

STRESS IN PLANTS CULTURED *IN VITRO*

Geert-Jan de Klerk

Wageningen Tissue Culture Center, BU Biodiversity and Breeding, Plant Research International, P. O. Box 16,
6700 AA Wageningen, The Netherlands, E-mail: geertjan.deklerk@wur.nl

REFERENCES

- Boyer J. S. (1982). Plant productivity and environment (crop genetic improvement). *Science*, 218: 443-448.
- Capell T., Bassie L., Christou P. (2004). Modulation of the polyamine biosynthetic pathway in transgenic rice confers tolerance to drought stress. *Proceedings of the National Academy of Sciences of the United States of America*, 101: 9909-9914.
- Carvalho L. C., Vilela B. J., Vidigal P., Mullineaux P. M., Amancio S. (2006). Activation of the ascorbate-glutathione cycle is an early response of micropropagated *Vitis vinifera* L. explants transferred to *ex vitro*. *International Journal of Plant Sciences*, 167: 759-770.
- Christmann A., Hoffmann T., Teplova I., Grill E., Muller A. (2005). Generation of active pools of abscisic acid revealed by *in vivo* imaging of water-stressed *Arabidopsis*. *Plant Physiology*, 137: 209-219.
- Clarke S. M., Mur L. A. J., Wood J. E., Scott I. M. (2004). Salicylic acid dependent signaling promotes basal thermotolerance but is not essential for acquired thermotolerance in *Arabidopsis thaliana*. *Plant Journal*, 38: 432-447.
- Clerkx E. J. M., El-Lithy M. E., Vierling E., Ruys G. J., Blankestijn-De Vries H., Groot S. P. C., Vreugdenhil D., Koornneef M. (2004). Analysis of natural allelic variation of *Arabidopsis* seed germination and seed longevity traits between the accessions *Landsberg erecta* and *Shakdara*, using a new recombinant inbred line population. *Plant Physiology*, 135: 432-443.
- Dat J. F., Lopez-Delgado H., Foyer C. H., Scott I. M. (2000). Effects of salicylic acid on oxidative stress and thermotolerance in tobacco. *Journal of Plant Physiology*, 156: 659-665.
- De Klerk G. J. (2002) Rooting of microcuttings: theory and practice. *In Vitro Cellular and Developmental Biology-Plant*, 38: 415-422.
- De Klerk G. J., Keppel M., Ter Brugge J., Meekes H. (1995). Timing of the phases in adventitious root formation in apple microcuttings. *Journal of Experimental Botany*, 46: 965-972.
- De Klerk G. J., Wijnhoven F. (2005). Water retention capacity of tissue-cultured plants: Performance of leaves from *in vitro* germinated mungbean seedlings. *Propagation of Ornamental Plants*, 5: 14-18.
- Ding C. K., Wang C. Y., Gross K.C., Smith D. L. (2002). Jasmonate and salicylate induce the expression of pathogenesis-related-protein genes and increase resistance to chilling injury in tomato fruit. *Planta*, 214: 895-901.
- Garg A. K., Kim J. K., Owens T. G., Ranwala A. P., Do Choi Y., Kochian L. V., Wu R. J. (2002). Trehalose accumulation in rice plants confers high tolerance levels to different abiotic stresses. *Proceedings of the National Academy of Sciences of the United States of America*, 99: 15898-15903.
- George E. F. (1993). Plant propagation by tissue culture. Part 1: the technology. *Exegetics*, 574 pp.
- Hiei Y., Ishida Y., Kasaoka K., Komari T. (2006). Improved frequency of transformation in rice and maize by treatment of immature embryos with centrifugation and heat prior to infection with *Agrobacterium tumefaciens*. *Plant Cell, Tissue and Organ Culture*, 87: 233-243.
- Ishii S. (1987). Generation of active oxygen species during enzymatic isolation of protoplasts from oat leaves. *In Vitro Cellular and Developmental Biology*, 23: 653-658.
- Johnston J. W., Harding K., Benson E. E. (2007). Antioxidant status and genotypic tolerance of *Ribes in vitro* cultures to cryopreservation. *Plant Science*, 172: 524-534.
- Kasukabe Y., He L., Nada K., Misawa S., Ihara I., tachibana S. (2004). Overexpression of spermidine synthase enhances tolerance to multiple environmental stresses and up-regulates the expression of various stress-regulated genes in transgenic *Arabidopsis thaliana*. *Plant and Cell Physiology*, 45: 712-722.
- Kevers C., Franck T., Strasser R. J., Dommes J., Gaspar T. (2004). Hyperhydricity of micropropagated shoots: A

