The impact of crop rotation and nutrition on Rhizoctonia disease incidence in cereals on grey calcareous soils of upper Eyre Peninsula

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Abstract
A rotation trial was conducted in a low rainfall cropping environment on a grey highly calcareous sand at Streaky Bay in South Australia during 2004-11. The purpose of the trial was to determine if disease suppression of Rhizoctonia and Take-all is achievable in such an environment. The rotations had either annual medic pasture or canola as a break for cereals (wheat, barley and triticale) or were continuous cereals. Most rotations also had two fertiliser treatments (granular fertiliser or fluid fertiliser) imposed. The influence of rotation and fertiliser inputs on soil microbial populations was monitored. Changing rotation and nutrient supply changed microbial population activity and diversity after eight years but disease suppression to Rhizoctonia and Take-all did not develop. Canola and medic lowered Rhizoctonia inoculum, but levels recovered following the cereal crop. Rhizoctonia disease incidence was generally lower in wheat after canola. In higher rainfall seasons, many rotations were limited by low nutrition.

Key Words Canola, Rhizoctonia, Take-all, fluid fertiliser, disease suppression.

Introduction
Rhizoctonia barepatch caused by the soil-borne fungus *Rhizoctonia solani* AG8 is an important soil-borne disease in cereal-based farming systems. *R. solani* grows as a saprophyte on soil organic matter and as a pathogen on a wide range of plants (O'Brien and Zamani 2003). Rhizoctonia barepatch is particularly severe in calcareous soils on the upper Eyre Peninsula, South Australia (SA), which has a Mediterranean environment and 350 mm of average annual rainfall.

The decline of *R. solani* disease symptoms and the development of biological disease suppression to Rhizoctonia and Take-all in a dryland cereal system were first observed in a tillage and rotation trial at Avon, SA (Roget 1995). In 1983, Rhizoctonia resulted in poor plant growth in 46% of the crop area, but this declined to negligible levels by 1990 with continuous cereal crops and stubble retention. The soil was an alkaline calcareous sandy loam, with pH 8.2, 1.6% organic carbon and 8% $CaCO_3$ (Roget 1995, Wiseman *et al*. 1996).

Such 'disease suppression' offered hope for substantially reducing the impact of Rhizoctonia in upper Eyre Peninsula farming systems, so a trial was established in 2004 on a grey highly calcareous soil. This trial was monitored for the impact of rotations and fertiliser management on Rhizoctonia and on the development of disease suppression by monitoring the changes in disease incidence and crop performance.

Method
This field trial was established in 2004 at Streaky Bay, SA with the rotations listed in Table 1. The fertiliser treatments were; District Practice Rotation had 12 kg P/ha and 11 kg N/ha applied as 18:20:0:0 (DAP) at the rate of 60 kg/ha; Granular fertiliser was applied to both of the other rotations (Intensive Cereal and Brassica Break) at 13.2 kg P/ha and 6 kg N/ha applied as 10:22:0:0 (MAP) at the rate of 60 kg/ha. Fluid fertilisers were 20 kg P/ha applied as ammonium polyphosphate (APP), 16.5 kg N/ha as urea ammonium nitrate (UAN), and trace elements (Zn, Mn and Cu) as liquid chelates at 0.9, 1.2 and 0.6 kg/ha, respectively. All fertilisers were applied annually at seeding in the seed row for all treatments.
The treatments had four replications in 1.8 by 60 metre plots which were direct drilled with narrow points between May and June each season, depending on the seasonal break. All cereal treatments (wheat, barley and triticale) were sown at 60 kg/ha, except in 2004 when 55 kg/ha was used for wheat. All canola and grass free annual medic pasture treatments were sown at 5 kg/ha. Weeds were controlled in crop and over summer seasonally. The trial was not grazed and all stubble residues remained on the plots.

The DNA based testing service, PreDicta® B (Ophel-Keller *et al.* 2008) was used to monitor disease

inoculum levels in autumn (March-May) annually. In 2009 and 2010, all treatments were in the cereal phase (wheat and barley, respectively) so intensive monitoring was undertaken. Soil samples were collected in March for PreDicta® B and soil mineral N levels. Soil samples were analysed for catabolic potential and diversity. Treatment effects on the catabolic potential (average substrate induced respiration) and catabolic diversity (relative response across different substrates) were analysed using ANOVA and canonical variate analysis using Genstat® 12th Edition.

