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ORIGINAL ARTICLE

Diagnostic tools for nutrition status in *Eucalyptus globulus*: changes in leaves, xylem and phloem sap compounds according to N-, P-, and K-withdrawal or salt application

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Abstract

Key message **The results presented here demonstrate the capacity for phloem sap as a diagnostic tool for monitoring the nutritional status of plants and highlight the processes of remobilisation and source–sink dynamics.**

Abstract It is essential to develop methods that accurately reflect plant nutritional status for growth. In a greenhouse experiment with potted eucalyptus, we studied the effects of withdrawing single macronutrients N, P, or K, or salt application on the abundance of components in phloem, xylem and leaves to identify and refine methods to rapidly and effectively assess the nutrient status of *Eucalyptus globulus* trees. Clear effects on growth (and photosynthesis) were found for "−N" treatment and NaCl application. Effects of nutrient withdrawal were detected indicating our methodologies are useful for nutrient availabilities below the threshold of growth responses. While "−P" resulted in significantly lower P in xylem sap, the corresponding effect for "−K" on K in xylem sap was not found, although Ca and Na increased. Salt application increased Na in xylem sap sixfold. In leaf material "−N" reduced N. Surprisingly, "+NaCl", "−P" and "−K" did not change the corresponding elements in leaves. Additionally, "−P"-treatment had the tendency to affect C-, N-, K- and particularly P-increment (n.s.). In phloem sap, "+NaCl" resulted in several effects, most prominently doubling Na concentration. Importantly, "−N" increased amino acids in phloem sap (n.s.). Statistically significant relationships between concentrations in leaves and phloem sap were found for $\delta^{13}C$ and amino acids. Within the results obtained from phloem sap, sugars and bivalent cations (Ca and Mg) are correlated with that obtained from the leaves as well as Na and P. The role and comparative advantages of phloem sap as a diagnostic tool for nutritional status are discussed.

Keywords Tasmanian blue gum (*Eucalyptus globulus*) · Nutrition · Salt stress · Leaves · Xylem · Phloem

Abbreviations

"−N"	N-withdrawal
"−P"	P-withdrawal
"−K"	K-withdrawal
"+NaCl"	Salt application

Introduction

Developing efficient tools for the rapid and reliable assessment of plant nutritional status is beneficial for both monitoring plant health and to provide diagnostic information to inform management of nutrient supplements. The availability of water, light and mineral nutrients is essential for plant biomass production as CO_2 is sequestered into photoassimilates to the extent that nutrients, temperature or water availability permits (Körner 2015). Thus, understanding plant nutrient status is a vital component of managing plant nutrition.

Nutritional supplements (fertiliser) are used to correct for nutrient deficiencies, primarily consisting of N, P and

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