- typically stress-induced change of physiological state. *Plant Cell, Tissue and Organ Culture*, 77: 181-191.
- Khanna H., Becker D., Kleidon J., Dale J. (2004). Centrifugation assisted *Agrobacterium tumefaciens*-mediated transformation (CAAT) of embryogenic cell suspensions of banana (*Musa* spp. Cavendish AAA and Lady finger AAB). *Molecular Breeding*, 14: 239-252.
- Langens-Gerrits M. M., De Klerk G. J. M. (1999). Micropropagation of flower bulbs. Lily and Narcissus. *In*: Hall R. D. (Ed.). *Methods in molecular biology*, vol. 111: Plant cell culture protocols. Humana Press: 141-147.
- Larkindale J., Knight M. R. (2002). Protection against heat stress-induced oxidative damage in *Arabidopsis* involves calcium, abscisic acid, ethylene, and salicylic acid. *Plant Physiology*, 128: 682-695.
- Larkindale J., Hall J. D., Knight M. R., Vierling E. (2005). Heat stress phenotypes of *Arabidopsis* mutants implicate multiple signaling pathways in the acquisition of thermotolerance. *Plant Physiology*, 138: 882-897.
- Levitt J. (1972). Responses of plants to environmental stresses. Academic Press, 697 pp.
- Lopez-Delgado H., Mora-Herrera M. E., Zavaleta-Mancera H. A., Cadena-Hinojosa M., Scott I. M. (2004). Salicylic acid enhances heat tolerance and potato virus X (PVX) elimination during thermotherapy of potato microplants. *American Journal of Potato Research*, 81: 171-176.
- Murashige T., Skoog F. (1962). A revised medium for rapid growth and bio assays with tobacco tissue cultures. *Physiologia Plantarum*, 15: 473-497.
- Panicot M., Masgrau C., Borrell A., Cordeiro A., Tiburcio A.F., Altabella T. (2002). Effects of putrescine accumulation in tobacco transgenic plants with different expression levels of oat arginine decarboxylase. *Physiologia Plantarum*, 114: 281-287.
- Papadakis A. K., Roubelakis-Angelakis K. A. (2002). Oxidative stress could be responsible for the recalcitrance of plant protoplasts. *Plant Physiology and Biochemistry*, 40: 549-559.
- Park E.-J., Jeknic Z., Chen T. H. H. (2006). Exogenous application of glycinebetaine increases chilling tolerance in tomato plants. *Plant and Cell Physiology*, 47: 706-714.
- Pellegrineschi A., Brito R. M., Velazquez L., Noguera L. M., Pfeiffer W., McLean S., Hoisington D. (2002). The effect of pretreatment with mild heat and drought stresses on the explant and biolistic transformation frequency of three durum wheat cultivars. *Plant Cell Reports*, 20: 955-960.
- Qiusheng Z., Bao J., Likun L., Xianhua X. (2005). Effects of antioxidants on the plant regeneration and GUS expressive frequency of peanut (*Arachis hypogaea*) explants by *Agrobacterium tumefaciens*. *Plant Cell, Tissue and Organ Culture*, 81: 83-90.
- Saher S., Piqueras A., Hellin E., Olmos E. (2005). Prevention of hyperhydricity in micropropagated carnation shoots by bottom cooling: Implications of oxidative stress. *Plant Cell, Tissue and Organ Culture*, 81: 149-158.
- Sakamoto A., Murata N. (2002). The role of glycine betaine in the protection of plants from stress: Clues from transgenic plants. *Plant, Cell and Environment*, 25: 163-171.
- Tong S., Ni Z., Peng H., Dong G., Sun Q. (2007). Ectopic overexpression of wheat TaSrg6 gene confers water stress tolerance in *Arabidopsis*. *Plant Science*, 172: 1079-1086.
- Van Der Weele C. M., Spollen W. G., Sharp R. E., Baskin T. I. (2000). Growth of *Arabidopsis thaliana* seedlings under water deficit studied by control of water potential in nutrient-agar media. *Journal of Experimental Botany*, 51: 1555-1562.
- Van Huylenbroeck J. M., Van Laere I. M. B., Piqueras A., Debergh P. C., Bueno P. (1998). Time course of catalase and superoxide dismutase during acclimatization and growth of micropropagated *Calathea* and *Spathiphyllum* plants. *Plant Growth Regulation*, 26: 7-14.
- Van Telgen H. J., Elagöz V., Van Mil A., Paffen A., De Klerk G. J. (1992). Role of plant hormones in lateral bud growth of rose and apple *in vitro*. *Acta Horticulturae*, 319: 137-142.
- Wojtaszek P. (1997). Oxidative burst: An early plant response to pathogen infection. *Biochemical Journal*, 322: 681-692.
- Ziv M. (1991). Vitrification: Morphological and physiological disorders of *in vitro* plants. *In*: Debergh P. C., Zimmerman R. H. (Eds.). *Micropropagation*. Kluwer Academic Publishers: 45-69.