Cold tolerant rice varieties

- a matter of need for Australia

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in a rice hull

- A dedicated crossing program has provided a critical mass of cold tolerant plants for screening of cold tolerance at the pollen microspore development stage, in numbers unprecedented in the Australian rice breeding program
- Staggered sowing dates and cold water treatment were demonstrated as sound field screening methods to deal with large numbers of breeding lines that are required to service a breeding program
- Strong research ties made possible through a federally funded research grant should expedite future germplasm exchange with China

A paper presented at the 4th International Temperate Rice Conference in June 2007 revealed just how at risk Australia is to low temperatures during the pollen microspore development stage of rice, compared with other mid-latitude rice production environments.

Luigi Mariani from University Deglistudi di Milano (Italy) presented the results of a sixty year analysis period (1948–2006) that showed Australian rice production has at least double the incidence of low temperatures during the pollen microspore development stage compared with California in the USA. Since 1988 the number of cold events encountered in California during this stage has been decreasing. In his presentation the author questioned how rice production was possible in Australia given it was the one of the few areas where the probability of cold damage was not on the decline.

Such 'big picture' research highlights the need for continued commitment of the Australian rice breeding program to increasing the cold tolerance of future rice varieties, particularly during the critical stage of microspore development. This article highlights the progress made thus far on this endeavour.

Cold tolerance development

Of the 678 crosses made as part of the rice improvement program in 2006–07, 65% were for cold tolerance purposes, with 44% being complex crosses (triple and backcrosses). Other glasshouse endeavours were the seed increase of 432 F_1 populations, of which again around half were for cold tolerance purposes. These numbers are unprecedented in the history of the rice improvement program and represent output of over triple of what was conventionally achieved.

The cold tolerance effort has been largely the result of a new glasshouse built at Yanco by NSW DPI. The insulation and heating capabilities enable almost year-long production, allowing the all-important cycling of early generation material for future field evaluation.

In the 2006–07 rice season, seven field trials were sown over four sowing dates and two locations: Rice Research Australia Pty Ltd (RRAPL) and Leeton Field Station. The trials at RRAPL encountered eight cold events, six from ambient conditions under shallow water, and two from cold water produced from the deep dam set up for this purpose (Figure 1). Over 4600 panicles were tagged allowing positive selection pressure for cold tolerance to be implemented for 35 F_2-F_3 populations and the benchmarking of 75 advanced lines including recently introduced cold tolerant standards.

The combination of cold night temperatures and shallow water depths around Australia Day showed good differentiation between tolerant (80% fertile) and sensitive (50% fertile) material, including a number of individuals derived from crosses between Reiziq and Chinese and Japanese cold tolerant varieties. This event also aided us to benchmark several varieties including Diamante from Brazil, which despite having good seedling cold tolerance, was totally decimated by cold temperatures at microspore.

Trialling international varieties in the local environment is necessary to ensure breeding efforts in Australia aren't swayed by a variety's reputation from other international breeding programs. The Australian bred advanced medium grain line YRM69 also performed well in both the cold tolerant nursery and district trial sites, obtaining yields 4 t/ha higher than Amaroo at a cold affected site.

Unfortunately, extremely high daily temperatures (greater than 40°C) encountered during mid February 2007 limited the success of the cold water nursery, as the return of the drainage water to the dam slowly raised water temperatures resulting in a screen which only allowed for the elimination of extremely cold sensitive material. Adding a dam for drainage water, reducing bay size and erecting shade cloth over the facility are measures already implemented to

prevent this impact in the coming season.

Seed increase at Leeton Field Station and the early sown trial at RRAPL were decimated by extremely high duck pressure close to harvest, slowing the progress of this material by one generation.

International exchange bolsters program

International exchange of both germplasm and knowledge has been assisted in the last 12 months through an ACIAR funded project *Australia-China linkage for improved rice cold tolerance*.

This project has already obtained cold tolerant varieties from China (Longdao3 and Longdao5) through a workshop held last December. A recent visit from an Australian contingent to over five research providers in China has paved the way for further collaboration and a possible germplasm exchange (Figure 2). Some highland cold tolerant varieties (Lon Thar Hmwe and Pandan wangi) acquired from a recent trip undertaken by Russell Ford to Myanmar and Indonesia are currently in quarantine. These efforts demonstrate the pro-active approach by this program in obtaining and incorporating future cold tolerant sources into the Australian rice breeding program.

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Figure 1: Cold water nursery at RRAPL. The 6 m deep dam (back) can deliver cold irrigation water (less than 17°C) to the 920 short-row plots. The combination of turgid water and a subterranean pipe that runs directly from the bottom of dam to this bay provides a cost effective method of cooling commonly known as "Geothermal" cooling.

Figure 2: From left, Laurie Lewin, Xiaochun Zhao (University of Sydney), local agronomist (Kumning) and Russell Reinke inspect cold tolerant varieties in the Yunnan Province (PR China) in September 2007.