# FINAL REPORT

GRDC
GRAINS RESEARCH
& DEVELOPMENT
CORPORATION

DAW00201

# Identification and characterization of disease suppressive soils in the Western Region

## PROJECT DETAILS

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| **PROJECT CODE:** | DAW00201 |
| **PROJECT TITLE:** | IDENTIFICATION AND CHARACTERIZATION OF DISEASE SUPPRESSIVE SOILS IN THE WESTERN REGION |
| **START DATE:** | 01.07.2010 |
| **END DATE:** | 30.06.2015 |
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## Summary

The main aim of this project was to identify, confirm and characterise cereal disease suppressive sites in Western Australia (WA) to rhizoctonia root rot (*Rhizoctonia solani* AG8), take-all (*Gaeumannomyces graminis* var. *tritici*), crown rot ( *Fusarium pseudograminearum*) or root lesion nematodes (RLNs). Eleven sites were identified as having suppression to either rhizoctonia root rot or fusarium crown rot. Disease suppression to rhizoctonia root rot was identified to have a biological basis. Suppression to rhizoctonia root rot was observed to occur in up to three consecutive years for one site. While the management practices were not able to be identified, this project confirmed that disease suppression occurs in WA soils and environments.

## Report Disclaimer

## Conclusions

o Disease suppression against soilborne pathogens *Rhizoctonia solani* and *F. pseudograminearum* has been demonstrated in WA cereal paddocks. Only two sites that were tested in two (SP-15) and three (SP-10) consecutive years were confirmed to be suppressive to rhizoctonia root rot, suggesting that long-term disease suppressive sites are even less common than short-term disease suppressive sites in WA. Three sites changed from suppressive to non-suppressive following a non-cereal crop.

o All soils were found to suppress disease to some extent when added in different proportions to sterilised soil.

o A direct soil sandwich plate assay was developed to test disease suppressiveness of soils to rhizoctonia root rot, which has potential to test a larger range of soils in WA.

o A temporal assessment indicated that while the level of suppressiveness of soils changed over time, the ability to suppress disease remained constant. This hypothesis needs to be confirmed in a paddock at different sites and over the entire cropping season.

o Evidence of highly structured soils was identified through nematode trophic group analysis. Unfortunately, too few sites were tested for suppressiveness to determine whether these soils were more suppressive to one or more soilborne diseases.

o Suppressive soils were found to be more similar in bacterial and fungal diversity than the non-suppressive soil. The three suppressive soils shared unique peaks in metabolite profiles with the long-term suppressive site at Avon in South Australia (SA).

o A correlation of disease suppression to copper (Cu), manganese (Mn), boron (B) and ammonium (NH4) was identified, but this was relatively weak. Further investigation of the effect of these and agri-chemical inputs and management factors in disease suppression in WA is required.

## Recommendations

o There is evidence in WA that some soils are suppressive and this was attributed to a biological basis. Soilborne diseases such as rhizoctonia root rot, take-all, fusarium crown rot and RLN currently cause losses of up to $96 per hectare in wheat production. Adopting management practices developed from the long-term Avon site and other locations could improve disease suppression and reduce a majority of the losses attributed to root diseases.

o This project has developed methodologies to confirm suppressiveness to these root diseases using a pot bioassay and a soil sandwich plate assay. Bioassays and molecular tests for confirmation of suppressive paddocks developed in this project and associated projects should be made available to grain growers in order for them to manage their paddocks accordingly to ensure their paddocks remain suppressive to root disease.

o Validation of molecular nematode trophic groups and other molecular tests developed through linked projects should be validated with confirmation bioassays. This test could then be made available to growers as an indicator of the health of their soil and its potential to suppress root diseases through the PreDicta B service.

## Outcomes

**Economic Outcomes**:
This project identified suppressive paddocks to rhizoctonia root rot and fusarium crown rot. These paddocks had medium to high levels of inoculum present in the soil (rhizoctonia root rot and fusarium crown rot) but no, or very low, levels of disease present - as identified through the survey phase of the project. While the project was not able to determine management practices that led to this suppression, the knowledge and awareness of root diseases and potential impacts (and that a non-chemical alternative to manage root pathogens could be achieved in WA's soils and environment), could provide grain growers with an economic response. Assuming reductions in the annual losses caused by root diseases by 3% and reduction in pesticides by 5% of the current level, then the annual benefit is estimated to be approx. $1.1 million (based on estimates by Murray and Brennan, 2010).