Cereal plants were collected at 6-8 weeks after sowing to score roots for Rhizoctonia infection (0-5 rating scale) and plots harvested for final grain yield. Treatment effects were tested using ANOVA in the Genstat® software.

Discussion

In 2005, the soil was characterised as a grey calcareous loamy sand with the 0 to 10 cm of soil having; pH ($CaCl_2$) of 7.8, $CaCO_3$ content of 78%, chloride at 16 mg/kg, Colwell phosphorus at 30 mg/kg and mineral nitrogen at 14 kg/ha (0-10 cm), 6.5 kg/ha (10-20 cm) and 41 kg/ha (20-60 cm).

Table 1: Rotation and grain yield (t/ha) of crops in the field trial at Streaky Bay, 2004-11.

Rotation	**Year**							
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Annual Rainfall (GSR) mm	289 (252)	289 (259)	202 (113)	236 (160)	179 (109)	356 (323)	453 (377)	373 (238)
District Practice	Wheat 1.33	Barley 0.88	Annual Medic Pasture	Wheat 0.65	Annual Medic Pasture	Wheat 3.95	Barley 3.07	Annual Medic Pasture
Intensive Cereal with Granular Fertiliser	Wheat 1.39	Barley 0.81	Triticale 0.23	Wheat 0.77	Wheat 1.39	Wheat 2.74	Barley 3.14	Wheat 0.81
Intensive Cereal with Fluid Fertiliser	Wheat 1.82	Barley 1.16	Triticale 0.42	Wheat 0.73	Wheat 1.61	Wheat 4.06	Barley 4.04	Wheat 1.79
Brassica Break with Granular Fertiliser	Canola 0.43	Barley 2.08	Canola 0.03	Wheat 0.77	Canola 0.43	Wheat 3.88	Barley 3.21	Canola 1.14
Brassica Break with Fluid Fertiliser	Canola 0.56	Barley 2.43	Canola 0.05	Wheat 0.64	Canola 0.57	Wheat 4.93	Barley 3.88	Canola 1.59
Yield lsd (P=0.05)		0.16	0.03	ns	0.11	0.30	0.28	0.14
Take-all Risk			Low in all treatments			Medium	Medium in IC and DP; Low in other treatments	Medium

***GSR = Growing Season Rainfall (April to October); IC=Intensive Cereal; DP=District Practice.**

In this environment, the rainfall pattern is winter dominant with a long term average of 298 mm annual rainfall and 243 mm growing season rainfall. The trial was located at a coastal site with average wheat yields of 1.2 t/ha. Research in the region has shown fluid fertilisers can improve early dry matter and grain yield due to the highly calcareous soil type which readily ties up phosphorus (McBeath et al. 2005).

Rhizoctonia inoculum level was strongly influenced by crop type (Figure 1). Both canola and medic (both grass free) reduced Rhizoctonia inoculum levels but inoculum levels increased again following one wheat crop. Barley did not increase Rhizoctonia inoculum levels as much as wheat. However, Rhizoctonia infection on barley roots 6 to 8 weeks after seeding was similar or greater than wheat with the same inoculum level (Figure 2).

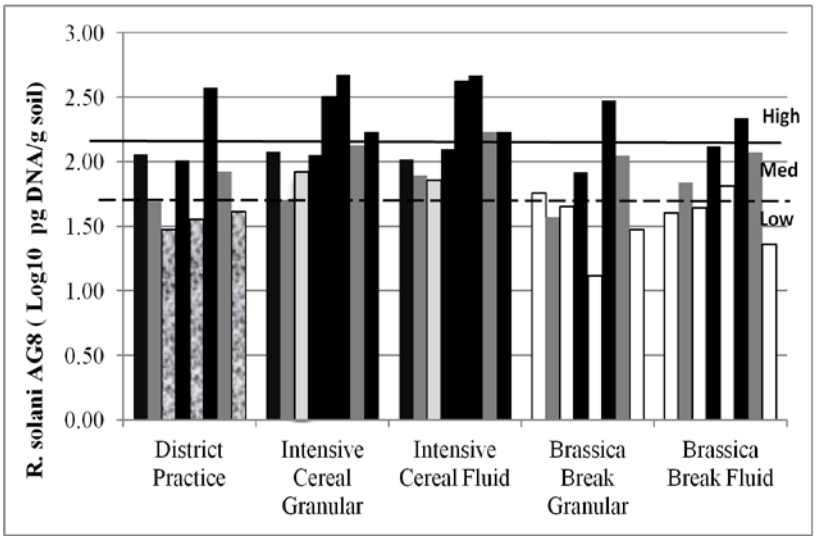

Figure 1. Rhizoctonia inoculum in the top 10 cm of soil at the beginning of each season (2005-2012) for each treatment of the field trial at Streaky Bay. (black bars – following wheat, dark grey - following barley, light grey - following triticale, grey pattern - following medic, white – following canola).

