FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

DAS60SR

Control of cereal leaf and stem diseases

PROJECT DETAILS

PROJECT CODE:	DAS60SR
PROJECT TITLE:	CONTROL OF CEREAL LEAF AND STEM DISEASES
START DATE:	01.07.1993
END DATE:	30.06.1996
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Summary

Leaf and stem diseases of wheat and barley are responsible for large losses in yield in these crops. Depending on seasonal conditions, losses can be slight, as in 1993, or very significant as in 1992. In 1992, early sowing and a wet spring resulted in stripe rust, leaf rust and septoria tritici blotch in wheat and scald, leaf rust and Arno Bay blotch (spot form net blotch) in barley, causing severe losses over wide areas. The barley variety evaluation trials conducted throughout South Australia in 1992 showed an average yield gain across all sites of 22% when Schooner plots were sprayed with fungicide. In most cases, leaf scald was the cause of yield loss in the untreated plots. In addition, further economic losses were incurred as many deliveries were downgraded from malting as a result of higher screenings.

It has long been recognised that the most effective, economic and sustainable means of controlling crop diseases is the use of resistant varieties. This involves the identification of sources of resistance, identifying variation in disease-causing pathogens and the screening of large numbers of breeders' lines either in field nurseries or under more controlled environment conditions. For several pathogens, notably barley scald and the rust diseases, there is a risk that varieties will lose their resistance to new races of the pathogens. For this reason, it is important in breeding for resistance that a diversity of resistance genes is deployed and that reliance is not placed in too few genes.

Changes in farm management practices have influenced the incidence of crop diseases. Earlier sowing, made possible by the advent of improved herbicides, has increased the presence of leaf scald. Minimum tillage and stubble retention have also led to Arno Bay blotch becoming a problem disease on the Eyre Peninsula and in the Victorian Mallee and to a lesser degree in other areas in recent years. Continuous sowing of wheat (particularly in 1996) has also led to an increase in yellow leaf spot (tan spot).

This project was a continuation of a similar one funded by the Grains Industry Research Committee of South Australia.

Recommendations

That variety resistance remains a top priority for combating cereal diseases. This control method is the most economic and sustainable and one that allows maximum flexibility to growers.

That scald and Arno Bay blotch are made priorities for resistance breeding in barleys. That durable resistance to scald is sought through the development of polygenic forms of resistance rather than the deployment of single genes.

That continued vigilance is given to maintaining a diversity of resistance to the wheat rusts and septoria ensuring that when resistance is overcome by new races that adequate resistance remains within breeding programs. That resistance to yellow leaf spot is pursued owing to the increased incidence of this disease with continuous sowing of wheat.

That monitoring and study of cereal pathogens continues, providing early warnings of race changes and of disease problems and ensuring that effective information and control methods are readily available.

Achievements/Benefits

Project Aims

- To collaborate in the production of disease resistant varieties with the wheat and barley breeding programs in the southern region.
- To determine the incidence, importance and seek control methods for leaf and stem diseases of cereals in the southern region.
- To provide a resource base for information and advice on leaf and stem diseases of cereals to growers, industry, advisers and scientists.

This project has identified, publicised and explained the incidence and severity of the leaf and stem diseases in wheat and barley to growers, industry and research scientists. This has enabled priorities to be set for the breeding programs and

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chemical companies in planning future strategies. The project also provided advice on the most appropriate breeding strategies for the control of the priority diseases, particularly scald, leaf rust and mildew in barley and stripe rust and septoria in wheat.

The project successfully obtained disease resistance data for varieties and breeding lines in the wheat and barley breeding programs in South Australia and, to a lesser extent, lines from other breeding programs in the southern region. Emphasis was placed on stripe rust and septoria in wheat and scald in barley. Most screening for these diseases was conducted in inoculated field nurseries. Mature plant resistance for stripe rust and scald cannot be reliably and efficiently screened in the glasshouse or in the seedling growth stages.

New sources for resistance in barley to scald, leaf rust and mildew were obtained and crossed into locally adapted lines for variety development. These sources were specifically chosen to transfer more durable forms of resistance into malting quality lines and each donor of resistance was itself of high malting quality. After early generation selection these lines have been or will be transferred to the main breeding programs.