**Environmental Outcomes:**
An increased understanding of soil biology and its ability to suppress soilborne pathogens generated through this project may lead to a reduction in the amount of pesticides applied to the soil and consequently reduce the broader use of pesticides and consequent off-target impacts.

**Social Outcomes:**
Social benefits from this project are tenuous. Nonetheless, increasing the non-chemical disease root control options available to growers will improve their image in the community and increase harmony between rural and urban communities. Training of scientists in disease suppressive bioassays and molecular tests in linked projects is building capacity in the soil biology research program for the benefit of the grains industry in Australia.

## Achievements/Benefits

See Attachment 1 for more details.

**Background:**
With crop disease losses and the cost of disease control on the rise, the Department of Agriculture and Food Western Australia (DAFWA) conducted surveys of cereal root disease incidence and severity during the early 1980s and again from 2006 to 2008 (Khangura et al., 2013). It was found that there had been no reduction in the incidence or severity of diseases during the intervening 25 years, despite the use of various management practices being implemented. In addition to this, there was a considerable increase in the incidence of crops affected by RLN throughout the cropping region of WA, the incidence of fusarium crown rot in the southern cropping region in WA and an increase in the incidence of rhizoctonia root rot.

As of 2009, wheat and barley have been estimated to have a gross value of $6 billion Australia wide and $2 billion for the Western Region, with an estimated annual loss caused by take-all, fusarium crown rot, rhizoctonia root rot and RLN being in excess of $351 million in Australia and $95 million in the Western Region alone (Murray and Brennan, 2009, 2010).

The 2006-2008 survey revealed that the highest levels of all root diseases in WA were in the southern high rainfall zone (HRZ). This zone has been identified in the DAFWA industry development plan as having scope for large increases in cropping areas and crop yields. Cultural management options are available for crop production in WA for rhizoctonia root rot, take-all, RLN and fusarium crown rot. However, the suite of options is relatively limited and grain growers and advisers require further options to facilitate integration of disease management with other paddock management requirements. To realise the planned increases in grain production, the impacts of root diseases need to be minimised. To do this, biological suppression of the limitations imposed by root diseases needs to be explored and defined. This will allow the costs to production incurred through chemical and mechanical control methods and rotations to be minimised.

This project concentrated primarily on identifying soil disease suppression of fusarium crown rot, rhizoctonia root rot, take-all and RLN in cereal crops. However, as only two sites were identified with potential suppression of RLN, further examination of suppression was limited to the other three soilborne diseases. There was a particular focus on the biotic component of soil disease suppression and how this can be influenced by management practices. Soil disease suppression is defined for the purposes of this project as 'the ability of a soil to suppress disease incidence or severity, even in the presence of the pathogen, host plant and favourable environmental conditions'.

Biological limitation of disease development and expression is evident through several effects:
1. Classical suppression, which causes a decline in the severity of a disease over time as the result of the action of beneficial organisms which protect plants against infection by a specific pathogen.
2. Non-specific suppression, which probably results from the competition for sites and resources around the root system as the numbers of organisms increase in the soil following the opening rains for the growing season.
3. A form of suppression which modifies, from year-to-year, the severity of diseases such as rhizoctonia root rot and Eradu patch such that a description of a year was developed as being suppressive or non-suppressive.

During this project, potential soilborne disease suppressive sites were identified and then bioassays were carried out to confirm disease suppressiveness of soils. Once disease suppression was confirmed, additional bioassays were conducted to establish whether the suppressiveness persisted through time. The influence of soil chemical characteristics and agri-chemicals on disease suppression was also investigated. The microbial communities in soils were profiled through determination of nematode trophic groups, metabolomics modelling and terminal restriction fragment length polymorphism (TRFLP) analysis.

The main aims of the project were:
1. To identify and confirm sites in WA as disease suppressive sites, using bioassays, for the following four soilborne diseases: rhizoctonia root rot, fusarium crown rot, take-all and RLN.
2. Investigate the temporal changes of disease suppressive soils.
3. Identify the effect of soil chemistry and agri-chemicals on disease suppression.
4. Characterise microbial attributes of disease suppressive sites by examining the nematode trophic groups and through metabolomics and TRFLP analysis.

**Achievements:**
A survey comparing anthesis disease levels to inoculum levels for 238 cereal sites during 2010 and 2011 identified a total of 28 sites as being indicative suppressive to rhizoctonia root rot, take-all, fusarium crown rot or RLN - as determined by sites having no, or low, disease and a medium to high level of pathogen inoculum in the soil. Eleven sites were identified as having moderate to high suppression to either rhizoctonia root rot or fusarium crown rot, but not take-all, using a bioassay measuring suppression potential. RLN was not assessed, as only two sites were identified as indicative suppressive. No sites were identified that were suppressive to both rhizoctonia root rot and *Fusarium* crown rot. Two sites that were tested in two and three consecutive years were confirmed to be suppressive to rhizoctonia root rot.

