Transport of dissolved CO_2 in xylem sap and subsequent assimilation in *Populus* trees in the field

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Background/Question/Methods

Photosynthesizing plants assimilate CO_2 from the atmosphere through stomata and return it to the atmosphere from all tissues by respiration. However, in trees, respired CO_2 builds up in woody tissues to concentrations many times higher than in the atmosphere. Internal CO_2 occurs in both gaseous and aqueous forms and some dissolved CO_2 moves upward in the transpiration stream, suggesting that CO_2 respired by roots and stem could be used as a substrate for fixation by green tissues higher in the tree. Previous investigations have demonstrated this mechanism, but only in detached leaves or branches. In this study, we introduced ^{13}C-labeled water into the transpiration stream near the base of four *Populus deltoides* trees to simulate root-respired CO_2 entering the stem. Labeled water was fed continuously to the xylem for two days; two additional days were allowed for the label to reach the top of the canopy. Trees were felled and separated into stem, branch, and leaf tissues. Tissue samples were immediately frozen for subsequent dissection and ^{13}C analysis. We hypothesized that the label would reach the leaves where it could be recycled photosynthetically; it might also be assimilated in other tissues along the transport pathway.

Results/Conclusions

The ^{13}C label was detected in branches and leaf parts throughout the trees. Preliminary analysis showed that average $\delta^{13}C$ of xylem tissue of branches was slightly enriched (-26.3). Inner bark was more enriched than xylem (-24.5). In these trees, branch xylem and inner bark had substantial green tissue and presumably could photosynthesize. Leaf petioles were the most highly enriched of any tissue (-23.3), with leaf primary veins only slightly enriched (-26.8). Leaf secondary veins were not significantly enriched (-27.8). The label was not detected in leaf mesophyll (-28.5) and whole leaf samples were not significantly different from mesophyll (-28.0). These results indicate that CO_2 can be transported from the base of the stem to the top of a tall tree (here more than 10 m) and can be “scrubbed” from the transpiration stream as it ascends. Dissolved $^{13}CO_2$ that reached the leaves was removed from the stream by petioles and primary veins and must have been substantially depleted before it reached the mesophyll. Although the quantity of respired CO_2 that is recycled internally is likely small compared to that assimilated from the atmosphere by leaves, it may be an important component of tree carbon balance during times of stress when leaf photosynthesis is limited.

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