Tomato Plants Ectopically Expressing Arabidopsis CBF1 Show Enhanced
Resistance to Water Deficit Stress1

Hsieh, Tsai-Hung; Lee, Jent-turn; Charng, Yee-yung; Chan, Ming-Tsair.
(Oct 2002)

Abstract:

A DNA cassette containing an Arabidopsis C repeat/dehydration-responsive element binding factor 1 (CBF1) cDNA and a nos terminator, driven by a cauliflower mosaic virus 35S promoter, was transformed into the tomato (Lycopersicon esculentum) genome. These transgenic tomato plants were more resistant to water deficit stress than the wild-type plants. The transgenic plantsexhibited growth retardation by showing dwarf phenotype, and the fruit and seed numbers and fresh weight of the transgenic tomato plants were apparently less than those of the wild-type plants. Exogenous gibberellic acid treatment reversed the growth retardation and enhanced growth of transgenic tomato plants, but did not affect the level of water deficit resistance. The stomata of the transgenic CBF1 tomato plants closed more rapidly than the wild type after water deficit treatment with or without gibberellic acid pretreatment. The transgenic tomato plants contained higher levels of Pro than those of the wild-type plants under normal or water deficit conditions. Subtractive hybridization was used to isolate the responsive genes to heterologous CBF1 in transgenic tomato plants and the CAT1 (CATALASE1) was characterized. Catalase activity increased, and hydrogen peroxide concentration decreased in transgenic tomato plants compared with the wild-type plants with or without water deficit stress. These results indicated that the heterologous Arabidopsis CBF1 can confer water deficit resistance in transgenic tomato plants.

References:

LITERATURE CITED

Bajaj S, Targolli J, Liu LF, Ho THD, Wu R (1999) Transgenic approaches to increase dehydration-stress tolerance in plants. Mol Breed 5: 493-503

Baker SS, Wilhelm KS, Thomashow MF (1994) The 5'-region of Arabidopsis thaliana COR15a has cis-acting elements that confer cold-, drought- and ABA-regulated gene expression. Plant Mol Biol 24: 701-713

Bray EA, Bailey-Serres J, Weretilnyk E (2000) Response to abiotic stresses. In BB Buchanan, W Gruissem, RL Jones, eds, Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists Press, Rockville, MD, pp 1158-1203

Chan MT, Chao YC, Yu SM (1994) Novel gene expression for plant cells based on induction of α-amylase promoter by carbohydrate starvation. J Biol Chem 269: 17635-17641

Chan MT, Yu SM (1998) The 3' untranslated region of a rice α-amylase gene mediated sugar-dependent abundance of mRNA. Plant J 15: 685-695

Feinberg AP, Vogelstein B (1983) A technique for radiolabeling DNA restriction endonuclease fragments to high specific activity. Anal Bio-chem 132: 6-13

Gilmour SJ, Sebolt AM, Salazar MP, Everard JD, Thomashow MF (2000) Overexpression of the Arabidopsis CBF3 transcriptional activator mimics multiple biochemical changes associated with cold acclimation. Plant Physiol 124: 1854-1865

Gilmour SJ, Zarka DG, Stockinger EJ, Salazar MP, Houghton JM, Tho-mashow MF (1998) Low temperature regulation of the Arabidopsis CBF family of AP2 transcriptional activators as an early step in cold-induced COR gene expression. Plant J 16: 433-442

Godoy JA, Lunar R, Torres-Schumann S, Moreno J, Rodrigo RM, Pintor Toro JA (1994) Expression, tissue distribution and subcellular localization of dehydrin TAS14 in salt-stressed tomato plants. Plant Mol Biol 26: 1921-1934

Godoy JA, Pardo JM, Pintor-Toro JA (1990) A tomato cDNA inducible by salt stress and abscisic acid: nucleotide sequence and expression pattern. Plant Mol Biol 15: 695-705

Hoekstra FA, Golovina EA, Buitink J (2001) Mechanisms of plant desiccation tolerance. Trends Plant Sci 6: 1360-1385

Horvath DP, McLarney BK, Thomashow MF (1993) Regulation of Arabi-dopsis thaliana L. (Heyn) COR78 in response to cold. PlantPhysiol 103: 1047-1053

Hsieh TH, Lee JT, Yang PT, Chiu LH, Charng Yy, Wang YC, Chan MT (2002) Heterologous expression of the Arabidopsis CBF1 gene confers elevated tolerance to chilling and oxidative stresses in transgenic tomato. Plant Physiol 129: 1086-1094

Ingram J, Bartels D (1996) The molecular basis of dehydration tolerance in plants. Annu Rev Plant Physiol Plant Mol Biol 47: 377-403

Jaglo KR, Kleff S, Amundsen KL, Zhang X, Haake V, Zang JZ, Deits T, Thomashow MF (2001) Components of the Arabidopsis C-repeat/ Dehydration-responsive element binding factor cold-response pathway are conserved in Brassica napus and other plant species. Plant Physiol 127: 910-917

Jaglo-Ottosen KR, Gilmour SJ, Zarka DG, Schabenberger O, Tomashow MF (1998) Arabidopsis CBF1 overexpression induces COR genes and enhances freezing tolerance. Science 280: 104-106

