

**FACTORS AFFECTING HIGH FREQUENCY GERMINATION AND REGENERATION
IN VITRO FROM SEEDS OF *PAPHIOPEDILUM CONCOLOR* (BATEMAN) PFITZER**

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REFERENCES

- AMOO S. O., FINNIE J. F., VAN STADEN. (2011). The role of meta-topolins in alleviating micropropagation problems. *Plant Growth Regulation*, 63: 197-206.
- AVERYANOV L., CRIBB P., KE LOC P., TIEN HIEP N., (2003). *Slipper Orchids of Vietnam. With an introduction to the Flora of Vietnam.* Kew, Compass Press Limited, The Royal Botanic Gardens, 308 pp.
- CHEN Y., GOODALE U. M., FAN X. L., GAO J. Y. (2015). Asymbiotic seed germination and in vitro seedling development of *Paphiopedilum spicerianum*: an orchid with an extremely small population in China. *Global Ecology and Conservation*, 3: 367-378.
- CITES (2022). Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendices I, II, and III, Geneva, Switzerland, 81 pp.
- CRIBB P. (2011). The genus *Paphiopedilum*, Second edition. The Royal Botanic Gardens, Kew: Natural History Publications, 100 pp.
- DUONG T. N., THUY D. T. T., NGUYEN T. D., VU Q. L., NGUYEN T. H., VAN K. T. T., CHENDANDA C. C. (2007). *In vitro* stem elongation of *Paphiopedilum delenatii* Guillaumin and shoot regeneration via stem node culture. *Propagation of Ornamental Plants*, 7: 29-36.
- ERNST R. (1982). *Paphiopedilum*: Orchid seed germination and culture - Methods. In: Arditti J. (Ed.). *Orchid Biology: Review and Perspectives*, vol. 2, Cornell University Press: 350-353.
- GEORGE E. F., HALL M. A., KLERK G. J. D. (2008). Plant growth regulators II: cytokinins, their analogues and antagonists. In: George E. F., Hall M. A., Klerk G. J. D. (Eds). *Plant Propagation by Tissue Culture*. Springer, Dordrecht: 205-226.
- HUANG L. C., LIN C. J., KUO C. I., HUANG B. L., MURASHIGE T. (2001). *Paphiopedilum* cloning in vitro. *Scientia Horticulturae*, 91: 111-121.
- HABERER G., KIEBER J. J. (2002). Cytokinins. New insights into a classic phytohormone. *Plant Physiology*, 128: 354-362.
- ILIEV I. (2017). Factors affecting the axillary and adventitious shoots formation in woody plants in vitro. *Acta Horticulturae*, 1155: 15-27.
- KAUTH P. J., DUTRA D., JOHNSON T. R., STEWART S. L., KANE M. E., VENDRAME W. A. (2008). Techniques and applications of in vitro orchid seed germination. In: Jaime A. Teixeira da Silva (Ed.). *Floriculture, Ornamental and Plant Biotechnology, Advances and Tropical Issues*, vol. 5, Global Science Books, Ltd.: 375-391.
- KNUDSON L. (1946). A new nutrient solution for germination of orchid seeds. *American Orchid Society Bulletin*, 15: 214-217.
- LI X. L., HANG C. Y., SONG Q., ZHOU J. Y., WANG X. G. (2016). *In vitro* asymbiotic germination and propagation of *Paphiopedilum concolor* (Lindl.) Pfitz. *Plant Science Journal*, 34: 127-134.
- LUAN V. Q., HUY N. P., NAM N. B., HUONG T. T., HIEN V. T., HIEN N. T. T., HAI N. T., THINH D. K., NHUT D. T. (2015). *Ex vitro* and *in vitro* *Paphiopedilum delenatii* Guillaumin stem elongation under light-emitting diodes and shoot regeneration via stem node culture. *Acta Physiologiae Plantarum*, 37: 1-11.
- LUAN V. Q., CUONG L. K., TUNG H. T., HIEN V. T., HIEU T., NHUT D. T. (2019). Effects of shoot tip removal, wounding manipulation, and plant growth regulators on shoot regeneration and plantlet development in *Paphiopedilum* species. *Scientia Horticulturae*, 256: 108648.
- MURASHIGE T., SKOOG F. (1962). A revised medium for rapid growth and bio assay with tobacco tissue cultures. *Physiologia Plantarum*, 15: 474-497.
- NGUYEN T. T., NGUYEN T. D., DAO X. T., CHU T. D., NGO X. B. (2018). *In Vitro* Propagation of a Vietnam Endemic Lady's Slipper Orchid (*Paphiopedilum vietnamense* O. Gruss & Perner). *Journal of Horticulture and Plant Resources*, 1: 1-8.
- NHUT D. T., TRANG P. T. T., VU N. H., THUY D. T. T., VAN KHIEM D., VAN BINH N., VAN K. T. T. (2005). A wounding method and liquid culture in *Paphiopedilum delenatii* propagation. *Propagation of Ornamental Plants*, 5: 158-163.
- RITTIRAT S., KLAOCHEED S., THAMMASIRI K., PRASERTSONGSKUN S. (2018). *In vitro* propagation and forest reestablishment of *Cymbidium finlaysonianum* Lindl., an endangered medicinal orchid. *Walailak Journal of Science and Technology*, 15: 711-724.
- SOONTHORNKALUMP S., NAKKANONG K., MEESAWAT U. (2019). *In vitro* cloning via direct somatic embryogenesis and genetic stability assessment of *Paphiopedilum niveum* (Rchb.f.) Stein: the endangered Venus's slipper orchid. *In Vitro Cellular & Developmental Biology - Plant*, 55: 265-276.
- TOKUHARA K., MII M. (1993). Micropropagation of *Phalaenopsis* and *Doritaenopsis* by culturing shoot tips of flower stalk buds. *Plant Cell Reports*, 13: 7-11.
- VACIN E. F., WENT F. W. (1949). Some pH changes in nutrient solutions. *Botanical Gazette*, 110: 605-613.

