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RESEARCH PAPER

Phloem sap and leaf δ^{13}C, carbohydrates, and amino acid concentrations in *Eucalyptus globulus* change systematically according to flooding and water deficit treatment

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Abstract

Phloem is a central conduit for the distribution of photoassimilate, nutrients, and signals among plant organs. A revised technique was used to collect phloem sap from small woody plants in order to assess changes in composition induced by water deficit and flooding. Bled phloem sap δ^{13}C and sugar concentrations were compared to δ^{13}C of bulk material, soluble carbon extracts, and the neutral sugar fraction from leaves. Amino acid composition and inorganic ions of the phloem sap was also analysed. Quantitative, systematic changes were detected in phloem sap composition and δ^{13}C in response to altered water availability. Phloem sap δ^{13}C was more sensitive to changes of water availability than the δ^{13}C of bulk leaf, the soluble carbon fraction, and the neutral soluble fraction of leaves. Changes in water availability also resulted in significant changes in phloem sugar (sucrose and raffinose), inorganic nutrient (potassium), and amino acid (phenylalanine) concentrations with important implications for the maintenance of phloem function and biomass partitioning. The differences in carbohydrate and amino acid composition as well as the δ^{13}C in the phloem, along with a new model system for phloem research, offer an improved understanding of the phloem-mediated signal, nutrient, and photoassimilate transduction in relation to water availability.

Key words: Amino acids, *Eucalyptus*, flooding, phloem sap, raffinose, sucrose, water deficit.

Introduction

Phloem is the major conduit for the transport of solutes and signalling among tissues of higher plants. The composition of phloem sap therefore offers considerable promise for use in diagnostic assessments of plant health. The development of such assessments is limited by our ability to sample phloem easily, with the characterization of phloem contents limited to a handful of studies of mainly herbaceous species (a for a review see Turgeon and Wolf, 2009).

Recently, several authors have begun investigating the nature and composition of phloem sap in tree species (Gessler *et al.*, 2004, 2007; Scartazza *et al.*, 2004; Tausz *et al.*, 2008) using a phloem collection technique originally developed by Hartig (1860) and further developed for *E. globulus* by Pate *et al.* (1974, 1984). Using a razor blade, a small incision is made in the stem to the depth of the cambium and phloem 'bleeds' from the surface of the cut. This method has considerable advantages over more traditional techniques of phloem sap collection (highlighted by Turgeon, 2006) in that it is fast and it avoids the need for chelating reagents and extraction procedures, thus reducing contamination from companion cell contents (for review see Turgeon and Wolf, 2009).