Effects of Atmospheric CO_2 Enrichment on Plant Hormones

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Investigating the effects of atmospheric CO_2 enrichment on plant hormones, Teng *et al*. (2006)[1] grew well watered and fertilized thale cress (*Arabidopsis thaliana* (L.) Heynh.) plants from seed to commencement of bolting in pots within controlled-environment chambers maintained at atmospheric CO_2 concentrations of either 370 or 700 ppm, while measuring a large number of plant properties and processes. This work revealed, among other things, that the elevated CO_2 increased the biomass production of the plants by 29%, leaf total non-structural carbohydrates by 76%, and - with respect to plant hormones - that it "significantly increased the IAA [indole-3-acetic acid, by 13.7%], GA3 [gibberellic acid, by 55.4%], ZR [zeatin riboside, by 15.6%], DHZR [dihydrozeatin ribosidem, by 55.9%] and iPA [isopentenyladenosine, by 74.6%] contents of leaves, but significantly reduced the ABA [abscisic acid, by 15.2%] content."

Elevated CO_2 increased the concentrations of several plant hormones in leaf and aerial root tips of an epiphytic CAM orchid by as much as 21-fold.

With respect to the significance of these findings, the six Chinese researchers write that plant hormones "can enhance plant growth and development by stimulating cell division, cell elongation and protein synthesis (Yong *et al*., 2000), whereas ABA is considered an inhibitor of leaf growth (Zhang and Davies, 1990)." In addition, they note that "plant hormone metabolism is dependent on the supply of carbohydrates (Taiz and Zeiger, 1998)." Therefore, based on what they learned from their experiment, they concluded that "higher carbohydrate production," *such as that induced by atmospheric CO_2 enrichment*, "may result in higher hormone concentrations, which in turn may enhance plant growth," a phenomenon that has also been observed by Jitla *et al*. (1997) and Li *et al*. (2002), the latter of whom reported that elevated CO_2 increased the concentrations of several plant hormones in leaf and aerial root tips of an epiphytic CAM orchid by as much as 21-fold.

In another paper, Li *et al*. (2009)[2] grew six-year-old *Ginkgo biloba* tree saplings in pots containing fertile soil out-of-doors in open-top chambers maintained at either 350 or 700 ppm

[1] http://www.co2science.org/articles/V10/N3/B2.php.
[2] http://www.co2science.org/articles/V12/N44/B2.php.

CO_2 at the Shenyang Arboretum of the Chinese Academy of Science in Shenyang, Liaoning Province, China, from 1 June to 30 September. In addition to measuring the growth of the trees' terminal shoots over this period, they also measured leaf concentrations of the endogenous plant-growth regulator indole-3-acetic acid (IAA). Their results indicated that after 40 days of exposure to elevated CO_2, the IAA concentration in the plants' leaves was significantly increased compared to that of plants in the control treatment, and that maximum IAA enhancement was observed 100 days after exposure, when leaf concentrations of IAA were fully 90% greater in the CO_2-enriched treatment. Likewise, they state that the growth increment of ginkgo terminal shoots in the high CO_2 chambers was increased by 44% from 20 days to 90 days of exposure to the elevated CO_2 conditions.

Atmospheric CO_2 enrichment magnifies the early growth and developmental impacts of plant hormones, which impact is truly a positive thing for a world that continues to struggle to feed its burgeoning population.

Introducing their study of the subject, Jiang *et al.* (2012)[3] write that "brassinosteroids (BRs) are a family of over 40 naturally occurring plant steroid hormones that are ubiquitously distributed in the plant kingdom," citing Clouse and Sasse (1998), Bishop and Koncz (2002), Krishna (2003) and Montoya *et al*. (2005). And they go on to report that "BRs play prominent roles in various physiological processes including the induction of a broad spectrum of cellular responses, such as stem elongation, pollen tube growth, xylem differentiation, leaf epinasty, root inhibition, induction of ethylene biosynthesis, proton pump activation, regulation of gene expression and photosynthesis, and adaptive responses to environmental stress," citing Clouse and Sasse (1998), Dhaubhadel *et al*. (1999), Khripach *et al*. (2000), Krishna (2003) and Yu *et al*. (2004), while noting that "as potent plant growth regulators, BRs are now widely used to enhance plant growth and yield of important agricultural crops," citing Khripach *et al*. (2000) and Divi and Krishna (2009). Against this backdrop, the authors conducted an experiment to discern the effects of increased atmospheric CO_2 on such plant steroid hormones in young cucumber plants grown at atmospheric CO_2 concentrations of either 380 (ambient) or 760 (enriched) ppm, and with or without being sprayed with a solution of brassinosteroids (0.1 µM 24-epibrassinolide).

In doing so, the six scientists determined that their doubling of the air's CO_2 concentration resulted in a 44.1% increase in CO_2 assimilation rate; and they write that the BR treatment "also

[3] http://www.co2science.org/articles/V15/N6/B2.php.

significantly increased CO_2 assimilation under ambient atmospheric CO_2 conditions, and the increase was close to that by CO_2 enrichment." Most interesting of all, in this regard, they report that the *combined treatment* of "plants with BR application under CO_2-enriched conditions showed the highest CO_2 assimilation rate, which was increased by 77.2% relative to the control." Likewise, they found that "an elevation in the atmospheric CO_2 level from 380 to 760 ppm resulted in a 20.5% and 16.0% increase in leaf area and shoot biomass accumulation, respectively," while the plants that received the BR application "exhibited 22.6% and 20.6% increases in leaf area and shoot biomass accumulation, respectively." Most importantly of all, however, they report that, once again, the *combined treatment* of "CO_2 enrichment and BR application further improved the plant growth, resulting in 49.0% and 40.2% increases in leaf area and shoot biomass, relative to that of the control, respectively."

In light of the above findings, it appears that atmospheric CO_2 enrichment magnifies the early growth and developmental impacts of plant hormones, which impact is truly a positive thing for a world that continues to struggle to feed its burgeoning population.

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Cover photo of a Ginkgo biloba tree branch provided by Microsoft.