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Research paper

Short-term effects of potassium fertilization on the hydraulic conductance of *Laurus nobilis* L.

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This study reports experimental evidence on the effect of short-term potassium fertilization on potassium uptake, tissue concentration and hydraulic conductance of pot-grown laurel plants. Potassium uptake and loading into the xylem of laurel seedlings increased within 24 h after fertilization. Potassium was not accumulated in roots and leaves, but the [K^+] of xylem sap was 80% higher in fertilized plants (+K) than in potassium-starved plants (−K), as a likely result of recirculation between xylem and phloem. Increased xylem sap [K^+] resulted in a 45% increase in transpiration rate, a 30% increase in plant hydraulic conductance (K_{plant}) and a 120% increase in leaf-specific conductivity of the shoot (k_{shoot}). We suggest that this increase was due to ion-mediated up-regulation of xylem hydraulics, possibly caused by the interaction of potassium ions with the pectic matrix of intervessel pits. The enhancement of hydraulic conductance following short-term potassium fertilization is a phenomenon that can be of advantage to plants for maintaining cell turgor, stomatal aperture and gas exchange rates under moderate drought stress. Our data provide additional support for the important role of potassium nutrition in agriculture and forestry.

Keywords: hydraulic conductance, ionic effect, mineral nutrition, potassium, xylem sap.

Introduction

Long-distance water transport in plants occurs through the xylem, both axially within tracheids and vessels and radially through pits in the walls of adjacent conduits. For many years the major constraints to xylem hydraulics were attributed to anatomical features, like the number, length and diameter of conduits. More recently, it has been shown that the hydraulic conductance of xylem can be modulated by changes in the xylem sap cation concentration due to ion-mediated volume changes of pectins in pit membranes (Zimmermann 1978, Zwieniecki et al. 2001). Pectins form charged gels and behave like typical polyelectrolytes, swelling under dilute solutions and shrinking when cations (like potassium, K^+) shield the negatively charged carboxylic groups. These volume changes are supposed to reversibly modify the dimensions of nanometre-sized pores in pit membranes, thus modulating the resistance to water flow through the pits and, hence, through the whole xylem network. In fact, intervessel pits build up a large fraction (up to 50%) of xylem hydraulic resistance (Wheeler et al. 2005).

This phenomenon, known as the 'ionic effect', has been repeatedly reported in excised stems under laboratory conditions (e.g., Zwieniecki et al. 2001, Boyce et al. 2004, Nardini et al. 2007, Aasamaa and Sõber 2010, Cochard et al. 2010), and recent experimental evidence suggests that it plays important functional roles in planta (Zwieniecki et al. 2004, Trifilò et al. 2008, Nardini et al. 2010, Sellin et al. 2010). Conclusive evidence about the underlying mechanisms and the general occurrence of the ionic effect are still missing (Cochard et al. 2010), and the possibility that results obtained in excised segments are due to experimental artefacts has also been hypothesized (Van Ieperen 2007). However, recent experimental