Crown rot management for durum and bread wheats for the southern region

Summary

Crown rot (CR) affects all winter cereals and has become increasingly important because of reduced tillage, stubble retention and more cereals in rotations. Anticipated project outcomes are a reduction in losses from CR in wheat in South Australia (SA) and Victoria (Vic), and expansion of durum production in SA.

Sampling strategies for assessing disease risk before sowing have improved. Field trials were used to quantify yield losses in cereal types and crop sequence effects on CR levels. Screening for varietal resistance and assessment of inter-row sowing as a management tool were also components of the trial, and results were validated using paddock monitoring. Extension activities made industry aware of the latest management recommendations.

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Conclusions
Use of DNA technology to track changes in *Fusarium* spp. levels in plants has the potential to significantly advance the understanding of CR disease and assist in speeding up development of management tools.

The predictive model suggested by results from meta-analysis of Vic and SA rotation data has the potential to become a useful management tool, if it can be field validated. This would build on and expand the findings of ‘Forecasting the risk of crown rot between successive wheat crops’ (David Backhouse). A model of this nature would allow the effects of planned management to be predicted. It would also be a good indicator of the effectiveness of the previous season’s break from cereal.

Efficiency of sampling and precision of estimation of CR and soil phosphorus (P) concentrations in paddocks may be improved by taking linear samples, rather than using commercial core sampling.

Knowing the level of CR in a paddock and understanding the implied risk from the level present are still the keys to managing losses from inoculum levels of this disease. Soil testing using DNA technology and current CR risk categories provide a reliable indicator for low risk of losses from CR in susceptible cereals, such as durum. Soil testing can be used after non-cereals and between old cereal rows, which makes it the most flexible risk assessment method. Soil testing is particularly important because experience from this project shows that CR levels can be high even if little stubble is visible. Levels may not decrease under a non-cereal or increase under a cereal, in some circumstances.

Growers should not sow durum or triticale where there is a risk from CR. Barley or the bread wheat Kukri® are the best options; while they do incur yield losses, these are likely only in about 50% of situations. Limited data suggest cereal rye is similar to barley and oats are similar to bread wheat in their risk from CR.

In paddocks where CR is high in old cereal rows, but low between them, inter-row sowing provides an opportunity for an extra cereal crop (even a susceptible cereal) without incurring penalties from CR. Although data analysis is not complete, it is probable that CR levels will not increase significantly because of the extra cereal, which has lowered infection rates and also provides humidity under its canopy to assist in breaking down the more highly infected residues from the previous cereal.

Resistance alone is unlikely to keep CR at a low risk level. There is significant carryover of inoculum even after the most resistant cereal types and varieties, for example, the risk of yield loss from CR is lowest in barley, but levels increase almost as much after a barley crop as they do after a durum crop. Even the most resistant breeders’ lines contribute significant levels of CR inoculum.

Paddocks with very low CR levels do not move to extreme levels quickly, but those with low-medium levels do. Once CR levels are extreme they become very difficult to manage and it can take more than two years to return to low-risk levels.

This project generated a large amount of data and there is potential for six scientific papers and three scientific notes to be...
Recommendations

Identify and quantify the factors which result in non-cereals failing to lower levels of crown rot (CR) and cause cereals to reduce them.

Complete sample DNA analyses, data analysis and interpretation for results from the 2008 assessments of in-crop *Fusarium pseudograminearum* concentrations over time, in different cereal types and varieties. Use these findings to modify or change disease assessment methods and target future research.

Complete comparison of linear and core sampling for assessment of *Fusarium* spp. and soil P concentrations.

Use existing data from paddock monitoring undertaken within this project for field validation of the predictive model, suggested by SA and Vic rotation work.

Outcomes

It is expected there will be economic benefits in the short, medium and long term for individual growers and the grains industry. At the farm level, better management of crown rot (CR) will result in improved and more consistent cereal yields and a higher probability of achieving premium grain quality. This is particularly important for the durum industry, where durum L attracts premium prices and security of supply underpins continuing export markets. More growers are likely to be attracted to growing durum if they are confident of managing CR. This is good for the industry as well as being good for on-farm gross margins.

Achievements/Benefits

Crown rot (CR) affects all cereals and is estimated to cost the Australian grains industry up to $56 million per annum. In SA, the disease is estimated to cost the durum industry up to $5 million per annum and in Vic, CR reduced state bread wheat production by approximately 2% between 1997 and 2008.

In southern Australia, significant yield losses from CR are mainly caused by *F. pseudograminearum* and *F. culmorum* (the latter is usually only an issue in high-rainfall areas). These fungi are hosted by all winter cereals and most grassy weeds, and can survive for many years on infected plant residues. The effect of these pathogens is worse where there is good, early-crop growth followed by a dry finish.

CR has increased in severity in recent years as a result of reduced tillage, stubble retention and more cereals in rotations. The recent inclusion of durum wheat in farming enterprises has also contributed to increased severity of CR on some properties. Yield losses have been exacerbated in recent years by lack of moisture during spring, which also favours inoculum build-up.

