Generating & evaluating a novel genetic resource in wheat in diverse environments

Funder: DEFRA (Project Ref: AR0914)
Collaborators: IOR-EFRC, John Innes Centre
Start Date & Duration: November 2001; 72 months

Overall Aim

To increase the sustainability and competitiveness of both non-organic and organic farming systems by developing genetically diverse wheat populations that will respond rapidly to on-farm selection for improved productivity and yield.

Abstract of Research

The potential for the adaptation of wheat to UK environments has been constrained by the framework of the pedigree selection method that has dominated plant breeding for a century. Pedigree breeding evolved as a method of selecting and fixing specific genotypes, which has clear advantages of simplicity and stability. However, the relatively limited number and range of true-breeding genotypes that are produced lack the ability to adapt to different and changing environments. There has been a tendency, therefore, to select for single genotypes that have broad adaptation or, in other words, to select against genotype x environment interaction. Because of the wide range of environments even within the wheat-growing area of the UK, pedigree line breeding may have thus imposed limits on the performance of wheat, particularly with respect to environmental buffering, thus increasing the need for synthetic inputs.

The research will therefore address the DEFRA ROAME A objective by identifying traits or sets of traits that determine or improve adaptation of wheat to the range of UK arable environments, production systems and markets. The principal objective of the project is to develop composite cross populations of wheat based on a wide range of key parent varieties. The parents will be selected partly on past knowledge of successful performance in terms of yield, quality and disease resistance and partly on the basis of molecular ancestry to try to ensure as wide range of diversity as possible. Following parental inter-crossing in all possible combinations, progeny population samples will be exposed to a range of widely different agricultural environments and systems through several seasons of, largely, natural selection. Performance of the population samples will be compared at different stages against both the parents grown as pure stands and as physical mixtures.

The research will deliver a unique insight into the evolution of a genetically diverse wheat population in a diverse range of environments. This will provide information on the characters of winter wheat that confer improved performance within each environment. From inclusion of production environments (including organic), it should be possible to determine key characters and ideotypes that contribute to successful production under these different systems. Population material from the project will provide a valuable genetic resource for breeders and growers and samples will be lodged in the gene bank at the John Innes Centre.

Objectives

1. To generate six distinct, highly heterogeneous composite-cross populations of winter wheat for further development and selection. The populations will comprise; one with parental material selected for good milling potential, one with parents selected for high yield potential and one comprising both sets of parent material. Each of these populations will then be split to either include or exclude heritable male sterility.
2. To evaluate the performance and evolution of composite-cross populations over time under a diverse range of environmental conditions and identify characteristics that confer improved productivity in these environments.

3. To track the genetic changes that accompany selection, so providing a better understanding of the assemblages of traits that underlie improved productivity in diverse environments.
4. To provide genetically diverse crop material for further selection by farmers and as a resource for future publicly funded research.
5. To disseminate the results to the scientific community and industry

Project Progress

Objective 1 (November 2001 – September 2003)

The following parents lines were selected:

High Quality: Bezostaya, Cadenza, Hereward, Maris Widgeon, Mercia, Monopol, Pastiche, Renan, Renesansa, Soissons, Spark, Thatcher.

High Yield: Bezostaya, Buchan, Claire, Deben, High Tiller Line, Norman, Option, Tanker, Wembley.

Additional crosses have also been made onto the male sterile lines: Male Sterile Plant 1, Male Sterile Plant 2, Male Sterile F2/F3 Bulk Popn 2/77, CIMMYT line: F1TOPDMSO102 NING 8201 DMS.

All 20 parent lines were inter-crossed in a half-diallel to provide 190 F_1 cross combinations. The F_1 seed that resulted from these crosses was then re-sown and grown on under greenhouse conditions. The F_2 seed resulting from these crosses has been bulked together, noting carefully the contributions of each of the crosses to each population, to provide the six composite cross populations that were sown in autumn 2003. The trial sites used are a stockless organic system (Wakelyns Agroforestry, Suffolk), a mixed organic system (Sheepdrove Organic Farm, Berkshire), an integrated farming system (Morley Research Centre, Norfolk) and a continuous wheat system (Metfield Hall Farm, Suffolk). Many agronomic and environmental parameters have been recorded throughout the season to permit comparison between parents and composites and to provide an understanding of evolutionary dynamics amongst different production systems.

Expected Benefits

- The research will deliver a unique insight into the evolution of genetically diverse wheat populations in a diverse range of environments. This will assist in elucidating the interaction between gene x environment.
- From inclusion of production environments, including organic, it should be possible to determine key characters and ideotypes that contribute to successful production under these different systems.
- The population material from the project will provide a valuable genetic resource for breeders and farmers and samples will be lodged in the gene bank at the John Innes Centre.

Project Output

Phillips, S. L. and Wolfe, M. S. (2004). Evolutionary plant breeding for low input systems. Journal of Agricultural Science. In Prep.

Phillips, S. L. and Wolfe, M. S. (2004). *Plant Breeding for Agricultural Diversity*. In: Organic Farming: Science and Practice for Profitable Livestock and Cropping. Ed. A. Hopkins, Proceedings of the BGS/AAB/COR conference. Occasional Symposium No. 37: 184-187.

Welsh JP and Wolfe MS. (2002). The performance of variety mixtures and the potential for population breeding in organic farming systems. *Proceedings of the ECO-PB Symposium: Organic seed production & plant Breeding – strategies, problems and perspectives*, Berlin.

Welsh JP, Wolfe MS, Snape J and Pearce BD. (2002). Generating and evaluating a novel genetic resource in wheat in diverse environments. In: *Proceedings of the 14th IFOAM World Congress*, Canada. 311.

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