

## INFLUENCE OF THE *CALCARISPORIUM ARBUSCULA* PREUSS ON *IN VITRO* GROWTH AND *EX VITRO* ADVENTITIOUS ROOTING OF TWO ELEPIDOTE RHODODENDRON CULTIVARS

Kristine Dokane<sup>1\*</sup>, Dace Megre<sup>2</sup>, Madara Lazdane<sup>3</sup>, and Uldis Kondratovics<sup>4</sup>

<sup>1</sup>University of Latvia, Institute of Biology, 3 Miera str., 2169 Salaspils, Latvia,

\*Fax: + 371 67944988, \*E-mail: kristine.dokane@lu.lv

<sup>2</sup>National Botanical Garden, Department of Plant Ecophysiology, 1 Miera str., 2169 Salaspils, Latvia

<sup>3</sup>University of Latvia, Botanical Garden, 2 Kandavas str., 1083 Riga, Latvia

<sup>4</sup>University of Latvia, Faculty of Biology, 1 Jelgavas str., 1004 Riga, Latvia

### REFERENCES

- ALTAMURA M. M. (1996). Root histogenesis in herbaceous and woody explants cultured *in vitro*. A critical review. *Agronomie-Sciences des Productions Vegetales et de l'Environnement*, 16: 589-602.
- ANDERSON W. C. (1984). A revised tissue culture medium for shoot multiplication of rhododendron. *Journal of the American Society for Horticultural Science*, 109: 343-347.
- BAE H., SICHER R. C., KIM M. S., KIM S. H., STREM M. D., MELNICK R. L., BAILEY B. A. (2009). The beneficial endophyte *Trichoderma hamatum* isolate DIS 219b promotes growth and delays the onset of the drought response in *Theobroma cacao*. *Journal of Experimental Botany*, 60: 3279-3295.
- BIZABANI C., DAMES J. (2015). Effects of inoculating *Lachnum* and *Cadophora* isolates on the growth of *Vaccinium corymbosum*. *Microbiological Research*, 181: 68-74.
- BOUGOURE D. S., CAIRNEY J. W. (2005). Fungi associated with hair roots of *Rhododendron lochiaie* (Ericaceae) in an Australian tropical cloud forest revealed by culturing and culture-independent molecular methods. *Environmental Microbiology*, 7: 1743-1754.
- BRAUNE W., LEMAN A., TAUBERT H. (1999). *Pflanzenanatomisches Praktikum I. Spektrum Akademischer, Verlag Heidelberg – Berlin*, 368 pp.
- DE ALMEIDA M. R., DE BASTIANI D., GAETA M. L., DE ARAÚJO MARIATH J. E., DE COSTA F., RETALLICK J., NOLAN L., TAI H. H., STRÖMVIK M. V., FETT-NETO A. G. (2015). Comparative transcriptional analysis provides new insights into the molecular basis of adventitious rooting recalcitrance in *Eucalyptus*. *Plant Science*, 239: 155-165.
- DE KLERK G. J. (2002). Rooting of microcuttings: theory and practice. *In Vitro Cellular & 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., VAN DER KRIEKEN W., DE JONG J. C. (1999). The formation of adventitious roots: new concepts, new possibilities. *In Vitro Cellular & Developmental Biology-Plant*, 35: 189-199.
- DOKANE K., LAZDANE M., KONDRATOVICS U. (2012). Endophytic fungi in roots of elepidote rhododendron. Seventh PhD Student Conference, Scandinavian Plant Physiology Society, Book of Abstracts: 45.
- DOKANE K., MEGRE D., LAZDANE M., KONDRATOVICS U. (2014). Does shoot anatomical heterogeneity influence *ex vitro* adventitious root formation in rhododendron microcuttings? *Propagation of Ornamental Plants*, 14: 171-176.
- DRUEGE U., FRANKEN P., HAJIREZAEI M. R. (2016). Plant hormone homeostasis, signalling, and function during adventitious root formation in cuttings. *Frontiers in Plant Science*, 7: 1-14.
- ENSMINGER I., BUSCH F., HUNER N. (2006). Photostasis and cold acclimation: sensing low temperature through photosynthesis. *Physiologia Plantarum*, 126: 28-44.
- FAKHRO A., ANDRADE-LINARES D. R., VON BARGEN S., BANDTE M., BÜTTNER C., GROSCH R., SCHWARZ D., FRANKEN P. (2010). Impact of *Piriformospora indica* on tomato growth and on interaction with fungal and viral pathogens. *Mycorrhiza*, 20: 191-200.
- GOND L. J., GUO S. X. (2009). Endophytic fungi from *Dracaena cambodiana* and *Aquilaria sinensis* and their antimicrobial activity. *African Journal of Biotechnology*, 8: 731-736.
- HALMSCHLAGER E., KOWALSKI T. (2004). The mycobiota in nonmycorrhizal roots of healthy and declining oaks. *Canadian Journal of Botany*, 82: 1446-1458.
- HARDOIM P. R., VAN OVERBEEK L. S., BERG G., PIRTTILÄ A. M., COMPANT S., CAMPISANO A., DÖRING M., SESSITSCH A. (2015). The hidden world within plants: ecological and evolutionary considerations for defining functioning of microbial endophytes. *Microbiology and Molecular Biology Reviews*, 79: 293-320.
- HATZILAZAROU S. P., SYROS T. D., YUPSANIS T. A., BOSABALIDIS A. M., ECONOMOU A. S. (2006). Peroxidases, lignin and anatomy during *in vitro* and *ex vitro* rooting of gardenia (*Gardenia jasminoides* Ellis) microshoots. *Journal of Plant Physiology*, 163: 827-836.
- ILIEV I., KITIN P., FUNADA R. (2001). Morphological and anatomical study on *in vitro* root formation of silver birch (*Betula pendula* Roth.). *Propagation of Ornamental Plants*, 1: 10-19.
- JI L. L., SONG Y. C., TAN R. X. (2004). A potent feed preservative candidate produced by *Calcarisporium* sp., an endophyte residing in stargrass (*Cynodon dactylon*). *Journal of Applied Microbiology*, 96: 352-358.
- KUREPIN L., HASLAM T., LOPEZ-VILLALOBOS A., OINAM G., YEUNG E. (2011). Adventitious root formation in ornamental plants: II. The role of plant growth regulators. *Propagation of Ornamental Plants*, 11: 161-171.
- LICHTENTHALER H. K. (1987). Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. *Methods in Enzymology*,

