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AXILLARY SHOOTS INDUCTION AND RHIZOGENESIS IN CURLY BIRCH UNDER A SHORTENED AND AN EXTENDED LIGHT-DARK CYCLES

Lidiya Vetchinnikova[1*], Tatjana Shibaeva[2], Kseniya Gudkova[1], and Alexander Titov[2]

[1]Forest Research Institute, Karelian Research Center, Russian Academy of Sciences,
11 Pushkinskaya str., 185910 Petrozavodsk, Russia, *E-mail: vetchin@krc.karelia.ru
[2]Institute of Biology, Karelian Research Center, Russian Academy of Sciences,
11 Pushkinskaya str., 185910 Petrozavodsk, Russia

REFERENCES

Azeez A., Sane A. P. (2015). Photoperiodic growth control in perennial trees. Plant Signal and Behavior, 10: Article e1087631.

Böhlenius H., Huang T., Charbonnel-Campaa L., Brunner A.M., Jansson S., Strauss S. H., Nilsson O. (2006). CO/FT regulatory module controls timing of flowering and seasonal growth cessation in trees. Science, 312: 1040-1043.

Chen H. C., Lee H. C., Lin T. Y., Li W. H., Chen B. S. (2004). Quantitative characterization of the transcriptional regulatory network in the yeast cell cycle. Bioinformatics, 20: 1914-1927.

Ch-u X., Wang M., Fan Z., Li J., Yin H. (2024). Molecular mechanisms of seasonal gene expression in trees. International Journal of Molecular Sciences, 25: Article 1666.

Collection of *in vitro* clones of rare species of the Betulaceae family (In Russian) (accessed 25 May 2025).

Dutta Gupta S., Agarwal A. (2017). Artificial lighting system for plant growth and development: chronological advancement, working principles, and comparative assessment. *In*: Dutta Gupta S. (Ed.). Light Emitting Diodes for Agriculture: Smart Lighting, Springer: 1-25.

Economou A. S., Read P. E. (1987). Light treatments to improve efficiency of *in vitro* propagation systems. HortScience, 22: 751-754.

Eriksson M. E., Hoffman D., Kaduk M., Mauriat M., Moritz T. (2015). Transgenic hybrid aspen trees with increased gibberellin (GA) concentrations suggest that GA acts in parallel with FLOWERING LOCUS T2 to control shoot elongation. New Phytologist, 205: 1288-1295.

Gao Y., Chen Z., Feng Q., Long T., Ding J., Shu P., Deng H., Yu P., Tan W., Liu S., Rodriguez L. G., Wang L., Resco de Dios V., Yao Y. (2024). ELONGATED HYPOCOTYL 5a modulates FLOWERING LOCUS T2 and gibberellin levels to control dormancy and bud break in poplar. Plant Cell, 36: 1963-1984.

Gering Kh., Zoglauer K., Goffman B., Pinker I. (1986). Effect of auxin and red light on rooting of birch shoots *in vitro*. *In*: Plant Cell Culture and Biotechnology, Nauka, Moscow: 106-110 (In Russian).

Gómez-Soto D., Allona I., Perales M. (2022). FLOWERING LOCUS T2 promotes shoot apex development and restricts internode elongation via the 13-Hydroxylation Gibberellin biosynthesis pathway in poplar. Frontiers in Plant Science, 12: Article 814195.

Hajdu A., Dobos O., Domijan M., Bálint B., Nagy I., Nagy F., Kozma-Bognár L. (2018). ELONGATED HYPOCOTYL 5 mediates blue light signaling to the *Arabidopsis* circadian clock. The Plant Journal, 96: 1242-1254.

Hartmann H. T., Kester D. E., Davies F. T., Geneve R. L. (2002). Hartmann and Kester's Plant Propagation: Principles and Practices. 7th edition. Prentice Hall, Upper Saddle River, New Jersey, 880 pp.

Janda T., Prerostová S., Vanková R., Darkó É. (2021). Crosstalk between light- and temperature-mediated processes under cold and heat stress conditions in plants. International Journal of Molecular Sciences, 22: Article 8602.

Junttila O., Hänninen H. (2012). The minimum temperature for bud burst in *Betula* depends on the state of dormancy. Tree Physiology, 32: 337-345.

Kondratovičs T., Zeps M. (2022). Effect of different spectral composition LED lighting on silver birch *in vitro* plantlet morphology. *In*: Treija S. (Technical Editor). Research for Rural Development 2022: Proceedings of the 28th Annual International Scientific Conference, Volume 37, Latvia University of Life Sciences and Technologies, Jelgava, Latvia: 63-69.

Lyr H., Polster H., Fiedler H.-J. (1967). Gehölzphysiologie. Jena, Fischer, 444 s.

Maurya J. P., Bhalerao R. P. (2017). Photoperiod- and temperature-mediated control of growth cessation and dormancy in trees: a molecular perspective. Annals of Botany, 120: 351-360.