Control options rely heavily on agronomic management strategies because fungicides do not control the CR pathogens and varietal resistance is limited. This project focused on four aspects of agronomically based CR management. This project overview is structured accordingly.

Project highlights

Pioneering the use of DNA analysis to track changes in concentrations of *Fusarium* spp. in plants during the growing season. This tool has potential to improve the understanding of how agronomic strategies (e.g. sowing date) affect CR, improve the effectiveness of treatments (e.g. targeting fungicide applications) and improve the reliability of resistance screening - DNA tests can be completed very early in the season. Work undertaken included time series comparisons of fungal DNA levels with rainfall, temperature and conventional disease assessment, which will improve understanding of the development of this disease and the best methods for assessing its progress and effects on plant productivity.

Combining data from Vic and SA rotation trials, to allow meta-analysis of results, will ensure that conclusions are reliable and broadly applicable and that prediction of changes in CR levels is a possibility.

Wide dissemination of project findings and latest management recommendations were made possible through unique opportunities to contribute to the GRDC Crown Rot Fact Sheet, the CR section of the Root Disease Risk Management
Resource Manual and the Root Disease Risk Management Workshop series, run by Dr Alan McKay.

Benefits to industry

As a result of this project, growers can confidently select paddocks with a low risk of CR for sensitive cereals, such as durum, and can identify paddocks with high CR levels, which need to be managed to reduce that risk. The suite of information developed during the course of the project provides the base on which growers can tailor a management program suited to their situation for reducing CR levels or for managing yield loss if a cereal must be grown where there is a significant risk of yield loss from CR.

Assessing the risk

Knowing the risk means knowing the levels of CR inoculum in paddocks. This knowledge underpins all decisions for managing the disease and reducing yield losses. Soil sampling is the most flexible assessment method because it can be used after non-cereals and between old cereal rows.

Project work included assessing the reliability of results from commercial core sampling, comparing core and linear sampling and validating risk categories. Methods included soil and stubble sampling in paddocks, PCR analysis of fungal DNA concentrations in samples, visual assessment of disease expression in-crop and yield measurements.

Highlights from research findings:

*Variability in soil sampling results is due to the highly variable spatial distribution of the fungus in cereal stubble.
*DNA analysis of samples collected using soil cores reliably selects low CR-risk paddocks for susceptible cereals.
*Linear sampling has the potential to be more efficient and provide more precise CR population estimates than soil coring.
*Durum variety Kalka® showed a 10% yield loss for each doubling of CR concentrations in soil pre-sowing at Hart (SA) in 2008.
*Risk category recommendations may underestimate potential yield loss by 10% at low CR-risk levels.
*Linear sampling has the potential to be more efficient in sampling for CR and P and providing more precise estimates of these variables than core sampling.

Reducing the risk

Reducing CR inoculum and keeping it at low levels is difficult, but it is the best method for lowering the risk of losses from the disease. This means understanding the factors affecting decreases and increases in CR levels and the extent to which each factor influences those changes.

Project work included quantifying changes in CR levels after cereals and non-cereals, assessing the effectiveness of microbial ameliorants. Methods included soil and stubble sampling in replicated trials (natural or naturalised inoculum sources), polymerase chain reaction (PCR) analysis of fungal DNA concentrations in samples, visual assessment of disease expression in-crop, plot yield measurements and paddock monitoring to validate trial results.

Highlights from research findings:

*CR levels are highest after cereals - predominantly durum and barley - and lowest after non-cereals, particularly peas and fallow.
*CR levels are unlikely to be kept at a low risk by using only resistant varieties.
*CR levels can remain unchanged after non-cereals.
*CR levels can decrease after a cereal.
*It can take two or more years of break from a cereal for CR levels to decrease to low-risk status.
*It may be possible to predict rotation effects on soil CR levels for individual paddocks.
*The bulk of an infected cereal crop has more influence on inoculum carryover than the cereal type or variety.
*Microbial ameliorants were not effective in accelerating reduction of CR levels in trials or commercial paddocks.
*F. pseudograminearum concentrations in cereal residues do not change significantly during dry summers.
*The rate of increase of CR DNA in plants was slower at the start of the season and faster after late tillering.
*Rates of CR DNA increase differed between bread wheat, durum and barley early in the growing season.
*The rate of CR DNA increase was similar for the three cereal types after late tillering.
*The time of change in rate of CR DNA increase was earliest in durum and latest in barley.

In an inter-row sowing trial with standing stubble, CR levels (as expected) were higher on old cereal rows than between them.
Less expected was the finding that even where the trial was heavily grazed and where cereal residues were minimal, there were still higher CR levels on old cereal rows than between them.

**Managing the risk**

For agronomic and economic reasons, it will often be necessary to sow a cereal in a paddock with medium to high CR levels. In these circumstances, it is important to understand the options for reducing the level of yield loss.

Project work included screening breeders' lines of bread wheat and durum for resistance to CR, quantifying yield losses in different cereal types and assessing the value of inter-row sowing for reducing yield losses. Methods included soil and stubble sampling in replicated trials (sown with seed inoculated with CR spores), PCR analysis of fungal DNA concentrations in samples, visual assessments of disease expression in-crop and plot yield measurements.