- MAO X. M., XU W., LI D., YIN W. B., CHOOI Y. H., LI Y. Q., TANG Y., HU Y. (2015). Epigenetic genome mining of an endophytic fungus leads to the pleiotropic biosynthesis of natural products. *Angewandte Chemie*, 127: 7702-7706.
- MUCCIARELLI M., SCANNERINI S., BERTEA C., MAFFEI M. (2003). *In vitro* and *in vivo* peppermint (*Mentha piperita*) growth promotion by nonmycorrhizal fungal colonization. *New Phytologist*, 158: 579-591.
- OSSELTON M. D., BAUM H., BEECHEY R. B. (1974). Isolation, purification and characterization of aurovertin B. *Biochemical Society Transactions*, 2: 200-202.
- PINTO C., RODRIGUES L.S., AZEVEDO J. L., PEREIRA J.O., CARNEIRO VIEIRA M. L., LABATE C. A. (2000). Symptomless infection of banana and maize by endophytic fungi impairs photosynthetic efficiency. *New Phytologist*, 147: 609-615.
- RAI M., ACHARYA D., SINGH A., VARMA A. (2001). Positive growth responses of the medicinal plants *Spilanthes calva* and *Withania somnifera* to inoculation by *Piriformospora indica* in a field trial. *Mycorrhiza*, 11: 123-128.
- READ D. J. (1996). The structure and function of the ericoid mycorrhizal root. *Annals of Botany*, 77: 365-374.
- ROZPADEK P., WEŻOWICZ K., NOSEK M., WAZNY R., TOKARZ K., LEMBICZ M., MISZALSKI Z., TURNAU K. (2015). The fungal endophyte *Epichloë typhina* improves photosynthesis efficiency of its host orchard grass (*Dactylis glomerata*). *Planta*, 242: 1025-1035.
- RUZIN S. E. (1999). *Plant Microtechnique and Microscopy*. Oxford University Press, New York, 322 pp.
- SAHAY N. S., VARMA A. (1999). *Piriformospora indica*: a new biological hardening tool for micropropagated plants. *FEMS Microbiology Letters*, 181: 297-302.
- SIRRENBURG A., GÖBEL C., GROND S., CZEMPINSKI N., RATZINGER A., KARLOVSKY P., SANTOS P., FEUSSNER I., PAWLOWSKI K. (2007). *Piriformospora indica* affects plant growth by auxin production. *Physiologia Plantarum*, 131: 581-589.
- SUKUMAR P., LEGUE V., VAYSSIERES A., MARTIN F., TUSKAN G. A., KALLURI U. C. (2013). Involvement of auxin pathways in modulating root architecture during beneficial plant–microorganism interactions. *Plant, Cell & Environment*, 36: 909-919.
- SUN L., PEI K., WANG F., DING Q., BING Y., GAO B., ZHENG Y., LIANG Y., MA K. (2012). Different distribution patterns between putative Ericoid Mycorrhizal and other fungal assemblages in roots of *Rhododendron decorum* in the southwest of China. *PloS ONE*, 7, e49867.
- USUKI F., ABE J. P., KAKISHIMA M. (2003). Diversity of ericoid mycorrhizal fungi isolated from hair roots of *Rhododendron obtusum* var. *kaempferi* in a Japanese red pine forest. *Mycoscience*, 44: 97-102.
- VADASSERY J., RITTER C., VENUS Y., CAMEHL I., VARMA A., SHAHOLLARI B., NOVÁK O., STRNAD M., LUDWIG-MÜLLER J., OELMÜLLER R. (2008). The role of auxins and cytokinins in the mutualistic interaction between *Arabidopsis* and *Piriformospora indica*. *Molecular Plant-Microbe Interactions*, 21: 1371-1383.
- WATSON P. (1965). Further observations on *Calcarisporium arbuscula*. *Transactions of the British Mycological Society*, 48: 9-17.
- ZHANG C., YIN L., DAI S. (2009). Diversity of root-associated fungal endophytes in *Rhododendron fortunei* in subtropical forests of China. *Mycorrhiza*, 19: 417-423.