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The uptake and flow of C, N and ions between roots and shoots in *Ricinus communis* L.
IV. Flow and metabolism of inorganic nitrogen and malate depending on nitrogen nutrition and salt treatment

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Abstract

***Ricinus* plants were supplied with nutrient solutions containing different N-sources or different nitrate concentrations and were also exposed to mild salinity. Between 41 and 51 d after sowing, the ratio of inorganic to total nitrogen in xylem and phloem saps, the content of inorganic nitrogen and malate in tissues, and nitrate reductase activities were determined. The flows of nitrate, ammonium, and malate between root and shoot were modelled to identify the site(s) of inorganic nitrogen assimilation and to show the possible role of malate in a pH-stat mechanism. Only in the xylem of nitrate-fed plants did inorganic nitrogen, in the form of nitrate, play a role as the transport solute. The nitrate percentage of total nitrogen in the xylem sap generally increased in parallel with the external nitrate concentration. The contribution of the shoot to nitrate reduction increased with higher nitrate supply. Under salt treatment relatively more nitrate was reduced in the root as compared with non-treated plants. Ammonium was almost totally assimilated in the root, with only a minor recycling via the phloem. Nitrate reductase activities measured *in vitro* roughly matched, or were somewhat lower than, calculated rates of nitrate reduction. From the rates of nitrate reduction (OH^--production) and rates of malate synthesis ($2H^+$-production) it was calculated that malate accumulation contributed 76, 45, or 39% to the pH-stat system during nitrate reduction in plants fed with 0.2, 1.0 or 4.0 mM nitrate, malate flow in the phloem played no role. In tissues of ammonium-fed plants no malate accumulation was found and malate flows in xylem and phloem were also relative low.**

Key words: Ammonium, *Ricinus communis*, phloem, xylem, transport, nitrate, nitrate reductase, nitrogen assimilation, malate.

Introduction

The contribution of roots and shoots to assimilation of inorganic nitrogen in higher plants may vary considerably, depending on species and nutritional conditions (Andrews, 1986). The site of nitrogen assimilation is likely to affect strongly phloem translocation of photosynthates for delivery of carbon skeletons for amino acid synthesis. When inorganic nitrogen is assimilated in the roots, an adequate supply of carbohydrates must be provided for organic nitrogen to be transported to the shoot via the xylem. The form of N is also of importance for charge balance in transport fluids and in tissues (Raven and Smith, 1976). With nitrate as the N-source, nitrate is the major inorganic anion in the xylem of *Ricinus* (Peuke and Jeschke, 1995) and this requires cotransport of cations. In addition to its functions as N-source and negative charge, nitrate may also represent an important intracellular osmoticum as pointed out by Smirnoff and Stewart (1985). If the root is the major site of N-assimilation more organic nitrogen than nitrate will be transported in the xylem. The last can be the case if

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Abbreviations: *NRA* nitrate reductase activity, NR nitrate reduction, FW fresh weight.