



# Streamlining the development of new cold tolerance rice varieties

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## in a rice hull

- Cold temperatures during the rice growing season can result in significant yield loss and significant income loss to the industry
- The deep water required on the rice field throughout the cold sensitive early microspore stage of pollen development, would not be necessary with cold tolerant rice
- The use of molecular markers to identify the genetics behind cold tolerance are being investigated
- The current methods used to investigate cold tolerance rely on selecting the appropriate time to expose crops to cold, which can be difficult

***As rice growers know all too well, cold temperatures damage the developing pollen, causing grain sterility and lower crop yields. Yield reductions of more than 1 t/ha, due to low temperatures, occur about one year in four (on average) and cost the Australian rice industry around \$50–60 million, depending on the year. Improvements in cold tolerance of rice will have significant economic benefits to the industry, as rice production could be increased and the capacity for a more stable supply of rice would secure current and future markets.***

Cold tolerance would also mean that the deep water required for temperature buffering during the early microspore stage would not be necessary. During a cold event, the water in a rice bay is around 7–8°C warmer than the surrounding air, insulating the developing panicle from the cold air and preventing damage to the pollen. To ensure the protection of the developing crop, the depth of water held is 20–25 cm during the most temperature sensitive phase of crop growth. If more cold tolerant varieties were available there would not be the same need for deep water.

Rice breeding programs are underway that are attempting to combine quality, economic and cold tolerance parameters in single rice varieties through the use of molecular markers. Molecular markers can identify those parts of the rice genome (the plant's genetic make-up) that control cold tolerance, as well as a variety of other parameters. The genetic information gained can be used to design tests to be used by breeding programs to identify specific characteristics.

## Understanding cold tolerance

Research into the genetics of cold tolerance is being funded because it is important to understand the genetics of the cold tolerant material that is being introduced into the breeding program. There are many different cold tolerant rice varieties in the world but it is unclear to what extent all of these varieties differ genetically, in terms of the way they tolerate cold. If the different cold tolerant varieties rely on the same gene (or genes) for cold tolerance, then there is no benefit in using multiple donors of cold tolerance in a breeding program. If on the other hand, the varieties differ in the way in which they tolerate cold then it may be possible to gather different cold tolerant mechanisms into a single rice variety, making it even more tolerant than existing varieties.

Using molecular markers, it is possible to get the DNA fingerprint of an individual plant and work out which parts of its genome are contributed by each of the parents. If this data is collected and then combined with the cold tolerance data for many plants, it is possible to work out which parts of the genome are responsible for the control of cold tolerance. By using this process on different cold tolerant parents, it will be possible to work out if the same or different parts of the genome control cold tolerance.

## Sorting good and bad

Molecular markers also supply the tools for separating 'good' genes from 'bad' genes in a breeding program. The objective of rice breeding is to combine the greatest number of desirable traits within a single variety. For example, a variety can have a comprehensive range of positive genes



for quality traits, yet lack an optimum combination of genes for desired agronomic traits. The response is to take the variety which has the desirable quality traits and cross it with a variety which has a more complete collection of genes for the desirable agronomic traits. However, the variety which supplies the favourable agronomic traits also passes the unfavourable quality traits on to its offspring, and so the many offspring will be a complicated mixture of favourable and unfavourable genes. The challenge then is to identify offspring from this cross which have the optimum collection of genes. This can be particularly difficult to achieve when traits are determined by genes which are physically close to each other because the gene encoding the favourable agronomic trait will often be in combination with a gene which encodes an unfavourable quality trait. For example, transferring cold tolerance into rice varieties adapted to Australian conditions has proven to be difficult due to the close linkage of cold tolerance genes with genes for poor milling quality. Because they effectively give a snap shot of a plant's genome, molecular markers can identify plants where the linkage between good and bad genes has been broken.

### Streamlining with molecular markers

Testing for cold tolerance, without molecular markers, needs to be undertaken on a large scale and the crop needs to be cold challenged at the sensitive pollen development stage (early microspore). If the cold challenge is at the wrong time, a rice plant may appear to be cold tolerant when it is not. Within a population of rice derived from a single cross there will be different levels of cold tolerance and different rates at which the plants mature due to their different genetic make up, so finding the 'right' time for cold challenge is difficult.

The use of molecular markers, which have identified a region of the genome that explains a large part of cold tolerance, may make it possible to get around some of the difficulties of testing for tolerance with cold temperature challenges. ☀

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**Figure 1: The use of molecular markers has the potential to streamline the development of cold tolerant rice varieties, saving millions of dollars of lost income to the industry, and reducing the need for deep water at the early microspore stage.**