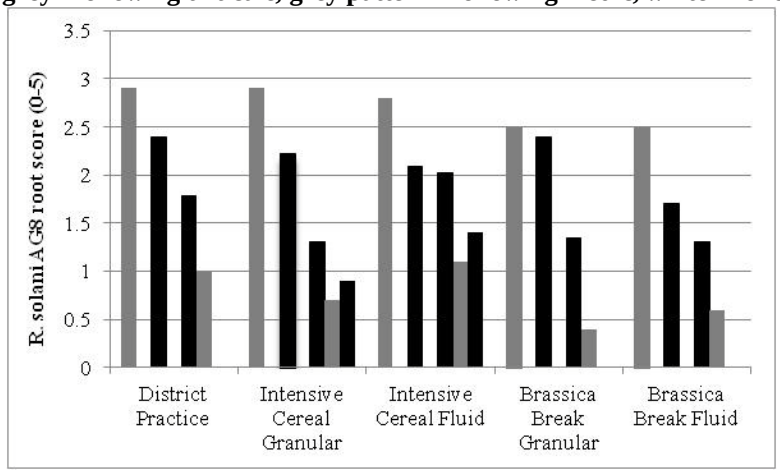

Figure 2. Rhizoctonia root score of cereal plants at 6-8 weeks post seeding (rating 0-5 where 0=no damage, 5=severe root damage) from 2005-2010 at Streaky Bay (black bars - wheat, dark grey – barley).

Fertiliser management did not affect inoculum levels or root infection (Figures 1 and 2). However, fluid fertiliser applications showed greater early dry matter (data not shown) and increased grain yield, especially in higher rainfall seasons (Table 1).

Microbial communities depend on carbon input from roots and stubble, and the breakdown of these influence plant available nutrients. The catabolic potential (substrate induced respiration, measured in µg CO_2/5hr) were; District Practice 0.20, Intensive Cereal Granular 0.25, Intensive Cereal Fluid 0.34, Brassica Break Granular 0.22 and Brassica Break Fluid 0.35 (LSD=0.1 at $P<0.05$). Both the fluid fertiliser applications had greater catabolic potential meaning the microbes under these systems can use more carbon or have greater microbial activity.

Fertiliser effects were the major driver of differences in catabolic diversity (data not shown). For example, the microbial community diversity under fluid treatments was different from the district practice treatments. Crops under fluid fertiliser applications produced greater amount of plant biomass (above and below ground) contributing to the greater differences in grain yield between brassica and cereal crops compared to district practice treatment. It is known that both the quality and quantity of carbon inputs from crops influence the composition of soil microbial communities. In this trial, although the management treatments caused some changes to the catabolic diversity, for this to result in increased disease suppression, it has to change the composition of microbial communities. The development of a sustained and higher level of disease suppression requires the maintenance of higher catabolic potential over many seasons (Gupta *et al*. 2011).

In 2009, surface soils were assessed for potential disease suppression to Rhizoctonia using a pot bioassay and disease suppression was similar in all rotations (data not presented). In spring of 2011, all cereals were

severely affected by Take-all disease. If biological disease suppression had developed, it should have controlled both Rhizoctonia and Take-all. This indicates that disease suppression had not been achieved after eight years in this soil type.

Conclusions

After eight years of several rotations and fertiliser management combinations, it has been shown that canola and grass-free medic have the ability to lower Rhizoctonia inoculum levels for one season compared to a wheat crop, but the inoculum will increase again following one wheat crop. In good seasons, the district practice treatment has shown that the yield is limited by nutrition, mainly phosphorus. Changing rotation and nutrition have changed the microbial population activity and diversity after eight years but disease suppression has not developed in this soil type and environment.

Acknowledgements

Thank you to SAGIT (South Australia Grain Industry Trust Fund) for providing funds for this research, the Williams family for having the trial on their property and Wade Shepperd and Ian Richter for technical assistance.

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