**Highlights from research findings:**

Cereal types with significant average yield losses in trials: durum 34%, triticale 20%, susceptible bread wheats 16% and oats 16% (on limited data). These cereal types had more than 5% yield loss in most trials. Cereal types with minimal average yield losses in trials: Kukri® 8%, moderately susceptible (MS) bread wheat, barley 7%, cereal rye 7% (on limited data).

* The above crop types had more than 5% yield loss in about half the trials.
* Improved sampling of varietal screening trials - disease assessment on 3x0.5m row samples, not 25 plants at random.
* Preliminary data indicated some durum lines show lower yield losses from CR than commercial varieties.

Advanced breeders' lines of durum wheat supplied by Dr Hugh Wallwork, Dr Tony Rathjen and Michael Quinn and screened in the field showed resistance at a level closer to bread wheat than commercial durum varieties.

Precision sowing between old cereal rows increased bread wheat (11%) and durum (33%) yields, but not barley yields in a bad CR season. As well as direct CR effects, there were agronomic ones, particularly for barley.

**Building management skills**

**Highlights:**

* Invitation to present on CR to growers at the Eyre Peninsula Agricultural Research Foundation disease workshop.
* Contribution to the GRDC Crown Rot Fact Sheet, from which there has been good feedback.
* Complete revision of the CR chapter in the highly regarded Root Disease Risk Management resource manual produced by Dr Alan McKay.
* Presentation of the CR session at four very successful Root Disease Risk Management workshop series venues, run by Dr Alan McKay.
* The comment by Dr Stephen Simpfendorfer that SA growers are more aware of CR than NSW growers.

Good relationships and interaction with the South Australian Durum Growers Association, the Hart Field-Site Group, individual growers and agribusiness personnel, which have allowed a two-way flow of information and ideas about CR and its management. In this respect, conducting semi-structured discussions with targeted individuals has been invaluable, providing a venue for finding out what works, and does not, in managing CR in commercial situations, allowing latest research findings to be disseminated and suggesting priorities for future research.

**Other research**

Use of polymerase chain reaction (PCR) to assess *Fusarium* spp. DNA concentrations in cereal plants was found to have potential as a research tool. A précis of the rationale, research and preliminary findings from field work in 2007 and 2008 are presented below. It has not been possible to complete all DNA analyses because of a shortfall in funds. The work was not anticipated or budgeted for in this project.

**Hypothesis 1**

That *Fusarium* spp. DNA can be detected in wheat and barley plants during the growing season.

Data (2007)
Findings

* PCR can detect *Fusarium* spp. DNA during the growing season.
* There were two phases of increase in *Fusarium* spp. DNA: slow early, much faster later in the season.

Phase 1: Differences between the cereal types were consistent with their accepted susceptibility to CR.

Phase 2: No significant differences in rates of growth between the cereal types.

* The more susceptible the cereal type, the earlier in the season the change (from Phase 1 to 2) occurred.
* Largest differences between cereal types were seen at head emergence.
* Late in the season, fungal DNA concentrations fell. All cereal types ended with similar concentrations of fungal DNA.
* Limited data indicated DNA analysis could differentiate between varieties.

Conclusions

* PCR has the potential to provide a more direct measure of varietal resistance and the effects of management treatments than visual disease assessments late in the season.
* PCR combined with visual disease assessment may assist in understanding the factors involved in development of this disease under field conditions.
* Head emergence may be the best time to take samples for resistance screening using PCR.

**Hypothesis 2**

That in-crop *Fusarium* DNA is a more robust indicator of varietal resistance than stem browning.

Supplementary hypothesis: that head emergence is the best DNA sampling time.

Data (2008)
Hart, Cambrai: 18 entries, samples at late tillering, head emergence, early grain-fill.
Records: visual disease assessments, samples for DNA analysis. DNA analyses incomplete.

Findings and conclusions

Once analysis and interpretation is completed, findings will be presented at national crown rot meetings and in scientific publications.

**Hypothesis 3**

That Phase 1 and 2 of fungal growth are stable across season, site and cereal type.

Data (2008)
Hart: durum, sampled fortnightly, early tillering to harvest.
Cambrai: durum, bread wheat, barley, triticale, cereal rye, oats; sampled fortnightly, early tillering to harvest.
Records: visual disease assessments, samples for DNA analysis. DNA analyses incomplete.

Findings

* That Phase 1 of fungal growth is affected by season and site.
* Initial leaf-sheath infection did not always progress through all leaf sheaths to produce stem infection. This is consistent with disease progress as seen in glasshouse varietal screening, where a droplet of CR inoculum is placed on the side of the base of young plants.

Conclusions

* Data may assist in understanding environmental, cereal type and crop growth factors with most influence on the fungus.
* Droplet test methods simulate paddock infection and are suitable for assessing seedling resistances.
Natural infection of leaf sheaths in the paddock early in the season may be a useful adjunct to traditional screening methods because it may provide insights into seedling resistances.

**Additional information**


Coordinated information for, contributed to and edited the GRDC Crown Rot Fact Sheet (Western, Northern, Southern), April 2009.


