoculum levels generally peak at crop maturity while rain post maturity of a crop and over the summer fallow causes a decline in inoculum.
5. In the absence of host plants, summer rainfall events of >20mm in a week substantially reduce the level of inoculum whereas inoculum levels can recover during prolonged dry periods. Multiple summer rainfall events reduce the rhizoctonia pathogen inoculum levels from high to lower disease risk whereas prolonged dry periods can even cause an increase in inoculum levels. The ideal time of sampling for DNA assessment of inoculum is closer to sowing, however, as samples need to be taken earlier to allow both for processing and planning a cropping program, sampling during March may be a preferred option to identify high risk disease paddocks.
6. Reduction in inoculum DNA was lower in colder soils compared to that in warm (>15 ^{o}C) and moist soils.
7. Weed control during summer significantly reduced Rhizoctonia pathogen inoculum levels. This complements benefits through moisture conservation and increased mineral N levels in the overall management of rhizoctonia disease impacts.
8. Summer cultivation, as applied in these experiments, caused some reduction in the inoculum levels in some seasons, however the disease risk remained high.
9. *R. solani* AG8 DNA levels are generally highest in the surface 5 cm of soil and decline with depth. Disturbance at sowing causes redistribution of inoculum through soil movement; however concentrations remain higher in the surface soils. Differences in particulate soil organic matter, microbial activity, CO_2:O_2 ratio and moisture are some of the factors influencing the depth based distribution. Inoculum levels were generally higher in the crop row compared to inter-row space.

B. Infection and disease impacts: Plant-soil-microbe interactions can influence the severity of disease incidence and the effect of rhizoctonia disease on crop yield

1. Soils and cropping systems that maintain higher microbial activity at the start of the season had lower disease incidence even with higher inoculum. Management practices such as stubble retention and reduced grazing generally promote soil microbial activity. Rhizoctonia root rot is generally worse in seasons following drought and dry summers which do not promote inoculum decline and result in lower microbial activity.
2. The level of disease incidence is due to a combination of inoculum level, level of soil microbial activity, the amount of soil disturbance below seeding depth, N levels at seeding, soil temperature and moisture during the seedling growth stage. Avoid disc seeders in high disease risk paddocks. Soil constraints such as compaction and herbicide residues (e.g. SU herbicides in alkaline soils) which restrict root growth exacerbate Rhizoctonia damage.
3. Crop rotation and tillage treatment had a significant effect on the microbial activity, microbial biomass and catabolic diversity in soils which contributed to lower disease impacts and cereal grain yield following non-cereal crop rotations. Crop rotation experiments at Karoonda, SA showed that non-cereal break crops reduce Rhizoctonia inoculum levels in all landscape positions (Dune, Swale).
4. Uneven crop growth, instead of distinct bare patches is now the most common symptom in the majority of crop paddocks affected by Rhizoctonia. Damage from the disease is greatest when root growth is restricted and/or soil temperatures drop to around 10 °C. When crops are sown early

into warm soils, seminal roots can escape severe Rhizoctonia damage, but as the temperature drops below 10 °C slowing the root growth, crown roots and seminal roots can still be infected causing uneven crop growth.

5. Disease suppression potential in Streaky Bay soil was very low compared to soils from Avon, Waikerie and Galong. Streaky Bay soil showed lower overall catabolic diversity and the diversity of Pseudomonas bacteria compared to soils from Waikerie and Avon (highly suppressive soil). The influence of specific microbial communities on disease incidence in different soil types requires further investigation.
6. There was a strong relationship between patch area and yield loss in wheat, for example at Streaky Bay grain yield declined by 0.27 t/ha (average) for every 10% increase in patch area. However, assessment of yield loss from Rhizoctonia based on the area of distinct patches underestimates the true costs. Rhizoctonia damage to crown roots can result in significant loss (>10%) in wheat grain yield.
7. Results from SARDI and DAFWA field experiments in SA and WA showed that liquid banding of fungicides produced greater and more consistent yield responses than seed treatments alone. Dual banding of Uniform® in-furrow 3-4 cm below the seed and on the surface behind the press wheel gave the most consistent yield and root health responses across seasons. Responses in barley were greater than wheat; responses also appear to be greater in better spring rainfall seasons. Banding BYF14182 in-furrow combined with EverGol® Prime seed treatment significantly improved root health. However, fungicide treatments need to be used as part of an integrated management strategy/package to effectively reduce Rhizoctonia impacts. Uniform® applied either by liquid banding or coated fertiliser has been registered to control rhizoctonia root rot.

Implications for commercial practice

The key to long term rhizoctonia disease control is to keep inoculum in the soil low in the crop and pasture phases and increase the ability of crops to tolerate the infection (create environments where plant infection is reduced and plant tolerance to infection improved). The success of available disease control strategies, e.g. soil disturbance, fertilizer addition or fungicides is greatest at low to medium inoculum levels and their effectiveness declines as inoculum levels increase or where disease suppressive activity is low. Overall, effective control of rhizoctonia disease in cereal crops requires both the reduction of the pathogen inoculum in the soil prior to seeding and control of the infection process in the crop itself. This has to be achieved through management practices spread over more than one cropping season and through an integrated management strategy.

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Further reading

GRDC Factsheet March 2012 (will be updated in 2015);
http://www.grdc.com.au/Resources/Factsheets/2012/03/Management-to-minimise-Rhizoctonia-disease-in-cereals

Table 2. Steps to be considered for effective control of Rhizoctonia disease impact in a cropping system

- Effective control of rhizoctonia disease in cereal crops requires both the reduction of the pathogen inoculum in the soil prior to seeding and control of the infection process in the crop itself; this has to be achieved through management practices spread over more than one cropping season.

Year 1 crop (Sept-Nov)	**Summer (Dec-April)**	**Season break (April-May)**	**Year 2 crop (May-August)**
Check for inoculum build-up	***Facilitate inoculum decline***	***Select appropriate crop***	***Manage infection and disease impact through management practices***
• To identify paddocks of high rhizoctonia disease risk for the following season, estimate the area of bare patches and/or zones of uneven growth during spring – verity root tipping that poor plant growth is due to rhizoctonia disease.	• In wet summers, good summer weed control is essential. In dry summers, inoculum level generally remains close to post harvest level. • Adopt practices that prolong soil moisture in the upper layers e.g. stubble retention, and help maintain higher microbial activity • Avoid cultivation which can cause loss of moisture and also reduces microbial activity at sowing	• Consider soil testing for pathogen inoculum level (PreDicta B test in Feb-March), to identify high disease risk paddocks, esp. if planning to sow cereals back on cereals or to select a crop • Select a non-cereal crop, e.g. canola or pulses, if you want to reduce inoculum levels • Remove autumn 'green bridge' before seeding with good weed control	• Sow early; if soils are warm within two weeks after season break and if soils are cold within 1 week after season break • Apply disturbance below seed to facilitate root growth – knife points reduce disease risk compared to discs • Avoid pre-sowing SU herbicides, • Supply adequate nutrition (N, P and trace elements) to encourage healthy seedling growth • Avoid stubble incorporation at sowing to minimize N deficiency in seedlings • Consider 'In-furrow' fungicide application – liquid band near soil surface and below the seed • Remove grassy weeds early • Apply nutrient / trace elements, foliar in crop, if required