FINAL REPORT

GRDC Grains Research & Development Corporation

Genetic approaches to resistance to Fusarium and Bipolaris in wheat and barley

DAQ566

Project Details

- **Project Code:** DAQ566
- **Project Title:** Genetic approaches to resistance to Fusarium and Bipolaris in wheat and barley
- **Start Date:** 01.07.2002 **End Date:** 30.06.2007
- **Supervisor:** Emma Colson (Science Leader)
- **Organisation:** Department of Agriculture, Fisheries and Forestry
  PO Box 102 Toowoomba QLD 4350
- **Contact Name:** Emma Colson
  Phone: 07 46398890
  Email: emma.colson@daff.qld.gov.au

Summary

This project provided information on the genetics of crown rot (CR) resistance to help breeding work, located new parent lines in wheat and barley, and provided an insight into yield losses that occur in commercial varieties with increasing levels of CR for risk management. Genetic experiments found some highly resistant lines were poor parents, and CR resistance was complex. Best parent lines and many specific crosses were identified for further work. New potential parent lines were identified in wheat and barley, some now used in breeding programs. Yield loss can be severe even with low levels of CR when combined with drought stress. CR can reduce yield even with a wet finish.

Conclusions

Within this project:

1. A much greater understanding of the genetics of CR resistance was developed. This knowledge was able to be applied when selecting populations that would provide the greatest response to selection for CR, as well as the highest levels of resistance, while also containing some adapted characteristics, making the final breeding work less difficult.
2. A large volume of new germplasm was screened searching for improved CR resistance. A number of sources were identified in both bread wheat and barley (although barley is still in need of much greater improvement), and a number of those have already been incorporated into the respective breeding programs. It was found that transgressive segregants can be produced in barley for CR resistance, providing opportunities to generate improved material, even in the absence of a new resistance source.
3. Growers need to be aware of their CR disease levels in their paddocks. At high levels of inoculum, even the best available genetic resistance will break down and high yield losses can occur. At intermediate levels, the grower can make a calculated risk of returns versus yield loss, while with no CR present, highly susceptible varieties can be attempted to try and maximise yield.

A wet finish to the cropping season will reduce the damage suffered, but not prevent yield losses in all cases. Yield losses of 0-57% and 0-90% were recorded in experiments grown with either irrigation or a wet finish. CR coupled with a dry finish will ensure yield losses occur in all varieties. Yield losses from 30-88% were recorded with a dry finish, even with low levels of inoculum.

Recommendations

It is recommended that:

1. The genetic knowledge gained from this project be exploited in an applied fashion, to produce rapid gains in CR resistance in a future project.

This can begin by targeting populations and specific crosses known to produce progeny with high CR resistance, as determined by the diallel experimentation. From these populations, those with complex genetic interactions controlling CR resistance can be avoided in favour of those with simpler additive models, or additive x additive epistasis, as determined by the generation means experiments. Favouring those populations that also have an adapted parent in the crosses will help speed the adoption of selected progeny, as they could also carry a number of useful agronomic traits. Exclusively using crosses of less adapted parents would require extensive work to produce a commercial variety.

1. A future project should continue to search for more and higher sources of resistance to CR in barley germplasm. The current level of resistance in barley is very low compared to bread wheat. The CR resistant parents are also not as resistant as those found in bread wheat. Identifying parent lines with bread wheat levels of resistance will enable breeding to lift the overall resistance levels. Screening barley from international programs and wild relatives, in collaboration with barley breeders, will help to locate resistant lines to use as parents in resistance breeding.
2. Yield losses in barley should be investigated to determine whether the situation is similar to that of wheat.

Outcomes

Increased yield and quality of wheat and barley through improved resistance to CR:

The increased genetic resistance available to bread wheat growers, once the results of this project are released through wheat breeders, will enable increased yield and quality of wheat and barley to occur in the presence of the stubble borne disease, CR. Stubble retention has resulted in higher disease carry over between crops, and a dry finish to the season results in severe yield losses, particularly in more marginal cropping areas. Varieties with resistance to CR will enable growers to plant in areas where the crop could not previously be grown. It will also give grow-

ers confidence to continue the practice of reduced tillage and stubble retention and derive the benefits of reduced erosion and retention of soil moisture over summer.

Risk management work highlighted the importance of growers understanding the levels of CR inoculum present in their paddock prior to planting. Use of a susceptible variety when disease is present will mean significant yield reductions. When CR is not present, a variety that will yield greatest can be selected, regardless of CR resistance, but this choice cannot be made without knowledge of the disease status. Yield loss in one Queensland (QLD) field experiment, combined with a dry finish, showed that extreme yield losses can occur when CR is present (up to 90% yield loss, compared to plots of the same variety growing without disease).