A new initiative was taken to demonstrate and develop the use of partial resistance to scald. This uses parents that possess low levels of resistance that, when combined, produce higher levels of resistance (transgressive segregation). Managed carefully, this method ensures that resistance in varieties is built up from a number of different genes which provides a more durable form of resistance. In the past, many varieties have had resistance to scald derived from single genes which, when lost to a new scald race, have become very susceptible. Results from screening of F_3 rows in 1995 showed that useful levels of resistance could be obtained from moderately susceptible varieties. This work is being developed further by project DAS226SR.

A number of breeding lines with diverse sources of resistance to stripe rust produced by this project were progressed to advanced generation testing in the Waite Program. These lines now provide a reservoir of useful resistances in adapted lines should the current resistance present in Australian lines break down to new races of rust.

This project has kept a watching brief for changes in the virulence of fungal pathogens that could lead to breakdowns in resistance of current varieties and breeding lines. Specific changes identified are detailed below.

Research into the chemical control of Arno Bay blotch has determined that none of the current seed treatments are effective against this pathogen and the only foliar fungicide with some partial control is Tilt®#. On the basis of this result, multiple applications of Tilt are being used in 1996 to try and determine yield losses to this disease. The efficacy of Tilt is thought to be inadequate to provide an economic return to growers. Barley grass is the only other host identified for Arno Bay blotch. Studies on Wirrega blotch have determined that this disease is unlikely to pose a threat in the short term since leaf infection is slight and only occurs from soil-based inoculum and therefore is unlikely to spread rapidly within a season. A damaging toxin has been identified with some isolates of this fungus and there remains a future threat that if isolates producing this toxin become more widespread then severe damage may occur in crops.

A need was identified to improve the stripe rust resistance status of the current wheats grown for hay and chaffing. Currently the preferred varieties are very susceptible and pose a threat to the grain industry by allowing build up of rust spores. A number of potential hay wheat lines with improved rust resistance have been identified in the project and sown in trials to assess their potential for hay production. Some preliminary crosses have also been made to combine rust resistance with improved quality.

Intellectual property summary

There is no intellectual property associated with this project that is appropriate for commercialisation. Support provided to breeders for production and commercialisation of varieties is subject to agreement between SARDI, GRDC and the breeding organisation.

Additional information

Publications

Wallwork, H. Cereal Variety Disease Guide. PISA Fact sheet (Annual Publication).
Wallwork, H. (1993). Cereal Seed Treatments 1993/94.

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Wallwork, H., Potter, T. and Lichon, A. (1994). Occurrence of Wirrega blotch in barley and other grass species in Australia. *Australasian Plant Pathology* 24: 22-25.
Wallwork, H. Loughman, R. and Khan, T.N. (1995). Biology and control of *Drechslera* diseases of barley in Australia. pp139-161 in "*Helminthosporia* Metabolites, Biology, Plant Diseases". Ed. Chelkowski, J. Institute of Plant Genetics, Polish Academy of Sciences.
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Discussion

Screening Methodology

Inoculum for a range of fungal pathogens was isolated, maintained and used to infect field plots and glasshouse plants. Inoculum for septoria screening was obtained from mixed isolates grown in weak agar broth and sprayed over plots at Kingsford and Roseworthy four to six times during July-September on damp evenings. A naturally infected nursery was sown each year at Wanilla on the Eyre Peninsula. Spores of stripe rust, leaf rust and stem rust were multiplied on glasshouse grown seedlings, collected with a cyclone spore collector and maintained at -80^{0} C. These spores were used to infect seedlings in the glasshouse for screening tests for major genes and to infect field nurseries at Roseworthy, Waite and Birdwood. Scald inoculum was stored as infected straw harvested from disease nurseries. This method ensured greater diversity in the inoculum population used for the screening. Specific isolates of interest were collected, cultured on agar plates and used as inoculum for glasshouse screening tests. This inoculum was also added as a spray to the field nursery and thereby contributed to the following year's infected straw. Arno Bay blotch and yellow leaf spot trials relied on natural inoculum in paddocks with retained stubbles and were sown on the southern and northern Eyre Peninsula, respectively.

