Control of cereal fungal diseases

Summary
This project has provided a resource to help the wheat and barley industries control fungal diseases. Information has been provided to growers on the identification and management of diseases and on the resistance status of varieties.

This project was responsible for the identification of disease resistance in breeding lines for the wheat and barley breeding programs in South Australia (SA). New sources of resistance were identified to help with the more intractable diseases and these were introgressed into adapted varieties for use by breeders. The genetics of resistance were also studied.

Diseases were monitored throughout SA, new strains identified and warnings provided to industry of pending problems.

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Conclusions

This project has obtained useful information on a range of diseases and provided an effective screening service to the wheat and barley breeding programs in South Australia (SA). This screening has also provided a reliable disease resistance guide for growers and advisers.

We believe that we have made a significant breakthrough in the hunt for resistance to crown rot in durums. The development of resistant lines in adapted backgrounds is underway and will continue in GRDC Project DAS00048. New resistance sources have been identified for crown rot in bread wheat and spot form net blotch and scald in barley.

A wide range of extension activities conducted by Dr Wallwork has meant that industry is much better informed on disease issues and threats and the area sown to highly susceptible varieties is much lower than it would have been without this project. In particular, this project has provided the resources required for Dr Wallwork to promote the benefits of Minimum Disease Resistance Standards for rusts as Chairman of the Australian Cereal Rust Control Program (ACRCP) Consultative Committee. This has helped to reduce the threat of rust and in particular prevent new rust strains building up to much higher levels than they are at present.

This project has shown that significant leaps in the understanding of the genetic control of cereal diseases can be made where effective pathology and screening resources are available, coupled with molecular support for programs such as the Australian Winter Cereals Molecular Marker Program (AWCMMP).

Recommendations

Disease problems change over time as seasons vary and farm management practices evolve. More recently there has been a rapid change in rust strains that has seriously restricted the choice of varieties suitable for cultivation. These factors make it more apparent than ever that the cereal industry needs to be vigilant in its control of cereal diseases and that disease control requires integrated approaches that take into account fungal pathology, farm management systems and plant breeding. Strong promotion of Minimum Disease Resistance Standards (MDRS) and less reliance on fungicides are also needed as part of this approach. Without greater care there is potential for a massive increase in inoculum loads that will in turn increase disease problems through pathogen change in future years. With strong advocacy and effective extension activities, plant pathologists with expertise across these areas can make a big difference to the sustainability of cereal farming.

This project brought together expertise in fungal biology, plant breeding and extension. Each of these activities reinforces the others. The extension role, because it usually involves two-way communication, helps ensure that the research remains relevant and practical, while the research and plant breeding components ensure that the extension is accurate and up-to-date. Where these activities are separated, research is likely to lose focus and immediacy and extension agronomists are more likely to propagate ideas from sources that may not reflect current local conditions. The combination of activities within this project therefore has much to recommend it as a model for other areas of GRDC funding. Unfortunately, with the increasing privatisation of plant breeding and extension activities it is likely that in future it will become harder for research projects to have behind them a practical understanding of the key issues underlying research problems.
The recommendation is to foster the continuation of multidisciplinary groups.

**Outcomes**

**Economic outcomes**

This project has provided growers with reliable and timely information on which varieties have the best resistance and which are highly susceptible and should be avoided. It was through this project that Dr Wallwork was able to steer the Minimum Disease Resistance Standards (MDRS) for rust resistance and which led to Stylet identified as being very susceptible (VS) to stripe rust and subsequently withdrawn from release to growers. Had Stylet been widely grown the consequences in terms of rust development, fungicide costs and yield loss would have been very high. In addition it is likely that, with increased inoculum, further new damaging rust strains would have appeared.

This project has led to an increased grower awareness of cereal diseases and how to identify and manage them. This has occurred from dissemination of information on the identification of diseases and new pathogen strains and advising growers and advisors of impending problems and management options for controlling diseases.

This project has assisted the wheat and barley breeding programs to identify breeding lines with useful resistance to fungal diseases and other susceptible lines that should be discarded. This will impact at a future date on the level of resistance in varieties that are released to growers and industry.

