An international effort, focused on the characterization of the genetic determinants of submergence tolerance, identified an indica landrace, FR13A, as the world's most tolerant of flooding. In collaboration with D. Mackill (International Rice Research Institute) we have now cloned the submergence tolerance (Sub1) locus from FR13A using a map-based cloning approach. The Sub1 locus encodes three putative transcription regulators of the AP2 class and RNA blot analysis indicates that the Sub1A mRNA levels increase dramatically in response to O2 deprivation in sub1 seedlings; whereas Sub1C levels decrease. The sub1A-2 allele possesses a single nucleotide change as compared to the Sub1A-1 allele. All five sequenced sub1A-2 (intolerant) alleles encode a proline at this position whereas the Sub1A-1 alleles from three tolerant lines examined encode a serine. Transgenic lines overexpressing the Sub1A-1 gene into a submergence intolerant line display enhanced submergence tolerance.

Our team has now developed a submergence tolerant version of the variety "Swarna" from India. Swarna is very popular in India and Bangladesh and is grown on more than 5 million hectares. It has good grain quality and high yield. With the submergence tolerant version, which we are temporarily calling Swarna-Sub1, we have found no significant differences compared to the intolerant Swarna in terms of yield or quality under normal (non-submerged) conditions. The yield of both varieties here in the Philippines is about 6 tons grain per hectare. Under submerged conditions, yield is reduced in both varieties, but Swarna-Sub1 has about double the yield of the normal Swarna. This would result in a 1-2 ton/ha yield advantage when submergence is present, a considerable improvement for poor farmers in Asia. Because Swarna is a widely grown variety in areas where submergence is common, we feel that the new submergence-tolerant version of Swarna represents a signficant advance over the previous breeding efforts, and will be acceptable to farmers.

Current experiments involve examining the expression profiles of the Sub1 vs sub1 lines using 45k microarrays, determining the significance of the serine to proline mutation and investigating whether the submergence tolerance phenotype of rice involves differential regulation of other stress response pathways (in collaboration with Julia Bailey-Serres, UCR). We are also testing if sowing of submergent tolerant seed into fields flooded to 15 to 20 cm would effectively limit weed growth and eliminate the need for herbicides.

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**Xu K, Xu X, Ronald PC, Mackill DJ**. 2000. A high-resolution linkage map in the vicinity of the rice submergence tolerance locus Sub1. MGG. 263. 681-689((pdf

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**Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Sigrid Heuer, Julia Bailey-Serres, Abdel Ismail, Ronald, P.C, David J. Mackill**. 2006. Sub1A encodes an ethylene responsive-like factor that confers submergence tolerance to rice. Nature. 442:705-708. (pdf)

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# Pictures of submergence-damaged fields.

Submergence of rice fields in northeast Thailand

After submergence of rice fields in Java, Indonesia

After submergence of rice fields in Java, Indonesia

After submergence of rice fields in Java, Indonesia

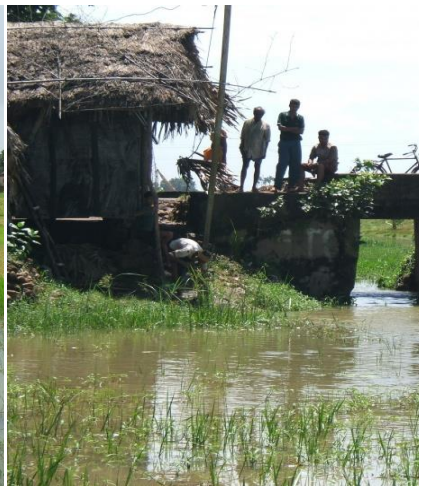
Submerged rice fields in Bihar, India

After submergence of rice fields in southern Thailand

Damage of the cultivar Swarna from Submergence (background) compared to tolerant cultivar (foreground)

Submergence damage

flooded rice fields along a river, I think this is in the Philippines (Biggs)



flooded field in Bangladesh(Abdel)

Gina Vergara flooded field, India 2005


Gina Vergara the flooded field is behind the bridge, India 2005