Smut spores were collected each year from smut nurseries and maintained in the refrigerator. Inoculation was effected by dusting of spores on seed and germinating those seed at about 5-10^{0} C for bunt and 15-20^{0} C for flag smut and barley covered smut.

Resistance screening

The project successfully obtained disease resistance data determining the resistance status of breeding lines in the wheat and barley breeding programs in South Australia and, to a lesser extent, lines from other breeding programs in the southern region. Between 2,000 and 4,000 wheat lines were screened each year for septoria, stripe rust and stem rust in inoculated field nurseries. Resistance data has been obtained in wheat for leaf rust, stem rust, flag smut and bunt in glasshouse tests and in pots in terraces at the Waite. In barley, field resistance data has been obtained for 1,000-2,000 breeding lines for scald in inoculated field nurseries. Mildew and covered smut have been screened in the glasshouse and in pots in terraces at the Waite. Wheat and barley secondary trials have also been scored for disease severity throughout SA each year and valuable data obtained for resistance in varieties and advanced lines for a range of diseases.

Resistance development in barley

New sources for resistance to scald, leaf rust and mildew were obtained and crossed into WI 2875, Schooner and Chebec. Progeny are being screened for resistance to these diseases prior to being passed to the barley breeding programs. Scald resistance has been obtained from European winter barleys with malting quality Halcyon, Puffin, Gleam, Sunrise and Melanie and a South African CIMMYT (International Maize and Wheat Improvement Center) selection B87/14. There is little or no scald resistance in malting quality spring barleys worldwide. Leaf rust resistance is being sourced from two Dutch varieties, Vada and Varunda which have been identified as having durable resistance. Single gene resistance to scald and leaf rust is also being utilised for short term improvement of WI 2875. The durable resistance gene for mildew *Mlo* from Chariot has been incorporated into lines which are currently being advanced in the breeding program.

The potential value of partial resistance to scald has been demonstrated through three crosses between Schooner, O'Connor and Arapiles, varieties with varying levels of partial resistance to scald. Schooner and O'Connor were selected as varieties which have consistently shown less disease than varieties such as Clipper, Galleon and Yagan despite being grown over large areas for many years. The partial resistance in these varieties can therefore be described as durable. Arapiles in Victoria had appeared also to be only moderately susceptible to scald but with the inoculum used in this trial Arapiles was found to be

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more susceptible and was thus less useful than initially hoped. Screening of random F_2 headrows in 1995 revealed increased and useful levels of resistance in transgressive segregants. The best resistance was obtained from Schooner and O'Connor which also had higher levels of partial resistance. This polygenic form of resistance can be enhanced with three or four-way crosses and should be more durable than single gene resistance. This work is being pursued further with a wider range of resistance sources and will be adopted for use in developing useful parents and breeding lines for the barley breeding programs.

Resistance development in wheat

Lines with resistance to stripe rust were developed by the leaf diseases project preceding this one. These lines were carried through to advanced generations in the University of Adelaide Wheat Breeding Program during this project where they now provide a wider diversity of resistance to this disease in the program. This ensures that in the event of a breakdown in resistance, there are a number of well adapted alternative breeding lines available for release. The screening program has ensured that all new released wheat varieties have improved levels of resistance to stripe rust. This has ensured that stripe rust is unlikely to be the problem it was in the 1980s and also in 1992. A stripe rust resistant Bindawarra line, Y10 Bindawarra, was made available to growers during 1996. This combines the superior biscuit quality of Bindawarra with improved disease resistance.

Pathogen virulence surveys

Changes in the incidence and importance of different diseases have been monitored in SA. New races of barley scald capable of attacking Skiff, Franklin(D), Tantangara and WI 2868 have been identified from a number of locations. Five new barley leaf rust races capable of attacking Franklin and varieties with the gene *Rph*3 were identified from the Lower Yorke Peninsula. A new virulent isolate of net blotch capable of attacking some previously resistant Queensland breeding lines has been identified from barley in the South-East. Wheat rust races have been monitored in association with the University of Sydney and a new race capable of attacking Tatiara and Meering has been tentatively identified in the South-East. A new population of *S. tritici* that is more damaging on wheat varieties related to Aroona has been identified on the Lower Eyre Peninsula. These identifications, sometimes only regional, have provided useful warnings and guidance to breeders on the potential value of current sources of resistance and the great importance of seeking diversity in genetic resistance.

