ZmDREB2.7
Drought Tolerance

A maize DREB gene capable of conferring drought tolerance in transgenic crops

DREBs/CFBs (Dehydration Responsive Element Binding proteins/C-repeat Binding Factors) are thought to be the major transcription factors (TFs) that control stress-inducible gene expression in the ABA-independent pathway. Transgenic expression of DREB’s has been shown to confer tolerance to abiotic stresses including tolerance to drought, cold, freezing, heat and even high salinity. However, there are many DREB gene family members and ectopic expression of DREBs does not always lead to a stress tolerant phenotype and also is often associated with undesirable phenotypes and growth abnormalities.

Prof Feng Qin and colleagues at the Chinese Academy of Sciences Institute of Botany in Beijing have conducted an in-depth characterisation of the maize DREB genes at various different levels of analysis. All of the 18 different functional maize DREB family genes were individually cloned and sequenced from inbred line B73. These sequences where then compared to determine their phylogenetic relationship and the synteny between rice, maize and sorghum genomes. For each of the 18 maize DREBs, their drought-responsive expression pattern and their protein transactivation activity was also characterised in detail. The nucleic acid variation for each maize DREB gene (and contiguous regulatory sequence) was analysed among a large panel of 368 maize varieties from both tropical and temperate regions.

The remarkable and perhaps surprising finding from this elegant and comprehensive analysis was that sequence variation associated with one maize DREB in particular, ZmDREB2.7, was significantly correlated with drought tolerance. No other ZmDREB showed such a striking association, even though previous reports have suggested that ZmDREB1.1/1A and 2.1/2A play an important role in maize stress tolerance. Interestingly, and maybe counterintuitively, the expression profiling indicated that ZmDREB2.7 is not very strongly induced by drought, unlike several other ZmDREBs which were very strongly drought-induced. Moreover, the specific sequence variation associated with drought tolerance among maize genotypes was not within the ZmDREB2.7 coding sequence but instead contained with the 5'UTR promoter region. (See also PBL Tech Id 14.581 ZmDREB2.7 Markers, Promoter and Haplotype). Transactivation activity, determined in a yeast HIS3 reporter assay for each maize DREB, grouped the 18 genes into three groups – seven strong activators, seven moderate activators and four weak/non activators, with ZmDREB2.7 among the strong activators. Thus, on the basis of expression profiling, the intragenic sequence variation and, arguably, the transactivation assay, ZmDREB2.7 would almost certainly have been overlooked as a stand-out candidate for a significant role in drought stress tolerance.

The expression of ZmDREB2.7 was characterised in a survey of 70 randomly selected maize inbred lines. It was found that under moderate/early drought stress (RLWC= 70%), ZmDREB2.7 gene expression level was positively correlated with increased survivability. However, no significant correlation was observed under either well-watered or severe/late drought conditions. This indicates that an early induction of ZmDREB2.7 gene expression, associated with the polymorphism in the 5'UTR, in response to drought stress, rather than a basic or slow response, is important for survival under drought stress.

The ectopic expression of ZmDREB2.7 conferred drought tolerance in transgenic Arabidopsis. No dwarfing or delayed flowering phenotype was observed. In the highest expressing transgenic line a very slight reduction in rosette leaf size was noted.
The patent applications on this technology (Tech Id 14.582) relate to transgenic plants of any species expressing ZmDREB2.7, with its own promoter or other promoters. The sister technology, Tech Id 14.581, relates to molecular markers for use in maize breeding, the ZmDREB2.7 5'UTR haplotype, and the use of the ZmDREB2.7 promoter to drive expression of genes other than ZmDREB2.7.

Drought stress tolerance of 35S:ZmDREB2.7 transgenic Arabidopsis plants – three independent lines.
Drought tolerance of transgenic 35S:ZmDREB2.7 Arabidopsis plants. Thirty two-day-old plants growing under favourable water conditions were exposed to drought stress by withholding water for 14 days. Photographs were taken both before and after the drought treatment followed by 6 days re-watering. Histograms show survival rates after the drought-stress treatment. The average survival rates and standard errors were calculated from three independent experiments, each with 30 plants per line.

The IOB work on ZmDREB2.7 is published in PLoS Genetics (Lie et al., 2013).

For more information or licensing interest, please contact Jan Chojecki at PBL.

References:
Liu et al. Genome-Wide Analysis of ZmDREB Genes and Their Association with Natural Variation in Drought Tolerance at Seedling Stage of Zea mays L. PLoS Genetics 9(9): e1003790. doi:10.1371/journal.pgen.1003790