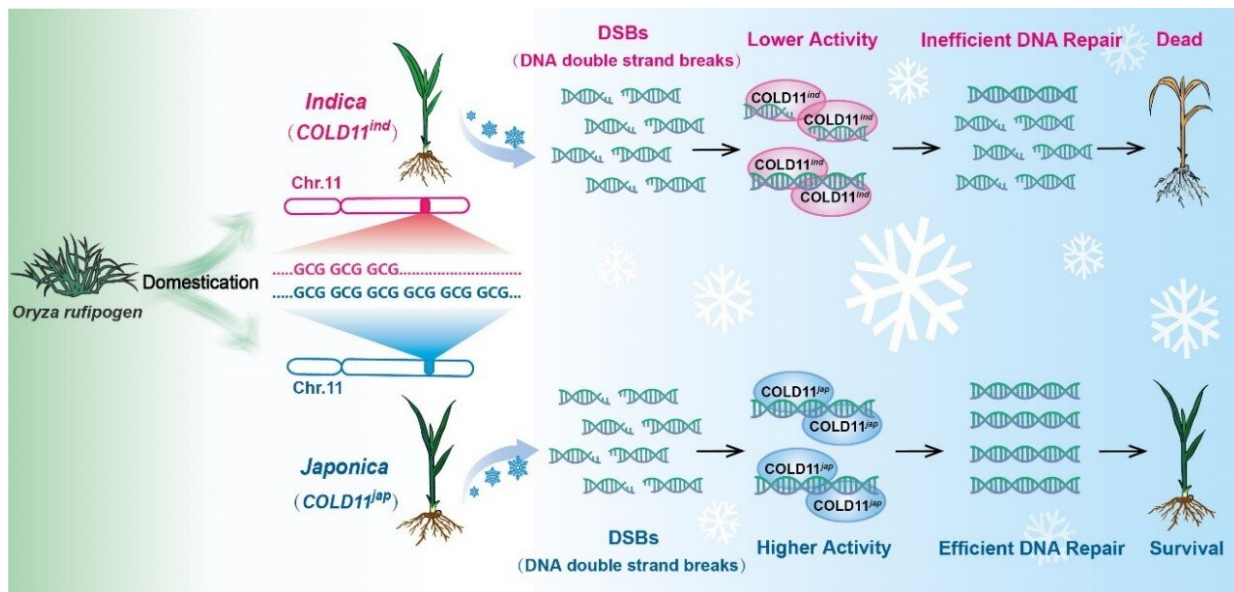


Researchers uncover key codon repeats regulating chilling tolerance in rice

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Schematic representation demonstrating domestication-selected *COLD11* modules for repairing DNA double-strand break induced by chilling in rice. Credit: Prof. Chong Kang's group

A recent study by Prof. Chong Kang's group from the Institute of Botany of the Chinese Academy of Sciences (CAS) has revealed a novel cold domesticated repair mechanism for DNA damage in rice, providing corresponding elite modules for the improvement of the chilling tolerance trait in rice with the codon repeats at a single site.

Results were published online in *Science Advances*.

Global climate change has led to a clear increase in abnormal environmental temperatures and [extreme weather events](#) in recent years. Thus, it is urgent that crops have the capacity to endure [extreme temperatures](#) in order to ensure stable yields. Although plants have evolved complicated and delicate protective mechanisms to survive chilling stress, DNA damage still occurs, thus lowering plants' defenses. Furthermore, the underlying regulatory mechanism has been largely unclear.

In this study, Prof. Chong's group, in cooperation with Prof. Li Qizhai's group from the Academy of Mathematics and Systems Science of CAS, and Prof. Cheng Zhukuan's group from the Institute of Genetics and Developmental Biology of CAS, used an approach that combines [population genetics](#), genomics, and cell and [evolutionary biology](#) to exploit the novel module for chilling [tolerance](#).

The researchers performed data-merging genome-wide association studies (DM-GWAS) based on multidimensional scaling. A series of loci were identified by GWAS using merged phenotypic data. One of these was qCTS11-1 on chromosome 11, which makes a clear contribution to rice chilling tolerance. Its major gene, COL11, was identified with fine-scale mapping. Loss-of-function mutations of COL11 caused reduced chilling tolerance, according to the researchers.

Different types of GCG codon repeats encoding alanine in the first exon of COL11 were observed for chilling-sensitive indica varieties and chilling-tolerant japonica varieties. The GCG codon repeat numbers had a clear, positive correlation with chilling tolerance. In addition, genome evolution analysis of representative rice germplasms suggested that numerous GCG sequence repeats were subjected to strong domestication selection during the northern expansion of rice planting.

Furthermore, COL11 encodes a DNA repair protein that plays an essential role in the repair of DNA double-strand breaks. The GCG repeat numbers in its first exon showed a positive correlation with its biochemical activity. This is the first report of a domestication-selected DNA damage [repair mechanism](#) and its corresponding elite modules involving chilling stress.

Using DM-GWAS of japonica and indica—two rice subspecies with substantial divergence in chilling tolerance—this study reveals that COL11 is a major quantitative trait loci gene for chilling tolerance.

The discovery of the key codon repeats in the first exon of COL11, confirmed by phylogenetic and geographic distribution analysis, opens the way for fine regulation of rice chilling tolerance with a single site. It is a potentially useful molecular module for improving the chilling tolerance trait in rice through molecular design.

More information: Zhitao Li et al, Natural variation of codon repeats in COL11 endows rice with chilling resilience, *Science Advances* (2023). [DOI: 10.1126/sciadv.abq5506](https://doi.org/10.1126/sciadv.abq5506).
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