Kasuga M, Liu Q, Miura S, Yamaguchi-Shinozaki K, Shinozaki K (1999) Improving plant drought, salt, and freezing tolerance by gene transfer of a single stress-inducible transcription factor. Nat Biotechnol 17: 287-291

Kavi KPB, Hong Z, Miao G-H, Hu C-A, Verma DPS (1995) Overexpression of Δ1-pyrroline-5-carboxylate synthase increases proline production and confers osmotolerance in transgenic plants. Plant Physiol 108: 1387-1394

Liu Q, Kasuga M, Sakuma Y, Abe H, Miura S, Yamaguchi-Shinozaki K, Shinozaki K (1998) Two transcription factors, DREB1 and DREB2, with an EREBP/AP2 DNA binding domain separate two cellular signal transcription pathways in drought- and low-temperature-responsive gene expression, respectively, in Arabidopsis. Plant Cell 10: 1391-1406

Obershall A, Deak M, Torok K, Sass L, Vass I, Kovacs I, Feher A, Dudits D, Horvath GV (2000) A novel aldose/aldehyde reductase protects transgenic plants against lipid peroxidation under chemical and drought stresses. Plant J 24: 437-446

O'Kane D, Gill V, Boyd P, Burdon RH (1996) Chilling, oxidative stress and antioxidant responses in Arabidopsis thaliana callus. Planta 198: 366-370

Parra MM, Del Pozo O, Luna R, Godoy JA, Pintor-Toro JA (1996) Structure of the dehydrin tas14 gene of tomato and its developmental and environmental regulation in transgenic tobacco. Plant Mol Biol 32: 453-460

Pinhero RG, Rao MV, Paliyath G, Murr DP, Fletcher RA (1997) Changes in activities of antioxidant enzymes and their relationship to genetic and paclobutrazol-induced chilling tolerance of maize seedlings. Plant Physiol 114: 695-704

Ross JJ, Reid JB, Gaskin P, Macmillan J (1989) Internode length in Pisum. Estimation of GA1 level in genotypes Le, le and led . Physiol Plant 76: 173-176

Shinozaki K, Yamaguchi-Shinozaki K (2000) Molecular responses to dehydration and cold: differences and cross-talk between two stress signal pathways. Curr Opin Plant Biol 3: 217-223

Smirnoff N, Bryant JA (1999) DREB takes the stress out of growing up. Nat Biotechnol 17: 229-230

Stockinger EJ, Gilmour SJ, Thomashow MF (1997) Arabidopsis thaliana CBF1 encodes an AP2 domain-containing transcriptional activator that binds to the C-repeat/DRE, a cis-acting DNA regulatory element that stimulates transcription in response to cold and water deficit. Proc Natl Acad Sci USA 94: 1035-1040

Thomashow MF (1999) Plant cold acclimation: freezing tolerance genes and regulatory mechanisms. Annu Rev Plant Physiol PlantMol Biol 50: 571-599

Thomashow MF (2001) So what' s new in the field of plant cold acclimation? Lots! Plant Physiol 125: 89-93

Thomashow MF, Gilmour SJ, Stockinger EJ, Jaglo-Ottosen KR, Zarka DG (2001) Role of the Arabidopsis CBF transcriptional activators in cold acclimation. Physiol Plant 112: 171-175

Wang H, Datla R, Georges F, Loewen M, Cuter AJ (1995) Promoters from kin1 and cor6.6, two homologous Arabidopsis thaliana genes: transcriptional regulation and gene expression induced by low temperature, ABA osomoticum and dehydration. Plant Mol Biol 28: 605-617

Xu D, Duan X, Wang B, Hong B, Ho THD, Wu R (1996) Expression of a late embryogenesis abundant protein gene, HVA1, from barely confers tolerance to water deficit and salt stress in transgenic rice. Plant Physiol 110: 249-257

Yamaguchi-Shinozaki K, Shinozaki K (1993) Characterization of the expression of a desiccation -responsive rd29A gene of Arabidopsis thaliana and analysis of its promoter in transgenic plants. Mol Gen Genet 236: 331-340

Yamaguchi-Shinozaki K, Shinozaki K (1994) A novel cis-acting element in an Arabidopsis gene is involved in responsiveness to drought, low-temperature, or high-salt stress. Plant Cell 6: 251-264

AuthorAffiliation
*Tsai-Hung Hsieh, Jent-turn Lee, Yee-yung Charng, and Ming-Tsair Chan

Institute of BioAgricultural Sciences, Academia Sinica, Nankang, Taipei, 115, Taiwan, Republic of China (T.-H.H., J.-t.L., Y.-y.C., M.-T.C.); and National Graduate Institute of Life Sciences, National Defense (.Medical Center, 114, Taiwan, Republic of China (T.-H.H

AuthorAffiliation
.Corresponding author; e-mail mbmtchan@ccvax.sinica.edu.tw; fax 886-2-26511164 *

Article, publication date, and citation information can be found at
.www.plantphysiol.org/cgi/doi/10.1104/pp.006783

Word count: **5757**