Changes in the xylem sap metabolome of tomato and lupin with Fe deficiency

Rubén Rellán-Álvarez[a], Anunciación Abadía[a], Oliver Fiehn[b], Javier Abadía[a], Ana Álvarez-Fernández[a]

[a]*Department of Plant Nutrition, Estación Experimental de Aula Dei (CSIC), PO Box 202, E-50080 Zaragoza, Spain,*
[b]*Genome Center, University of California, Davis, CA 95616, USA*

Abstract

Plant xylem sap contains mainly water and minerals, but also has low concentrations of a wide array of organic compounds, including amino acids, organic acids, hormones, polyamines and proteins. Changes in xylem sap composition caused by abiotic stresses such as Fe deficiency are important for plant growth and development, and for instance it is well known that signals travelling via xylem from roots to shoots modulate plant growth and transpiration [1]. In previous studies dealing with changes in xylem sap composition in response to Fe deficiency, only a small number of compounds have been determined simultaneously [2, 3]. In this study, an untargeted metabolomic analysis was carried out to quantify the changes in xylem sap constituents under Fe deficiency and Fe resupply. Xylem samples were obtained by detopping Fe-sufficient (grown with 45 μM Fe(III)-EDTA), Fe-deficient (grown with 0 μM Fe) tomato (*Lycopersicum esculentum* Mill.) and lupin (*Lupinus albus* L.) plants. Also, xylem was obtained from Fe-resupplied tomato plants (6, 12, 18 and 24 hours after Fe resupply with 45 μM Fe(III)-EDTA). Metabolites in xylem sap were analyzed by gas chromatography coupled to mass spectrometry (GC-MS), following the recommendations described by the Metabolomics Standards Initiative [4]. More than 200 compounds were found in the xylem of both species, and approximately 80 of them were identified using the Fiehn Library (http://fiehnlab.ucdavis.edu/Metabolite-Library-2007). The relative concentrations of 48 and 41 identified metabolites changed with Fe deficiency in tomato and lupin, respectively, with 24 being common in the two species (including several carboxylates, amino acids, and ribose). Major changes were found in tomato, with the highest –Fe/Fe ratio found for alpha-ketoglutaric acid (91.1), suberyl glycine (7.1), triptophan (6.4), malic acid (6.2), citric acid (5.7) and 2-hydroxyglutaric acid (4.6). In lupinus changes were less pronounced, with the highest –Fe/Fe ratios being for aconitic and maleic acids (2.6 and 2.5, respectively). Iron resupply to Fe-deficient tomato plants led to further changes, including major increases in organic acids in the first hours after Fe resupply. Twenty-four hours after Fe resupply, many of the compounds which showed changes in the –Fe/+Fe ratios approached values found in the Fe-sufficient controls.

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[2] López-Millán *et al.* (2000) *Plant Physiol.* **124:** 873
[3] Larbi *et al.* (2003) *J. Plant Physiol.* **160:** 1473 (doi: 10.1078/0176-1617-01010)
[4] Fiehn *et al.* (2008) *Plant J.* **53:** 691. (doi:10.1111/j.1365-313X.2007.03387.x)

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