# Developing cold tolerance for yield stability & less water use

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**in a rice hull**

- Complex rice crossing programs were performed with the aim of producing progeny with cold tolerance and strong agronomic and quality characteristics
- Additional sources of cold tolerance are being sought and may eliminate the need for deep water at the early microspore stage, paving the way for aerobic rice culture and reducing water requirements for rice culture

***Developing cold tolerance in Australian rice varieties has been identified as a major priority of the rice industry's R&D program. Yield losses due to cold temperatures at the early microspore stage can be significant at the farm and industry level. Cold damage in the 2004–05 season is believed to have cost the industry $38.6 million at the farm gate with further economic losses incurred at the mills due to lower throughput and poor grain quality. A further benefit of cold tolerance could be the possibility of achieving yield potential without having deep water at the early microspore stage, which is currently needed to protect the developing microspore from cold damage.***

Complex genetic crosses are being performed and evaluated to obtain progeny with desirable agronomic and quality attributes, with the aim of producing commercially viable cold-tolerant rice varieties. Six populations developed from crosses with Australian varieties were investigated in the 2005–06 season to allow selections of individuals whose cold tolerance was evenly matched to the best cold tolerant varieties grown internationally.

Despite a relatively warm rice season, drill sowing outside the recommended window (22 September to 14 December) and maintaining shallow water resulted in good differentiation between cold sensitive and cold tolerant varieties in cold tolerance nurseries at Rice Research Australia, *Old Coree*, Jerilderie. The selection pressure resulting from these field conditions was restricted to the lines which had encountered temperatures below 15°C at the early microspore stage. To detect any effects of the low temperature events, any panicles which were flowering 15 days after any cold event had occurred, were manually tagged (Figure 1).

The impact of a cold event was then gauged by comparing the fertility levels exhibited by a known cold tolerant (or sensitive) standard cultivar of comparable maturity to the variety or line under evaluation. For example, Figure 2 shows that the cold tolerant Hungarian variety HSC55 had twice the level of spikelet fertility when compared to the cold sensitive Russian variety Sprint, when both varieties experienced temperatures below 15°C at the early microspore stage. However, this difference was not evident when temperatures at early microspore exceeded 15°C, the threshold for damage to the young microspore. Therefore it was possible to select the lines with most cold tolerance in the program, when there were significant fertility differences between known sensitive and tolerant cultivars. Over 2000 individual panicles were tagged this season, allowing cold tolerance to be selected in early generations of three crosses with commercial varieties (Paragon, Quest and Illabong) that are in the cold tolerance program.

*Figure 1: Tagging flowering panicles for cold tolerance assessment in the first week of 2006 at Old Coree, Jerilderie.*

Table 1 illustrates the spikelet fertility averages for material that was flowering on 24 March 2006, which had experienced an average minimum temperature at young microspore of 13.8°C. Of note was the performance of the advanced medium grain line YRM69 (see 'A season to test yield potential' pp 35-41 of this edition). The cold tolerance of this breeding line was similar to its parent, M103, a cold tolerant Californian medium-grain, and both M103 and YRM69 had superior cold tolerance to Quest. Although YRM69 and M103 do not match the fertility level of the cold-tolerant Japanese line Jyoudeki, they are still valuable as parents as their levels of cold tolerance exceeds that of anything grown commercially in Australia to date. In comparison, crosses involving Hungarian sources of cold tolerance (HSC55), produce progeny that have high grain number per panicle hence less likely to have low yield potential under favourable conditions as is the case with Japanese sources of cold tolerance.

The averages for spikelet fertility and grains per panicle for two populations in Table 1 (ie Quest_CT19//HSC55/Illabong and Paragon/HSC55) indicate the potential to achieve progeny of higher cold tolerance than Quest_CT19 and Paragon, which both have excellent yield potential in warm seasons (see 'A season to test yield potential' pp 35-41 of this edition). Selected progeny from these populations will progress through seed increase for further plot evaluation, as well as provide donor germplasm for further backcrossing within the Rice Breeding Program.

***Table 1: Average spikelet fertility (mean ± standard deviation) and grains per panicle (mean ± standard deviation) of rice flowering on 24 March 2006, which experienced 13.8ºC at the young microspore stage.***

| Variety/population# | Spikelet fertility (%) | Grains per panicle |
|---|---|---|
| Jyoudeki | 83.17 ± 0.99 | 110.44 ± 8.15 |
| M103 | 69.05 ± 2.17 | 164.13 ± 8.19 |
| YRM69 | 67.48 ± 1.93 | 168.15 ± 8.57 |
| Quest_CT19 | 54.51 ± 2.63 | 184.67 ± 10.00 |
| Quest_CT19//HSC55/Illabong# | 55.29 ± 3.19 | 159.89 ± 13.88 |
| Paragon/HSC55# | 63.64 ± 4.88 | 129.63 ± 18.99 |

