**Marker-Trait Associations for Cold Tolerance in Rice at Various Growth Stages**

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**Abstract**

Global climate change-induced weather extremes, such as colder winters impede early spring rice planting in the US. Temperatures lower than 17 °C affect rice productivity by poor seed germination, seedling stand, pollen fertility, and seed set. Therefore, some rice breeding efforts focus on developing cold tolerant cultivars. Previous studies have showed varietal differences to cold stress. To understand cold tolerance mechanisms, we evaluated 288 rice varieties that included 145 US breeding lines and 143 exotic cultivars for their germinability, growth, and development under cold conditions. Although varietal differences were expectedly observed for stage-specific tolerance, cultivar Palmyra had the highest germination and better root and shoot growth under cold. Under reproductive stage cold, only three temperate rice genotypes were able to successfully set seeds. Genomic association analysis identified a common set of SNP markers significantly associated with germination and growth under control and cold conditions. Markers in eight genomic regions, explaining between 3.2 to 47.3% of the phenotypic variances, showed significant associations specifically with cold tolerance traits. Two of the genomic regions were not reported earlier. Genes linked to the significant SNPs were involved in diverse functional categories. The cultivars possessing cold tolerance traits can be used as donors to transfer the genes into US rice germplasm to extend their cultivation beyond a single season crop or successful ratoon crops. The validated markers can be used to facilitate marker-assisted breeding and the discovery of potentially novel cold tolerance genes will improve our understanding of cold tolerance mechanisms in rice.