

**PHOTOSYNTHETIC PHOTON FLUX DENSITY AND PLANT GROWTH REGULATORS  
AFFECT SOMATIC EMBRYOGENESIS IN *AGAPANTHUS PRAECOX* WILLD. SUBSP.  
*ORIENTALIS* (F. M. LEIGHT.) F. M. LEIGHT.**

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**REFERENCES**

- BASKARAN P., VAN STADEN J. (2013). Rapid *in vitro* micropropagation of *Agapanthus praecox*. South African Journal of Botany, 86: 46-50.
- BELIĆ M., ZDRAVKOVIĆ-KORAĆ S., JANOŠEVIĆ D., SAVIĆ J., TODOROVIĆ S., BANJAC N., MILOJEVIĆ J. (2020). Gibberellins and light synergistically promote somatic embryogenesis from the *in vitro* apical root sections of spinach. Plant Cell, Tissue and Organ Culture, 142: 537-548.
- CHAIWANON J., WANG W., ZHU J., OH E., WANG Z. (2016). Information integration and communication in plant growth regulation. Cell, 164: 1257-1268.
- CHENG Y., LIU H., TONG X., LIU Z., ZHANG X., JIANG X., YU X. (2021). Somatic embryogenesis and triterpenoid saponin production in *Aralia elata* (Miq.) Seem. Scientia Horticulturae, 285: Article 110162.
- DOU H., NIU G., GU M., MASABNI J. G. (2017). Effects of light quality on growth and phytonutrient accumulation of herbs under controlled environments. Horticulturae, 3: Article 36.
- FARHADI N., PANAHANDEH J., AZAR A. M., SALTE S. A. (2017). Effects of explant type, growth regulators and light intensity on callus induction and plant regeneration in four ecotypes of Persian shallot (*Allium hirtifolium*). Scientia Horticulturae, 218: 80-86.
- FEHÉR A., PASTERNAK T. P., DUDITS D. (2003). Transition of somatic plant cells to an embryogenic state. Plant Cell, Tissue and Organ Culture, 74: 201-228.
- FRIML J., VIETEN A., SAUER M., WEIJERS D., SCHWARZ H., HAMANN T., OFFRINGA R., JÜRGENS G. (2003). Efflux-dependent auxin gradients establish the apical-basal axis of *Arabidopsis*. Nature, 426: 147-153.
- GUO H. H., GUO H. X., ZHANG L., FAN Y. J., FAN Y. P., ZENG F. C. (2019). SELTP-assembled battery drives totipotency of somatic plant cell. Plant Biotechnology Journal, 17: 1188-1190.
- HUTCHINSON M. J., SENARATNA T., SAHI S. V., SAXENA P. K. (2000). Light mediates endogenous plant growth substances in thidiazuron-induced somatic embryogenesis in geranium hypocotyl cultures. Journal of Plant Biochemistry and Biotechnology, 9: 1-6.
- JEON M.-W., ALI M. B., HAHN E.-J., PAEK K.-Y. (2005). Effects of photon flux density on the morphology, photosynthesis and growth of a CAM orchid, *Doritaenopsis* during post-micropropagation acclimatization. Plant Growth Regulation, 45: 139-147.
- JIMÉNEZ V. M., BANGERTH F. (2001). Endogenous hormone concentrations and embryogenic callus development in wheat. Plant Cell, Tissue and Organ Culture, 67: 37-46.
- KEPCZYŃSKA E., ZIELIŃSKA S. (2006). Regulation of *Medicago sativa* L. somatic embryos regeneration by gibberellin A<sub>3</sub> and abscisic acid in relation to starch content and  $\alpha$ -amylase activity. Plant Growth Regulation, 49: 209-217.
- KOIRALA M., GONCALVES DOS SANTOS K. C., GÉLINAS S.-E., RICARD S., KARIMZADEGAN V., LAMICHHANE B., LIYANAGE N. S., MERINDOL N., DESGAGNÉ-PENIX I. (2023). Auxin and light-mediated regulation of growth, morphogenesis, and alkaloid biosynthesis in *Crinum × powellii* 'Album' callus. Phytochemistry, 216: Article 113883.
- LI K., YU R., FAN L.-M., WEI N., CHEN H., DENG X. W. (2016). DELLA-mediated PIF degradation contributes to coordination of light and gibberellin signalling in *Arabidopsis*. Nature Communications, 7: Article 11868.
- LIU W., WANG C., SHEN X., LIANG H., WANG Y., HE Z., ZHANG D., CHEN F. (2019). Comparative transcriptome analysis highlights the hormone effects on somatic embryogenesis in *Catalpa bungei*. Plant Reproduction, 32: 141-151.
- LIU Y., JAFARI F., WANG H. (2021). Integration of light and hormone signaling pathways in the regulation of plant shade avoidance syndrome. aBIOTECH, 2: 131-145.
- LOCHMANOVÁ G., ZDRÁHAL Z., KONEČNÁ H., KOUKALOVÁ Š., MALBECK J., SOUČEK P., VÁLKOVÁ M., KIRAN N. S., BRZOBOHATÝ B. (2008). Cytokinin-induced photomorphogenesis in dark-grown *Arabidopsis*: a proteomic analysis. Journal of Experimental Botany, 59: 3705-3719.
- MARZI D., BRUNETTI P., MELE G., NAPOLI N., CALÒ L., SPAZIANI E., MATSUI M., DE PANFILIS S., COSTANTINO P., SERINO G., CARDARELI M. (2020). Light controls stamen elongation via cryptochromes, phytochromes and COP1 through HY5 and HYH. The Plant Journal, 103: 379-394.