New sources of resistance have been identified, in particular resistance to crown rot in wild relatives of durum wheat. Development of adapted germplasm has commenced with lines taken to the B1F4 generation. In time, possibly seven years, this should lead to the release of varieties that are not highly susceptible to this disease. This will allow durum crops to be grown in closer rotation and expand the area in which they can be grown.

This project has also been responsible for the phenotypic evaluation of numerous wheat populations for resistance to *Septoria tritici* blotch, yellow leaf spot and crown rot and barley populations for resistance to spot form net blotch, scald and common root rot. This work has resulted in the identification of molecular markers linked to genes for resistance to some of these diseases. Some of this information is now being used by the wheat and barley breeding programs in the development of improved varieties.

**Environmental outcomes**

This project will lead to a decrease in the requirement for fungicide sprays. This will reduce the chemical and fuel inputs required for farming in South Australia and thereby increase the sustainability of the cereal industry and the land on which it is based.

**Social outcomes**

This project, through improving the sustainability of cereal cropping, will lead to improved regional development.

**Achievements/Benefits**

**Background**

Fungal diseases of cereals are sporadic in occurrence and severity. This variation comes about from changes in seasonal conditions, farm management practices, varieties grown and changes in pathotypes of the fungi. Where conditions are favourable any one pathogen can lead to severe losses over several years and growers are required to make significant changes to their varieties, rotations or other practices to avoid damage. In other situations a disease may cause significant losses in one year then not recur for some time.

Many of these situations can be avoided through careful judgement of risks and active promotion and implementation of effective strategies.

**Extension**

This project continues the aim of providing the advice required to identify these risks and to advocate plans to avoid...
problems developing. Where this possibly unrealistic objective falls short, further advice and strategies are given to provide the most effective remedies to counter the losses incurred.

The most effective strategy to avoid serious losses is firstly to avoid ever growing a variety that is highly susceptible to any pathogen. One of the principal achievements of this project has been to strongly promote this idea through advocating Minimum Disease Resistance Standards for breeding programs, through frequent reiteration of the dangers of growers using varieties that are highly susceptible and presenting this as a ‘social disease’, and attempting to counter industry promotion of fungicides as a substitute for resistance.

Another effective strategy has been to improve the knowledge of growers and advisers about the important diseases of cereals, in particular how they survive and spread from one season and crop to another and how they can be managed. To this end, Dr Wallwork has been an annual contributor at GRDC Updates and numerous field days, workshops and other forums as well as a provider of information through a variety of other channels such as fact sheets, media articles and phone enquiries.

Resistance evaluation

Because the best means of controlling diseases is the use of resistant varieties, this project has focused on identifying existing and new resistance sources in wheat and barley varieties, breeding lines and introduced germplasm. Field nurseries have been successfully established each year to screen for adult plant resistance to scald (~3,000 lines a year), spot form net blotch (~3,000 lines), net form net blotch (~400 lines), Septoria (two sites, ~4,000 lines), yellow leaf spot (~500 lines), stripe rust and leaf rust (~3,000 lines). A system of outdoor pot tests, located on the Waite Terraces, Adelaide, has also been used to screen for adult plant resistance to crown rot, common root rot, take-all (in triticale) and the smut diseases (combined, ~35,000 plants). Growth room screening has been used where seedling tests provide a reliable indicator of field resistance: for resistance to yellow leaf spot, some genes for resistance to spot form net blotch and the three rusts of wheat.

The screening for smuts and common root rot has been conducted mainly to identify any new advanced cereal lines that are highly susceptible so warnings on their use can be provided prior to release.

In order to conduct these tests, and also supply rust spores to the wheat program for their breeding nurseries, a supply of pathogen isolates is collected and maintained in storage. Any suspected new pathotype is isolated and checked and, if required, multiplied and stored for future use.

This project has conducted annual tours of each of the moderate to high rainfall S3 and S4 variety evaluation sites where leaf diseases are likely to occur to evaluate advanced lines and new varieties from interstate and local breeders for disease levels. This has provided more accurate comparative data on resistance rankings and helped identify new strains and regional differences in fungal pathotypes. Information from these evaluations has been published in Cereal Sowing Guides and Cereal Variety Disease Guides.