- WATTANAPAN N., NUALSRI C., MEESAWAT U. (2018). *In vitro* propagation through transverse thin cell layer (Ttcl) culture system of lady's slipper orchid: *Paphiopedilum callosum* var. *sublaeve*. Songklanakarin Journal of Science and Technology, 40: 306-313.
- WATTANAWIKKIT P., BUNN E., CHAYANARIT K., TANTIWIWAT S. (2011). Effect of cytokinins (BAP and TDZ) and auxin (2,4-D) on growth and development of *Paphiopedilum callosum*. Kasetsart Journal (Natural Science), 45: 12-19.
- ZENG S., WU K., TEIXEIRA DA SILVA J. A., ZHANG J., CHEN Z., XIA N., DUAN J. (2012). Asymbiotic seed germination, seedling development and reintroduction of *Paphiopedilum wardii* Sumerh., an endangered terrestrial orchid. Scientia Horticulturae, 138: 198-209.
- ZENG S., WANG J., WU K., TEIXEIRA DA SILVA J. A., ZHANG J., DUAN J. (2013). *In vitro* propagation of *Paphiopedilum hangianum* Perner & Gruss. Scientia Horticulturae, 151: 147-156.
- ZENG S., HUANG W., WU K., ZHANG J., TEIXEIRA DA SILVA J. A., DUAN J. (2016). *In vitro* propagation of *Paphiopedilum* orchids. Critical Reviews in Biotechnology, 36: 521-534.
- ZHANG Y. Y., WU K. L., ZHANG J. X., DENG R. F., DUAN J., TEIXEIRA DA SILVA J. A., HUANG W. C., ZENG S. J. (2015). Embryo development in association with asymbiotic seed germination *in vitro* of *Paphiopedilum armeniacum* S. C. Chen et F. Y. Liu. Scientific Reports, 5: Article 16356.