- MURASHIGE T., SKOOG F. (1962). A revised medium for rapid growth and bio assays with tobacco tissue cultures. *Physiologia Plantarum*, 15: 473-497.
- MURPHY A. S., HOOGNER K. R., PEER W. A., TAIZ L. (2002). Identification, purification, and molecular cloning of N-1-naphthylphthalamic acid-binding plasma membrane-associated Aminopeptidases from Arabidopsis. *Plant Physiology*, 128: 935-950.
- PENG J., HARBERD N. P. (2002). The role of GA-mediated signalling in the control of seed germination. *Current Opinion in Plant Biology*, 5: 376-381.
- PULLMAN G. S., MEIN J., JOHNSON S., ZHANG Y. (2005). Gibberellin inhibitors improve embryogenic tissue initiation in conifers. *Plant Cell Reports*, 23: 596-605.
- REN Z., LV X., ZHANG D., XIA Y. (2018). Efficient somatic embryogenesis and bulblet regeneration of the endangered bulbous flower *Griifinia liboniana*. *Plant Cell, Tissue and Organ Culture*, 135: 523-533.
- SALISBURY F. J., HALL A., GRIERSON C. S., HALLIDAY K. J. (2007). Phytochrome coordinates Arabidopsis shoot and root development. *The Plant Journal*, 50: 429-438.
- SERRET M. D., TRILLAS M. I. (2000). Effects of light and sucrose levels on the anatomy, ultrastructure, and photosynthesis of *Gardenia jasminoides* Ellis leaflets cultured *in vitro*. *International Journal of Plant Sciences*, 161: 281-289.
- SUZUKI S., OOTA M., NAKANO M. (2002). Embryogenic callus induction from leaf explants of the Liliaceous ornamental plant, *Agapanthus praecox* ssp. *orientalis* (Leighton) Leighton: histological study and response to selective agents. *Scientia Horticulturae*, 95: 123-132.
- SUZUKI R. M., KERBAUY G. B., ZAFFARI G. R. (2004). Endogenous hormonal levels and growth of dark-incubated shoots of *Catasetum fimbriatum*. *Journal of Plant Physiology*, 161: 929-935.
- TANG L. P., ZHANG X. S., SU Y. H. (2020). Regulation of cell reprogramming by auxin during somatic embryogenesis. *aBIOTECH*, 1: 185-193.
- THOMAS C., BRONNER R., MOLINIER J., PRINSEN E., VAN ONCKELEN H., HAHNE G. (2002). Immuno-cytochemical localization of indole-3-acetic acid during induction of somatic embryogenesis in cultured sunflower embryos. *Planta*, 215: 577-583.
- TOKUJI Y., KURIYAMA K. (2003). Involvement of gibberellin and cytokinin in the formation of embryogenic cell clumps in carrot (*Daucus carota*). *Journal of Plant Physiology*, 160: 133-141.
- WANG Y., HE S., LONG Y., ZHANG X., ZHANG X., HU H., LI Z., HOU F., GE F., GAO S., PAN G., MA L., SHEN Y. (2022). Genetic variations in ZmSAUR15 contribute to the formation of immature embryo-derived embryonic calluses in maize. *The Plant Journal*, 109: 980-991.
- YANG X., ZHANG X. (2010). Regulation of somatic embryogenesis in higher plants. *Critical Reviews in Plant Sciences*, 29: 36-57.
- YIN L., LAN Y., ZHU L. H. (2008). Analysis of the protein expression profiling during rice callus differentiation under different plant hormone conditions. *Plant Molecular Biology*, 68: Article 597.
- YUE J., ZHANG D., REN L., SHEN X. (2016). Gibberellin and auxin signals control scape cell elongation and proliferation in *Agapanthus praecox* ssp. *orientalis*. *Journal of Plant Biology*, 59: 358-368.
- YUE J., DONG Y., DU C., SHI Y., TENG Y. (2022a). Transcriptomic and physiological analyses reveal the acquisition of somatic embryogenesis potential in *Agapanthus praecox*. *Scientia Horticulturae*, 305: Article 111362.
- YUE J., DONG Y., LIU S., JIA Y., LI C., WANG Z., GONG S. (2022b). Integrated proteomic and metabolomic analyses provide insights into acquisition of embryogenic ability in *Agapanthus praecox*. *Frontiers in Plant Science*, 13: Article 858065.
- ZHANG D., REN L., YUE J.-H., WANG L., ZHUO L.-H., SHEN X.-H. (2013). A comprehensive analysis of flowering transition in *Agapanthus praecox* ssp. *orientalis* (Leighton) Leighton by using transcriptomic and proteomic techniques. *Journal of Proteomics*, 80: 1-25.