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REVIEW PAPER

Correlations in concentrations, xylem and phloem flows, and partitioning of elements and ions in intact plants. A summary and statistical re-evaluation of modelling experiments in *Ricinus communis*

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Abstract

Within the last two decades, a series of papers have dealt with the effects of nutrition and nutrient deficiency, as well as salt stress, on the long-distance transport and partitioning of nutrients in castor bean. Flows in xylem and phloem were modelled according to an empirically-based modelling technique that permits additional quantification of the uptake and incorporation into plant organs. In the present paper these data were statistically re-evaluated, and new correlations are presented. Numerous relationships between different compartments and transport processes for single elements, but also between elements, were detected. These correlations revealed different selectivities for ions in bulk net transport. Generally, increasing chemical concentration gradients for mineral nutrients from the rhizosphere to the root and from the xylem to leaf tissue were observed, while such gradients decreased from root tissue to the xylem and from leaves to the phloem. These studies showed that, for the partitioning of nutrients within a plant, the correlated interactions of uptake, xylem and phloem flow, as well as loading and unloading of solutes from transport systems, are of central importance. For essential nutrients, tight correlations between uptake, xylem and phloem flow, and the resulting partitioning of elements, were observed, which allows the stating of general models. For non-essential ions like Na^+ or Cl^-, a statistically significant dependence of xylem transport on uptake was not detected. The central role of the phloem for adjusting, but also signalling, of nutrition status is discussed, since strong correlations between leaf nutrient concentrations and those in phloem saps were observed. In addition, negative correlations between phloem sap sugar concentration and net-photosynthesis, growth, and uptake of nutrients were demonstrated. The question remains whether this is only a consequence of an insufficient use of carbohydrates in plants or a ubiquitous signal for stress in plants. In general, high sugar concentrations in phloem saps indicate (nutritional) stress, and high nutrient concentrations in phloem saps indicate nutritional sufficiency of leaf tissues.

Key words: Castor bean, flow model, long distance transport, nutrient deficiency, nutrients, phloem transport, signalling, uptake, xylem transport.

Introduction

On land, Higher Plants face the problem of having photosynthesis, i.e. the site for the capturing of light energy and CO_2, displaced from the site where water and mineral nutrients are taken up. Therefore, one of the chief requirements for land plants is the presence of long-distance transport systems. In cormophytes, these demands are fulfilled by the actions of phloem and xylem. The xylem transports water, mineral nutrients, metabolic products, and signals from the root to the shoot. By contrast, the phloem transports assimilation products from photosynthetically active or remobilizing 'source' tissues, to growing areas within the shoot and the root, the so-called 'sinks', via