Summary

The review of variety testing and release procedures in the Australian grains industry, under the chairmanship of Prof Alec Lazenby, recommended that variety testing be undertaken in a small number of agro-ecological environments. Subsequently, wheat breeders identified five major agro-ecological environments for variety development in southern Australia. These were identified from experience, rather than from a rigorous analysis of environmental and variety adaptation data. The agro-ecological environments were:

- A Wimmera environment in western Victoria (VIC).
- A Mallee environment which extends from north-western VIC to the western Eyre Peninsula of South Australia (SA).
- A duplex soil zone, which is a medium rainfall environment in SA.
- A high rainfall zone in north-eastern and south-western VIC.
- An irrigation zone.

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Conclusions
There are three broad mega-environments for wheat in SA and VIC. These are based on rainfall and temperature and provide a much better explanation of genotype x environmental (GxE) interactions for yield of wheat in southern Australia than environments based on fixed, geographical boundaries.

Recommendations
Wheat breeders in southern Australia should consider structuring their breeding programs to develop varieties for the three mega-environments described previously. Individual trials in the southern region should be classified according to these three environments, regardless of where they occur, and analysed accordingly. This will require knowledge of anthesis dates for each trial, with temperature and rainfall data usually available from the Australian Bureau of Meteorology (BoM). Newly released varieties could be recommended according to type of environment, which would require a knowledge of the probability of occurrence of each mega-environment type in each district.

Outcomes

Economic Outcomes
This project provides the foundation for an improved variety evaluation and recommendation program for wheat in southern Australia. This should lead to a faster rate of gain in yield, with improved profits for wheat growers.

Ms Bell has joined the Birchip Cropping Group and her training should contribute to the effectiveness of that group.

Achievements/Benefits

Overview of Project Achievements
In 1993, wheat breeders and agronomists agreed to retain seven diverse check varieties in Stage 4 testing for three seasons. These were Dollarbird, Goroke, Janz, Machete, Meering, Rosella and Trident. These varieties were grown at all sites in SA and VIC for the 1994, 1995 and 1996 seasons, for a total of 165 environments. Subsequently, it was found that a breeding line, VF519, had also been grown in all environments. Data on grain yield, along with sowing and flowering date, disease incidence, temperature and rainfall were analysed to identify the major environmental factors influencing variety adaptation of wheat in southern Australia and to determine the major agro-ecological environments for wheat breeding in this region. Another aim was to provide post-graduate training in the analysis of variety adaptation for Ms Cherie Bell.
Results

The three seasons were diverse, with below average yields in 1994 and above average yields in 1996. The range in yields was from 0.24 t/ha to 8.25 t/ha.

Initial analyses revealed large variety x environmental interactions, with a strong dependence of individual trial residual variances on trial means. A power transformation of 0.38 substantially reduced this dependence. Cross-over interactions were important, accounting for 30% of the GxE interactions on the transformed scale.

The success of partitioning a region into component agro-ecological environments can be measured as a transfer of GxE variation into the genotypic component. Ms Bell’s analyses using this criterion showed that there was very little gain from sub-zoning the wheat growing region of VIC and SA into the agro-ecological environments defined by the wheat breeders. Furthermore, the three-way component of the GxE interaction variance, that is the component due to the interaction of varieties with both years and locations, was the largest component. This suggested that interactions with climatic events, such as temperature and rainfall, were the important determinants of GxE interaction.

Disease and soil factors, such as boron levels, were not important determinants of interactions in this data-set. Rainfall and temperature were the important determinants. Across all varieties and dryland environments, rainfall during the 30 day period prior to anthesis explained the greatest proportion of the variation (17%). However, maximum temperature for the 30 days after anthesis explained the greatest proportion of the GxE interaction (7.3%), suggesting that these varieties differ in genes important for tolerance to high temperatures after anthesis. Both of these tests were statistically significant. Using these environmental attributes, three mega-environments were defined. These were:

1. An environment experiencing 200-300mm rainfall between sowing and anthesis and average maximum daily temperatures below 26°C between anthesis and harvest. This is a Wimmera-type environment.
2. An environment with less than 200mm rainfall between sowing and anthesis and higher than 26°C maximum daily temperatures between anthesis and maturity. This is a Mallee-type environment.
3. An environment experiencing more than 300mm rainfall between sowing and anthesis and below 26°C between anthesis and harvest. This is a high rainfall environment.

A much higher proportion of both the environmental variation and variety x environmental interaction variation could be explained by these three mega-environments than by the original agro-ecological environments defined by the breeders.

Other research

Implementation of these concepts of environmental adaptation requires a classification of the entire southern wheat belt according to the probability of occurrence of the three mega-environments. These probabilities can be calculated using data from the Australian BoM, and are likely to vary by both district and sowing date. An evaluation of the concepts over more years, and especially varieties, is warranted.

A better understanding of the genetic basis for the post-anthesis temperature x variety interactions should assist with the development of better varieties, especially for the Mallee mega-environment.

Additional information

Publications