Germplasm development

To help improve the availability of useful resistance sources to breeding programs, this project has been seeking new sources of resistance to some diseases and incorporating these into adapted lines. The focus has been on diseases for which the breeding programs are not screening either because of the difficulty in identifying and transferring resistance (crown rot, common root rot) or those subject to genetics studies aimed at introducing greater diversity (spot form net blotch). The main focus over the past three years has been on crown rot resistance in bread wheat and in particular durums, where the disease has been a major limiting factor on development of the industry because no resistance to this disease had previously been identified.

New sources of resistance have been identified in synthetic wheats from the International Maize and Wheat Improvement Centre (CIMMYT) and checked over multiple years of screening in pot tests on the Waite Terraces. The most promising of these sources was a line identified by CIMMYT as having scab resistance. This line, which appears to have resistance rather better than Sunco, was crossed to two Australian susceptible varieties and doubled haploid populations developed. These are being screened for crown rot resistance during 2004 with the aim of identifying molecular markers linked to the resistance gene and identifying whether the resistance is at a different locus to that in Sunco and Kukri.

Four lines of Triticum dicoccum have been identified over five seasons of screening as having useful resistance suitable for durums. The most promising of these lines has been backcrossed to Kalka durum and F2 seed screened during 2003 to
identify the most promising families for further selection. After summer screening for plant type, B1F4 seed is being screened for crown rot resistance during 2004. The most promising families from these should be further crossed and screened in the field during 2005.

A long-held objective of this project has been to incorporate resistance to common root rot in barley. While not a dramatic disease, common root rot is a constant problem in close rotations and consistent small losses occur over a wide area. Surveys in the 1980s showed the disease to be widespread and barley particularly affected; no doubt largely due to its following wheat in many rotations. The best source of resistance in a reasonably adapted barley was found in B1602, a six-row barley from the United States. Screening of a doubled haploid population identified a linkage to the six-row trait but two recombinants appeared to have broken this undesirable linkage. A new doubled haploid population derived from these lines is being screened for the second time in 2004. Any resistant lines will be used for further crossing, hopefully with the use of a marker to aid variety development.

New sources of resistance to spot form net blotch have been sought because most current effective sources seem to be located on the same segment of chromosome 7H and may have a similar origin. These sources have been crossed to susceptible adapted lines and F3 lines were grown at Turretfield, South Australia, in 2003 to identify any that may be different. Useful new sources will be transferred to the barley program for use as parents.

Research

This project aimed to ensure that as new issues arise we have the expertise to identify and investigate them and provide solutions to industry. Where extra resources are required, in crown rot management, for example, new funds (DAS00032) are sought to assist in achieving the required results. A specific example during this project was the research conducted on Pyrenophora semeniperda for the Department of Agriculture, Fisheries and Forestry (Australia) (AFFA) as part of a problem that arose with Chinese quarantine concerns over this pathogen. A staff member from this project was transferred to a GRDC-funded project to conduct this research during 2002. We had the ability to do this work because we had previously investigated this pathogen as part of this project as a precaution in case it should prove a problem. Our knowledge of the life cycle of this unusual fungus enabled us to convince the Chinese that it was not likely to cause epidemics in China. This helped save Australia’s main export market for malting barley.

This project has provided the resources to conduct genetic studies into the control of resistance to some diseases. It has funded the development of double haploid populations and screening of populations for resistance to Septoria tritici blotch, yellow leaf spot, spot form net blotch, crown rot and common root rot. This research, undertaken in collaboration with Kevin Williams, in the SA Research and Development Institute (SARDI), was contributed to and reported through the Australian Winter Cereal Molecular Marker Program (AWCMMP) and has led to the identification of genetic loci and molecular markers for these diseases.

This project supported research activities in several other projects. We have supplied fungal cultures, advice and assisted in training of students in pathology techniques. Recent examples are students with Amanda Able and Kevin Williams in the University of Adelaide and Klaus Oldach in the Australian Centre for Plant Functional Genomics. We also supplied rust screening services to Ian Dundas, who is working on the introgression of stem rust genes into wheat from alien sources.

Other research

This project has been continued as project DAS00048 with similar aims and outputs.

More recent research has been carried out in projects DAS00096 and DAS00099.

Additional information
