CO_2-INDUCED STARCH ACCUMULATION IN PLANTS

Will rising atmospheric CO_2 levels significantly boost starch production in plants?

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In reviewing the literature, it is clear that CO_2-induced starch accumulation is occurring in a variety of different plants. In a study by Janssens *et al*. (1998)[1], for example, a six-month period of atmospheric CO_2 exposure of 700 ppm caused a 90% increase in root starch accumulation in Scots pine seedlings relative to control seedlings that were exposed to ambient CO_2 concentrations of 350 ppm. Studying the same species, Kainulainen *et al*. (1998)[2] reported a significant enhancement in needle starch concentrations after three-years of atmospheric CO_2 enrichment to 300 ppm above ambient. Similar results have also been reported in tropical trees, where ten (Lovelock *et al*., 1998[3]) and four (Wurth *et al*., 1998[4]) species exhibited approximate doublings of their leaf starch contents in response to a doubling of the atmospheric CO_2 content. In other tree studies, Rey and Jarvis (1998)[5] also noted a 100% CO_2-induced increase in leaf starch contents of birch seedlings exposed to an atmospheric CO_2 concentration of 700 ppm, while Pan *et al*. (1998)[6] reported a whopping 17-fold increase in this parameter for apple seedlings grown at an atmospheric CO_2 concentration of 1600 ppm.

In another study, Liu *et al*. (2005)[7] found that the *combined* effects of elevated CO_2 and ozone (O_3) acting together produced a significant increase in leaf non-structural carbohydrates of 3- and 4-year-old European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) Karst) seedlings under both mixed and monoculture conditions, which result was similar to what was observed under CO_2 enrichment alone. Hence, they concluded that "since the responses to the combined exposure were more similar to elevated pCO_2 than to elevated pO_3, apparently elevated pCO_2 overruled the effects of elevated pO_3 on non-structural carbohydrates."

- ✓ *100% CO_2-induced increase in leaf starch contents of birch seedlings exposed to an atmospheric CO_2 concentration of 700 ppm.*
- ✓ *17-fold increase in this parameter for apple seedlings grown at an atmospheric CO_2 concentration of 1600 ppm.*

Also studying the combined effects of elevated carbon dioxide and ozone were Kostiainen *et al.*

1 http://www.co2science.org/articles/V2/N7/B2.php.
2 http://www.co2science.org/articles/V2/N10/B4.php.
3 http://www.co2science.org/articles/V2/N4/B2.php.
4 http://www.co2science.org/articles/V2/N4/B1.php.
5 http://www.co2science.org/articles/V1/N2/B2.php.
6 http://www.co2science.org/articles/V1/N2/B1.php.
7 http://www.co2science.org/articles/V8/N27/B2.php.

(2006)[8], who examined fast-growing silver birch (*Betula pendula* Roth) clones that were grown out-of-doors at Suonenjoki, Finland, in open-top chambers maintained at ambient and 1.9x ambient CO_2 concentrations in combination with ambient and 1.5x ambient O_3 concentrations. Among their various findings, the researchers reported that the elevated CO_2 treatment increased trunk starch concentration by 7%. Recognizing that "the concentration of nonstructural carbohydrates (starch and soluble sugars) in tree tissues is considered a measure of carbon shortage or surplus for growth (Korner, 2003)," the Finnish researchers stated that the "starch accumulation observed under elevated CO_2 in this study indicates a surplus of carbohydrates produced by enhanced photosynthesis of the same trees (Riikonen *et al*., 2004)." In addition, they report that "during winter, starch reserves in the stem are gradually transformed to soluble carbohydrates involved in freezing tolerance (Bertrand *et al*., 1999; Piispanen and Saranpaa, 2001), so the increase in starch concentration may improve acclimation in winter." Considering this response, it can be appreciated that the ongoing rise in the air's CO_2 content should be a boon to silver birch (and likely many other trees) in both summer and winter in both pristine and ozone-polluted air.

It is therefore likely that rising atmospheric CO_2 levels will significantly boost starch production in plants, thereby increasing the availability of an important raw material that can be metabolized to help sustain enhanced growth under a variety of stressful situations.

It should also be noted that elevated CO_2 concentrations increase starch concentrations within non-woody herbaceous plants. Reid *et al*. (1998)[9], for example, documented a 148% increase in soybean leaf starch contents, due to a doubling of the atmospheric CO_2 concentration, at both normal and elevated concentrations of ozone. And in another agricultural crop, exposure to 1000 ppm CO_2 caused a 10-fold increase in leaf starch concentrations of potato (Ludewig *et al*., 1998[10]).

It is therefore likely that rising atmospheric CO_2 levels will significantly boost starch production in plants, thereby increasing the availability of an important raw material that can be metabolized to help sustain enhanced growth under a variety of stressful situations.

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[10] http://www.co2science.org/articles/V2/N4/B3.php.

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Cover photo of new leaves on tree branch provided by iStockphoto.