In a soil dilution experiment with a selection of 10 suppressive and non-suppressive site soils, a significant reduction in rhizoctonia root rot disease was shown when the 100% sterile soil was compared against the 100% natural soil for all sites tested. This indicated that all soils tested have some level of general suppression to disease.

A soil sandwich plate assay was developed in which the suppressiveness of a soil could be tested directly on *R. solani*. In this test, the two suppressive soils had significantly smaller colony scores than those for the non-suppressive soil. The soil sandwich plate assay was used to test the temporal suppressiveness of potted soils from four sites at five sampling times during July to September 2014. Despite the suppressiveness of soils varying with time, the three soils previously identified as suppressive in a rhizoctonia root rot bioassay had consistently smaller colonies at all sampling times than the one non-suppressive site.

In nematode trophic group assessments of 27 sites at pre-sowing, 14 sites had soils that were relatively well structured soils. In assessments of soils from 76 focus paddock sites, there were several that had high numbers of the higher structure nematodes - which may indicate these sites were sown with minimal disturbance and may be highly structured soils.
Three suppressive soils and one non-suppressive soil were investigated for microbial community diversity using TRFLP and metabolomics analysis. Suppressive soils were found to be similar in bacterial and fungal diversity than the non-suppressive soil. The three suppressive soils share unique peaks in metabolite profiles with the long-term suppressive site at Avon in SA.

In soil chemical characteristic correlations with disease suppression, rhizoctonia root rot suppressive soils were positively correlated to Cu, B and Mn and negatively correlated to NH4. Correlation of suppressive soils with agri-chemical inputs and other management practices was not possible to complete, as there were too few entries in the database for these variables.

This project has had a number of extension activities to growers and advisers through annual Crop Updates, Ground Cover articles, media releases and field talks.

**Benefits to the industry:**
The project has been able to promote to the grains industry, through media releases, Crop Updates and Ground Cover articles, that WA does have evidence of suppressive soils to rhizoctonia root rot and this has been shown to have a biological basis. As part of this message, the underlining issue of root diseases and associated constraints on production has made the industry more aware of this issue, as evidenced by the increase in testing for root disease, such as through the PreDicta B service.

The main soilborne diseases, such as rhizoctonia root rot, take-all, fusarium crown rot and RLN, currently cause losses up to $96/ha in wheat production. With the knowledge that diseases can be a constraint on production and that there is evidence of suppressive sites in WA, adopting management practices that improve suppression can reduce a majority of these losses.

It is possible that an increased understanding of soil biology and its ability to suppress soilborne pathogens generated through this, and linked projects in the Soil Biology Initiative II, may lead to a reduction in the amount of pesticides applied to the soil and consequently reduce the broader use of pesticides and consequent off-target impacts.

References:

Murray, G. M. and J. P. Brennan (2009). Estimating disease losses to the Australian wheat industry. Australasian Plant Pathology 38, 558-570.
Murray, G. M. and J. P. Brennan (2010). Estimating disease losses to the Australian barley industry. Australasian Plant Pathology 39, 85-96.

## Other research

o When tested over two consecutive years in bioassays, some sites that were identified as suppressive in one year (e.g. FP-130, SP-9 and SP-51) were not suppressive in the preceding year. All three sites had been sown to a non-cereal when they were non-suppressive. The project was not able to evaluate agri-chemical inputs and other management strategies that led to an increase or reduction in disease suppression. This project, and linked projects, have developed the methodologies and skills to assay soils to investigate the effects of these factors on changes in the disease suppression potential in a randomised split block design across a range of soil types incorporating the good practices (such as continuous cereal and stubble retention), as well as conventional practices (such as removing stubble and crop rotation). A selection of commonly used agri-chemical inputs, particularly pesticides, is another factor that could be trialled across both practices in a paddock trial.

o Using the developed suppression potential bioassays and soil sandwich plate assays, further test disease suppressiveness in relation to:
o the nematode trophic group analysis and to validate/calibrate the South Australian Research and Development Institute (SARDI) molecular nematode trophic group test under development
o soil chemical characteristics, including different soil types in WA
o mouldboard ploughing, which has been observed to increase disease (possibly as result in changes in the disease suppressive organisms components), and
o agri-chemical inputs and management.