Rice Research: Open Access

Sperotto, J Rice Res 2014, 3:1
DOI: 10.4172/2375-4338.1000e108

Editorial Open Access

Cold Tolerance in Rice Plants: Why, How and When?

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Rec date: Sep 10, 2014, **Acc date:** Oct 3, 2014, **Pub date:** Oct 8, 2014

Editorial

Low temperature stress is one of the major abiotic factors which reduce rice yield in several countries [1]. Losses can range from 0.5 to 2.5 t/ha [2] and grain yields can drop by up to 26% [3], mostly due to low temperature during the reproductive stage, even though cold temperature can be harmful during the entire developmental stage of rice plants, from germination to grain filling [4,5]. During germination, the most common symptoms of cold temperature damage are delayed and lower percentage of germination [6]. During early growth stages, it can severely affect seedling establishment, showing yellowing of the leaves, growth retardation, and decreased tillering [5]. When cold coincides with the reproductive stage of the rice plant, sterility of the spikelets is the most common symptom of injury, but incomplete panicle exsertion and spikelet abortion may also occur, along with delayed and incomplete grain maturation [7]. Irrespective of the developmental stage, the duration of low temperature is an essential element determining the extent of cold damage; however, the critical air temperature that induces cold damage depends on the cultivar [8]. It is already known that some rice cultivars can tolerate stressful conditions and are able to grow under low temperature [9]. These cold tolerant rice cultivars normally belong to *japonica* subspecies [10], which are more adapted to temperate climates. Therefore, the challenge still remains to develop cold tolerant *indica* genotypes suitable for high-latitude regions.

The use of molecular markers allowed notable progress in mapping cold tolerance in rice [11-13]. Technical advances have allowed the identification (and function) of the genes responsible for rice QTLs, such as a combination of PCR-based screening, development of near-isogenic lines and searches for hits in EST databases [14], fine mapping based on microsatellite markers, including markers identified from publicly available genomic sequences [15] and map-based cloning [16]. Several QTLs related to cold-tolerance in different developmental stages have been identified by several groups (for a comprehensive review see [5]), explaining up to 50% of the cold tolerance variation. Although some genes have been identified based on previous QTL discovery [11,15,17,18], there is a lot to be done in the search for genes within QTL regions that are effectively shown to be important for cold tolerance in rice. Many genes have been isolated and characterized as responsive to cold stress (mostly encoding transcription factors responsible for transcriptional regulation of different stress-inducible genes), and some of them lead to cold tolerance when over-expressed in rice plants (for a comprehensive review see [5]). However, no master genes have been clearly identified so far for cold tolerance in rice.

Although much progress has been achieved in the understanding of cold tolerance in rice plants, decreased productivity caused by low temperatures remains as a problem, especially in places where indica rice is cultivated. According to [5], new cold tolerant cultivars will need to be designed according to the growth stage when plants will be exposed to cold in a particular region, and a combined strategy that join efforts from breeders and plant biologists could speed up the production of successful projects aiming for cold tolerant in rice plants [19]. Such integration would also have positive outcomes if a set of genes with the most promising results based on experimental data were analyzed in two or more rice genotypes, with contrasting level of cold tolerance. This could allow the identification of important mutations to be used as markers in breeding programs. Also, future efforts will certainly be more elucidative if high throughput techniques (such as microarray analysis, large scale sequencing and proteomics) are more intensely used. Hopefully, the scientific community will be able to deliver cold tolerant rice plants to ensure food security to the next generations.

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