GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

VF00008

Characterisation of low phytic acid wheat and barley

PROJECT DETAILS

PROJECT CODE:	VF00008
PROJECT TITLE:	CHARACTERISATION OF LOW PHYTIC ACID WHEAT AND BARLEY
START DATE:	30.01.2008
END DATE:	30.11.2009
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Summary

Phytic acid (PA) in grains results in malnutrition in humans and animals, low efficiency of P fertilisers and environmental pollution. Development of crops with low PA became a global strategy to combat these issues. The project generated low PA mutants from Australian wheat and barley varieties Wyalkatchem⦶ and Dash⦶ in China under the International Atomic Energy Agency (IAEA) project "Identification and characterisation of low phytic acid wheat and barley". The aim of this visit was to introduce and characterise these mutants into the DAFWA wheat and barley breeding programs.

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product registrations listed in PUBCRIS for current information relating to product registration.

Old or Archival Reports (Projects that concluded in 2007 or earlier)

The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions

Major conclusions and recommendations:

Low phytic acid wheat and barley mutants were generated first time from Australian varieties, which provided basis for the Australian wheat and barley breeding programs to develop low phytic wheat and barley varieties in the future. The progress in the current project demonstrated that mutation breeding is an efficiency approach to develop new germplasm or varieties with novel traits. We have also investigated more than 400 barley germplasm for grain P content. This information is critical for the breeding programs to select parents for development of new varieties with low phytic acids through either conventional or mutation breeding. Candidate genes and molecular markers developed in the project will accelerate the breeding process for low phytic acid. Comparisons between three lpa mutants and their wild type Dash⦶ showed that the lpa mutants have reduced seed viability and grain weight. Further breeding effort is required to convert these mutants into commercial varieties

It is a world trend to develop low phytic crops, which address nutritional and enviromental issues. Low phytate rice, maize, soybean and barley varieties have been developed and commercialised in other countries. Australia is far behind these other countries.

The following key issues should be addressed in the future;

1. Fast track development of Australian low phytate wheat and barley varieties in order to close the gap with our major international competitors;
2. Development of new mutants with enhanced P re-useable efficiency from the Australian major wheat and barley varieties with better adaptation, yield and quality;
3. Industry partners for evaluation of the low phytate wheat and barley on animal nutrition and environmental effects;
4. Industry partners for fast track release of low phytate wheat and barley;
5. Understanding mechanisms of different low phytate mutants and their relationships with grain yield, quality and seed vigor in order to identify the most suitable phytate level for commercial production.

Achievement/Benefit

Project achievements:

More than 100 potential low phytic acid wheat and barley mutants were generated by 250 Gy Cobalt-60 gamma ray irradiation and introduced into Australia. Three lpa mutants, designated as B14, B31, B34, were identified from the Dash⦶ mutant population. These mutants were verified to be uniform in low phytic acid contents when planted in Western Australia two consecutive seasons in 2008 and 2009, respectively. The mutant lines are under field evaluation in 2009/2010 and 2010/2011 and are ready for delivery to the commercial breeding programs.Two wheat potential lpa mutants are also under field trials for agronomic performance. Three candidate genes, lpa1-1, lpa2-1, lpa3-1, controlling low phytic acid has been mapped on barley chromosome 2H, 7H, 1H, respectively, which showed good synteny with rice chromosome 4, 6, 5, respectively. Gene-specific molecular markers were developed for selection of low phytic acid genes. In addition, variations in

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the contents of inorganic# P (Pi) in the whole grains were evaluated in 400 barley accessions including the old, modern, update, and imported varieties or germplasm. The Pi content ranged from 0 (very low level) to 6.26 mg/g with an average of 1.98 mg/g, which will provide basis for further improvement of Australian barley varieties for P use efficiency.

Industry benefits:

Biofortification breeding with the aim to develop new crop varieties with increased content and/or bioavailability of important micronutrients has become an important tool in combatting global malnutrition. Phytic acid or hexa-myo-inositol phosphate is a compound found in most cereals and grain legumes. It accounts for about 70% of phosphate in barley and wheat grains and is not digestible by humans and mono-gastric animals. Phytic acid sequesters divalent cations such as Fe2+, Zn2+, Cu2+, Ca2+, Mg2+ and Mn2+. In humans and other mono-gastric animals; such as pigs and chickens the presence of large amounts of phytic acid in the diet can be related to two significant issues. It can significantly compromise the uptake of divalent nutrients resulting in mineral nutrient deficiencies. Small scale human and animal experiments have shown 50% higher iron (Fe) and 76% higher Zn efficiency of low phytic acid maize. It is a significant issue for pregnant and lactating women and for growing pigs and chickens. The second aspect, especially in relation to young pigs and chickens fed diets high in phytic acid, is that a significant amount of phosphate will be unavailable and will be excreted in the faeces. This has consequences for intensive animal husbandry and effluent management. The phosphate will eventually end up in river and lake system. Thus, high phytic acid in grains results in malnultrition in humans and animals, low efficiency of P fertilisers and environmental pollution. Development of crops with low phytic acid is becoming a global strategy to combat these issues, which supported by FAO, WHO and IAEA of United Nation. New varieties with low phytic acid have been developed in rice, maize, barley and soybean, and commercialised in USA, Europe, Canada, Japan and China. Australian international market competitor Canada has released its first low phytic acid barley. The low phytic acid mutant research will make Australia the international leader on breeding low phytic acid wheat varieties in the world. The research on barley will reduce the gap between Australia and Canada barley industry on phytic acid. The new wheat and barley varieties will eventually enable growers to produce high nutrition crops, make more profits for barley and wheat end-users, improve P fertilizer efficiency and protect water system from P pollution.

Other Research

Other opportunities that emerged during the course of the project:

A large number of mutants have been generated in wheat and barley with novel traits, including novel wheat quality and high temperature tolerance. For example, a wheat mutant has more than doubled grain Zn content; a barley mutant demonstrated high grain plumpness under high temperature stress. Futher research projects are required to further characterise these new gemplasm.

Mutation breeding techniques have played a very significant role in addressing world food and nutritional security problems by developing new mutant germplasm and mutant varieties. By the end of 2009, induced mutations have made significant contributions in development and release of more than 3000 mutant varieties in more than 170 crop species by more than 60 countries in the world. Some new nuclear techniques, such as ion beam irradiation and space mutation, have the potential to increase the efficiency of mutation breeding. New opportunities such as the use of high-throughput screening techniques are also emerging. These can increase the speed and efficiency of mutation induction and development of new mutant varieties. The current project has established a wide international network for mutation through the International Atomic Energy, which will provide opportunity for Australian researchers and breeders to access the new techniques.

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