# represents populations of individuals that segregate for cold tolerance

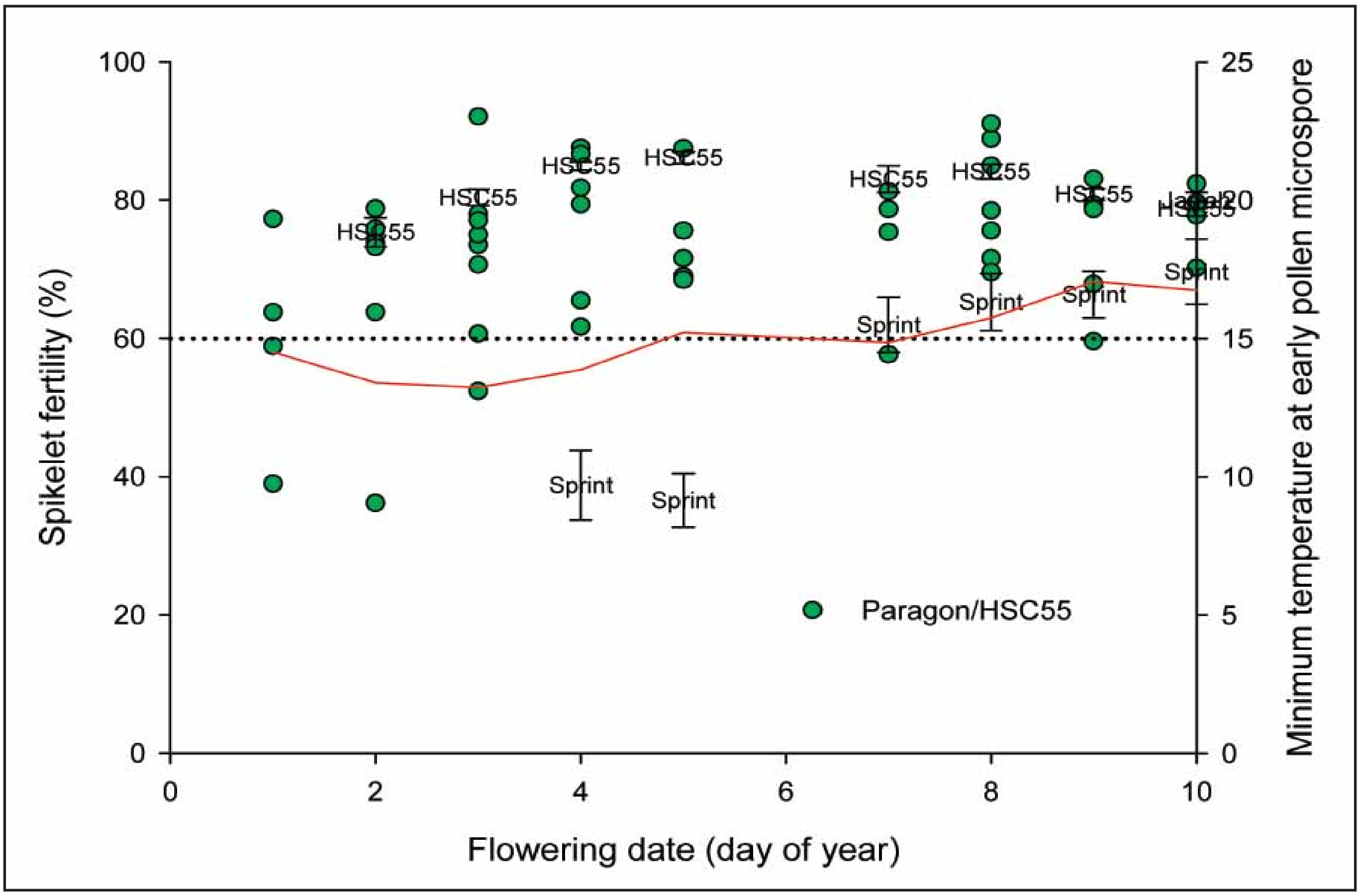


***Figure 2: Spikelet fertility for three lines of rice: cold tolerant HSC55 (Hungarian), cold sensitive Sprint (Russian) and a line from a cross between Paragon and HSC55. The graph shows the resulting spikelet fertility (filled grain) in relation to flowering date (the first 10 days of 2006). The red line shows the minimum air temperature (°C) experienced at the early microspore stage for that plant/material, and the black line indicates the critical level for cold damage in cold tolerant lines.***

In past Rice CRC cold tolerance projects several hundred lines of rice were identified as having useful cold tolerance. In the 2005–06 season, seed stocks of these lines were increased and 220 promising lines were harvested. Of particular interest to the industry are the lines derived from crosses made with either Langi or Reiziq, which are very sensitive to cold damage. These lines, together with recent crosses from this project, will be evaluated in a purpose-built cold water nursery in the coming season at *Old Coree*. Unlike the early and late-sown trials reported above, which relied upon seasonal variation in minimum temperatures to create cold damage at the young microspore stage, the cold water nursery will use water that is cooled through subterranean pipes and deep earthen dams to impose a controlled cold event at the early microspore date of the recurrent parent (ie Reiziq or Langi). This will result in the ability to choose progeny with maturity similar to that of the desired parent, and will further simplify future cold tolerant evaluation and backcrossing.

Collaborative RIRDC funded research (Southern Cross University, Sydney University, University of Queensland, CSIRO Plant Industry) is continuing to expand on the existing skill and knowledge base of rice cold tolerance. Japanese and Chinese varieties of rice with high levels cold tolerance will be the focus of this research with a collective aim of identifying molecular markers for cold tolerance (ie pieces of genetic code that impart cold tolerance in the plant). Finding such molecular markers would mean that the DNA of early generation lines could be analysed to determine cold tolerance, rather than having to impose cold temperatures conditions in the field and physically monitor the response by measuring spikelet fertility. The search is also on for international rice varieties with exceptional levels of cold tolerance that would remove the need for deep water at the early microspore stage, paving the way for aerobic rice culture. This search for a quantum leap in cold tolerance will no doubt be assisted through NSW DPI's involvement in such activities as the 'Australia-China linkage for improved rice cold tolerance' funded by ACIAR.


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***Figure 3: Automated temperature and water depth sensor (foreground) in cold tolerance plots at* Old Coree *and Peter Snell in the background tagging flowering rice panicles.***