Good stock will make better cold rice

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- Broad spectrum cold tolerance will be incorporated into future Australian bred rice varieties through the utilisation of targeted selection nurseries
- Suitable international aerobic lines have been identified for future breeding efforts if characteristics can be incorporated with cold tolerance
- The Australian rice industry is well situated to capitalise from future cold tolerant varieties thanks to the collaborative efforts of three research providers facilitated by RIRDC

The need for and benefits of cold tolerance in Australian rice varieties is well established. In fact, research on cold tolerance remains one of a few areas of work funded with drastically depleted resources of the RIRDC Rice R&D Committee.

A wide range of rice varieties and breeding lines from around the world has been used to find 'donors' for cold tolerance in the Australian rice breeding program, managed from Yanco Agricultural Institute since 1963. The results of this work, with particular focus on cold tolerance at the young microspore stage, will soon be published in a number of articles in scientific journals.

Analysis and compilation of the results of this work has revealed some robust sources of cold tolerance in the donor material for a number of different growth stages of rice. In addition to cold tolerance at young microspore, several varieties have shown

__Figure 1.__ Shade (50%) and cool irrigation water were used to promote cold damage to segregating populations; the treatment is centred around the young microspore stage of the local parent, in this case Amaroo and Doongara

good cold tolerance at the germination, seedling and flowering stages of rice growth (Table 1). Although not as effective as hundreds to thousands of years of natural selection at high altitude areas like the Chinese donor material, these results show some headway in improving cold tolerance through conventional breeding efforts. For example, the improvement of Quest over Amaroo in terms of cold tolerance at the germination and booting (young microspore stage) are evident, so is the superiority of Langi over Pelde.

The strategic field based approach used over the last two seasons will ensure board spectrum cold tolerance from these donors is incorporated into future Australian bred rice varieties. Field based nurseries, located at Rice Research Australia Pty. Ltd (RRAPL) near Jerilderie, use early (mid September) and late (late November) sowing dates to increase exposure of segregating populations to low temperatures at the seedling and flowering stages respectively. Although early and late sowing dates have an increased risk of encountering low night temperatures at the most sensitive young microspore stage, a standard sowing date (mid October) is also used with a shading and cool irrigation treatment (Figure 1).

The combination of shade and cool irrigation water (less than 18°C) is purposely implemented at the young microspore stage of the Australian variety (eg Amaroo) to ensure tolerant progeny of similar maturity can be identified. In addition to the three cold tolerant nurseries (September, October and November sown), two aerobic (non-flooded) nurseries were also sown at RRAPL this season, all in short row configurations (Figure 2). The non-flooded practice of aerobic culture was adopted in these nurseries but irrigation flushes were stretched out to 10 day intervals to represent a worst case irrigation strategy. The aerobic trials were instigated strictly for observation purposes for future donor stock (hence the severity), as large advances in cold tolerance needs first to be achieved before a truly aerobic rice growing system can be implemented in the current rice production area.

Good cold tolerance measured

Due to a rather cool summer in 2007–08, regularly occurring cold events saw good levels of cold damage (at young microspore) being measured over all three sowing dates with selected panicles being tagged (7290 panicles tagged). A combination of cold water and shade magnified the difference between sensitive and tolerant material for the October sowing.

Over 20 F_2 populations were screened for cold tolerance this season (2007–08). These were derived from crosses between local varieties: Reiziq, Opus, Doongara, Kyeema, Paragon and Amaroo to tolerant donor stock Banjiemang, HSC55, Jyoudeki and Lijiangheigu. Double haploid lines developed by Xiaochun Zhao (University of Sydney) from crosses with the Chinese

*Table 1. Cold tolerance of rice varieties used in the current breeding program, at four growth stages (*Ye et al., *in press)*

Variety	Origin	Cold tolerance[1] at four growth stages			
		Germination	Seedling	Booting (young microspore)	Flowering
Amaroo	Australia	S	T	S	S
B55	China	T	T	T	T
Banjiemang	China	T	T	T	T
HSC55	Hungary	T	T	T	T
Jyoudeki	Japan	S	T	M	M
Langi	Australia	M	M	M	S
Lijiangheigu	China	T	T	T	T
M103	USA	M	M	M	T
M104	USA	M	M	M	T
Pelde	Australia	S	S	S	S
Quest	Australia	M	T	M	S
Reiziq	Australia	M	M	S	S
YRL 39	Australia	S	S	S	T
YRM 64	Australia	S	S	M	S

[1] S = susceptible, M = moderate, T = tolerant

Figure 2. An aerial shot (April 2008) of the cold tolerance nurseries at Old Coree*, bays from left to right, late sown cold, aerobic nursery, cold water nursery and early sown cold nursery (already harvested). Note deep earthen dams used to cool irrigation water.*

donor lines were also evaluated. At the time of writing this article, the results for the progeny were still being processed, however good separation was evident from panicle fertilities for donor (80%) and local varieties (40%).

Two soil types were used for the aerobic nurseries, a heavy clay and a loamier soil. Each trial comprised over 30 international rice varieties including material from China, Africa (WARDA), India, America, Europe and the Philippines (IRRI) which reportedly have some adaptation to aerobic culture, and F2 populations derived from crosses with local lines to these international sources. Although looking good earlier on, the trial in the lighter soil actually committed too much growth to vegetative development and so flowered later and encountered cold temperatures. Results on the heavier soils strongly highlighted the best of the international germplasm as well as indicating scope for early generation selection under these conditions.

Figure 3. Postdoctoral research fellowship recipient Dr Ye Changrong (University of Queensland) inspects cold tolerance nurseries at Jerilderie. Ye is standing behind cold tolerant donor Banjiemang

Interestingly, although fairing reasonably well, donor cold stock (Table 1) were far from the best performers in the aerobic trials with Indian and IRRI lines showing greater adaptation. Suffice to say, in addition to cold tolerance, other attributes will be required to be incorporated into breeding stock if progress towards an adapted Australian aerobic variety is to become a reality. Attributes suited to aerobic production like heat tolerance, already exist in Australian varieties, but the logistics of pairing this with cold tolerance has yet to be explored.

Strategic effort will deliver

Due to well orchestrated involvement of the RIRDC Rice R&D Committee, the Australian rice industry has at hand some of the sturdiest cold tolerant material that has arisen from the targeted breeding efforts of three research providers (University of Sydney, University of Queensland and NSW DPI) into populations that should soon deliver a commercial variety. Fortunately these efforts have concentrated on two of the most sensitive commercial varieties (Doongara and Reiziq), and have had the foresight to utilise backcrossing to ensure that other less desirable characteristics from the donor material (Figure 3) are minimised.

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Further information

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