Arno Bay blotch *(Pyrenophora teres f maculata)*

Three seed treatment trials using Armour®#, Baytan®#, Raxil®#, Vincit®#, Vitavax®# and Imazalil®# in replicated plots have been conducted at Arno Bay in 1993 (Table 1) and Yeelanna and Arno Bay in 1994. Similar data was obtained in each trial and clearly showed that none of these chemicals has any useful effect against Arno Bay blotch. A foliar fungicide trial was conducted in a crop at Padthaway that was observed to be heavily affected at the mid-tillering stage in 1994. Five spray treatments with four replicates were applied at three dates and on 19 October, the number of blotches on the second to last leaf were counted. The results (Table 2) showed no efficacy of Impact®# and a small but not significant effect of Folicur®#. Tilt ®# (propiconazole#) was observed to have a significant ($P<0.05$) effect against the fungus reducing the number of spots per leaf by about two thirds after the three applications. Because the observed efficacy of Tilt was low, it is unlikely that use of this product will provide an economic return to growers. On the basis of this result, Tilt is being used in 1996 with multiple applications to try and determine yield losses to Arno Bay blotch in the Victorian Mallee and on the Eyre Peninsula. Trials with other more promising new chemicals are being conducted as part of project DAS226SR.

Table 1: Arno Bay blotch seed treatment trial, Arno Bay 1993.

Treatment	Mean number of blotches				
	7 July total	26 July total	7 July >4mm	26 July >?mm	26 July >10mm
Vitavax	13.6	18.5	1.9	7.9	3.6
Baytan	12.6	9.9	1.4	3.3	1.1
Raxil	11.5	18.5	1.8	4.5	1.9

Vincit	10.4	14.4	0.9	3.6	1.0
Vincit/ Imazalil	10.1	13.6	2.1	5.4	2.8
Armour	10.1	15.0	1.1	4.5	1.1

Table 2: Arno Bay blotch fungicide spray trial, Padthaway 1994.

Treatment	No of blotches per leaf
Untreated	4.80
Impact 250	5.16
Impact 500	5.13
Folicur 250	3.60
Tilt 250	1.60

Wirrega blotch (*Drechslera wirreganensis*)

Studies on Wirrega blotch have identified the sexual stage of the fungus and determined that this disease is closely related to ringspot. The disease has been identified at a range of locations across SA and in 1994 in Western Australia. In 1996 it was also identified in South Africa. It has been discovered that neither Wirrega blotch nor ringspot spreads from leaf to leaf, infection coming instead from soil-borne grass seeds. Because of the small size of most lesions and the inability to spread rapidly within a season, Wirrega blotch poses little threat in the short term. A damaging toxin has been identified with some isolates of Wirrega blotch and there remains a future threat that if isolates producing this toxin become more widespread, then severe damage may occur in crops in the future.

Chemical control of scald

Research into providing useful guidelines for the chemical control of scald is ongoing but only one useful trial result has been obtained due to adverse seasonal conditions in 1993 and 1994. These trials aim to provide growers with a set of guidelines as to the level of disease, growth stage and yield potential for spraying to be economic. Further trials will be conducted by project DAS226SR to obtain a range of different spraying scenarios.

Industry Implications

This project has provided essential support to the cereal breeding programs enabling them to better identify resistance to a range of fungal diseases in their breeding lines. The project has also identified sources of resistance from within Australia and from overseas and these have or are being incorporated into the breeding programs.

The project has demonstrated the value of partial resistance in scald for developing durable resistance in the barley breeding program. The project has also identified sources of scald resistance that are unreliable and which should be used with caution by breeding programs.

This project has identified Arno Bay blotch as a new and potentially major new disease of barley in the southern region and identified it as a consequence of short rotation, stubble retention farming systems. Control options have been clearly identified and publicised.

Advice has been widely disseminated on the identification and control of a range of fungal diseases in cereals. This will have led to improved disease management strategies on farm and reduced losses and costs to growers.