Yield of wheat grown with CR showed a response, not to the yield potential, but to the level of genetic resistance to CR. Breeding for yield advantages will not be effective without improved CR resistance, for all growers who suffer the disease on their property.

Achievement/Benefit

Background:
Crown Rot (CR) caused by *Fusarium pseudograminearum* is a major soilborne disease problem in the wheat and barley industries. The disease is widespread and causes losses in yield and quality in QLD, New South Wales (NSW), Victoria, and South Australia (SA). Brennan and Murray estimated that the disease was causing losses of up to $56 million in bread wheat throughout Australia. In QLD losses have been estimated at up to 50% in some areas and losses of 20-30% occur regularly.
The disease may also cause a loss in quality primarily due to the production of small grain. As well, bread wheat and barley crops following a durum crop may incur high losses due to the high carryover of inoculum from the durum crop. CR is carried over from one season to the next in diseased residues. Retention of residues is important to avoid soil erosion and to maximise retention of soil moisture during summer fallows in northern Australia. Producers often resort to burning in summer when losses from CR have been high. Management strategies such as crop rotations can reduce CR but the disease has been found in wheat grown four years after a previous susceptible crop. Varieties with resistance to CR will allow the industry to expand into areas where CR is a problem.
Breeding for CR resistance has proven difficult in the past, so this project was designed to shed light on the genetics of CR resistance to help understand the genetics, and assist in CR resistance breeding. New sources of resistance are continually being sought in bread wheat, although a number of resistant lines exist. In barley, no such resistant lines exist, so there is even greater need to locate CR resistance.
Genetic resistance is a vital tool for the management of CR, coupled with management strategies. Information on the risk growers will encounter when they choose a certain level of genetic resistance over another is needed to enable informed decisions.

The aims of this project were to generate:

1. Increased yield and quality of wheat and barley through improved resistance to CR.
2. Germplasm with improved genetic resistance to CR in bread wheat, durum wheat and barley.
3. Advice on growing wheat varieties in high and low risk CR areas.

Achievements:

1. The genetics of CR resistance have proven to be complex, and highly dependent on the resistant parent, as well as being influenced by gene interactions. The knowledge obtained through this project has enabled a selection of populations to be targeted for their superior ability to transfer high levels of resistance to progeny, coupled with some potential for combined agronomic traits, increasing their usefulness to breeders.
2. New sources of resistance to CR in bread wheat have been identified, and some are incorporated in Australian wheat breeding programs. New sources of resistance in barley have been identified, and some are being incorporated into the Barley Breeding Australia Northern Node (BBA-North) breeding program. Seedling resistance has been detected in a barley doubled haploid population between *Hordeum spontaneum* and Tallon[A]. As part of the activities of the Australian Winter Cereal Molecular Marker Program (AWCMMP) this population has been sent for diversity arrays technology (DArT) analysis to identify mo-

lecular markers. Intercrosses between some moderately-resistant to moderately-susceptible barley lines has produced improved resistance.

3. The importance of growers knowing the level of CR in their paddock was highlighted. With this information growers can optimise their varietal selection to ensure they maximise yield. The northern region may suffer greater yield loss to CR than the southern growing areas, particularly when the crop suffers drought stress in combination with CR. There was an inverse reaction between the incidence of *F. pseudograminearum* and *Bipolaris sorokiniana* (Bs) in varieties with a range of reaction to CR.

Benefits to the industry:
An outcome of this project will ultimately be the release of varieties with resistance to CR. When these varieties are available, the wheat and barley industries will be less limited by the distribution of CR. It will also give greater confidence to growers to retain stubble and thereby incur the benefits of reduced erosion over summer and increased retention of soil moisture from summer rain. Growers can use knowledge of their levels of disease to make a choice of variety that will provide the maximum yield for their situation.

Collaboration Organisations

Dr. J Nicol, CIMMYT, Turkey - Exchange of germplasm with resistance to CR and common root rot (CRR).

Additional Information

Colson, E S; Wildermuth G B; McNamara, R B; Davis, M L and Coverdale, S M (2004). Impact of crown rot on wheat varieties grown in different levels of inoculum of Fusarium pseudograminearum in the field. Proceedings of the Third Australasian Soilborne Diseases Symposium. Ophel Keller, K M and Hall, B H (Eds) p117.