Mogilevskaya I. V., Zholobova O. O. (2025). Optimizing *in vitro* photoperiod for improved morphogenesis in smoke tree (*Cotinus coggygria* Scop.). Research on Crops, 26: 167-174.

Morini S., Fortuna P., Sciutti R., Muleo R. (1990). Effect of different light-dark cycles on growth of fruit tree shoots cultured *in vitro*. Advances in Horticultural Science, 3: 163-166.

Morini S., Sciutti R., Fortuna P. (1992). *In vitro* growth response of *Prunus cerasifera* shoots as influenced by different light-dark cycles and sucrose concentrations. Plant Cell, Tissue and Organ Culture, 28: 245-248.

Morini S., Muleo R., Sciutti R., Fortuna P. (1993). Relationship between evolution of CO_2 and growth of plum shoot tips culture *in vitro* under different light-dark regimes. Physiology Plantarum, 87: 286-290.

Morini S., Perrone S. (2006). Effects of short light-dark regimes on *in vitro* shoot rooting of some fruit tree rootstocks. Biologia Plantarum, 50, 429-432.

Murashige T., Skoog F. (1962). A revised medium for rapid growth and bioassay with tobacco tissue cultures. Physiologia Plantarum, 15: 473-497.

Olsen J. E. (2010). Light and temperature sensing and signaling in induction of bud dormancy in woody plants. Plant Molecular Biology, 73: 37-47.

Pinker I., Zoglauer K., Göring H. (1989). Influence of light on adventitious root formation in birch shoot cultures *in vitro*. Biologia Plantarum, 31: 254-260.

Praveena C., Veeresham C. (2014). Multiple shoot regeneration and effect of sugars on growth and nitidine accumulation in shoot cultures of *Toddalia asiatica*. Pharmacognosy Magazine., 10 (Suppl 3): 480-486.

Puhakainen T., Li C., Boije-Malm M., Kangasjärvi J., Heino P., Palva E. T. (2004). Short-day potentiation of low temperature-induced gene expression of a C-repeat-binding factor-controlled gene during cold acclimation in silver birch. Plant Physiology, 136: 4299-4307.

Roeber V. M., Schmülling T., Cortleven A. (2022). The photoperiod: handling and causing stress in plants. Frontiers in Plant Science, 12: Article 781988.

Romero J. M., Serrano-Bueno G., Camacho-Fernández C., Vicente M. H., Ruiz M. T., Pérez-Castiñeira J. R., Pérez-Hormaeche J., Nogueira F. T. S., Valverde F. (2024). Constans, a hub for all seasons: how photoperiod pervades plant physiology regulatory circuits. Plant Cell, 36: 2086-2102.

Sæbø A., Krekling T., Appelgren M. (1995). Light quality affects photosynthesis and leaf anatomy of birch plantlets *in vitro*. Plant Cell, Tissue and Organ Culture, 41: 177-185.

Singh R. K., Bhalerao R. P., Eriksson M. E. (2021). Growing in time: exploring the molecular mechanisms of tree growth. Tree Physiology, 41: 657-678.

Skinner D. Z., Bellinger B., Hiscox W., Helms G. L. (2018). Evidence of cyclical light/dark-regulated expression of freezing tolerance in young winter wheat plants. PLoS ONE, 13: Article e0198042.

Vaillant V., Bade P., Constant C. (2005). Photoperiod affects the growth and development of yam plantlets obtained by *in vitro* propagation. Biologia Plantarum, 49: 355-359.

Vetchinnikova L., Kuznetsova T., Titov A. (2017). Effect of BAP on growth, amino acid content and lipid fatty acid composition of curly birch *in vitro* shoots. Acta Horticulturae, 1155: 251-256.

Vetchinnikova L. V., Titov A. F. (2021). Curly birch: major results and research prospects. Karelian Research Centre of the Russian Academy of Sciences, Petrozavodsk, Russia, 243 pp. (In Russian).

Vetchinnikova L. V., Titov A. F. (2022). Effect of cadmium on gemmation and rhizogenesis in Karelian birch. Russian Journal of Plant Physiology, 69: Article 72.

Welander M. (1988). Biochemical and anatomical studies of birch (*Betula pendula* Roth) buds exposed to different climatic conditions in relation to growth *in vitro. In*: Hanover J. W., Keathley D. E. (Eds). Genetics Manipulation of Woody Plants. Plenum Publishing Corporation, New York: 79-99.

Wynne J., McDonald M. S. (2002). Adventitious root formation in woody plant tissue: the influence of light and indole-3-butyric acid (IBA) on adventitious root induction in *Betula pendula*. In Vitro Cellular & Developmental Biology-Plant, 38: 210-212. https://doi.org/10.1079/IVPIVP2001266

Zhao J., Thi L. T., Park Y. G., Jeong B. R. (2020). Light quality affects growth and physiology of *Carpesium triste* Maxim. cultured *in vitro*. Agriculture, 10: Article 258.

Zimmerman T. W., Scorza R. (1994). Benzyladenine and shortened light/dark cycles improve *in vitro* shoot proliferation of peach. HortScience, 29: Article 698.