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The uptake and flow of C, N and ions between roots and shoots in *Ricinus communis* L. II. Grown with low or high nitrate supply

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Abstract

Seedlings of *Ricinus communis* L. cultivated in quartz sand were supplied with a nutrient solution containing either 0.2 mol m^{-3} NO_3^- or 4.0 mol m^{-3} NO_3^- as the nitrogen source to obtain insufficiently (low supply, nitrogen-limited) or well-fed plants (high supply, control). During the period between 41 and 51 d after sowing, the flows of C, N and inorganic ions between root and shoot were modelled on the basis of empirical observation and expressed on a fresh weight basis. With a low nitrate supply the biomass production was decreased while the root/shoot ratio was drastically increased and the water content in the shoot was slightly reduced. Nitrogen was transported in the xylem mainly in the form of nitrate in both treatments. However, in nitrate-limited plants the ratio of nitrate to total nitrogen was lower, indicating a higher fraction of whole-plant nitrate reduction occurring in the root. The spectrum of amino acids in phloem sap was changed due to N-limitation. Nitrate and cation uptake, as well as photosynthesis was strongly decreased in nitrate-limited plants. The partitioning of C, N and ions was shifted in favour of the root compared to well-fed plants. Transport of C, N, and cations in the xylem was decreased. Flows of ions and elements in the phloem were increased relative to uptake and xylem transport. In contrast, the chloride flows were nearly the same in low- and well-fed plants, pointing to a role of chloride as a compensating ion for nitrate.

Key words: N-deficiency, *Ricinus communis*, transport, xylem, phloem, nitrogen, carbon, cations, chloride.

Introduction

The level of nitrogen supply is one of the major factors which can determine the growth of plants. In natural habitats the concentration of nitrate in the soil solution is around 1 mol m^{-3} or lower and can rise in agriculturally influenced regions up to 20 mol m^{-3} and more (Andrews, 1986). However, nitrate is not only a nitrogen source. In higher plants environmental nitrate affects several processes including the induction of a high affinity nitrate transport system, changes in root morphology and increased root respiration (Redinbaugh and Campbell, 1991). Intracellularly nitrate may act as an important osmoticum (Smirnoff and Stewart, 1985) together with malate which is generated to prevent intracellular alkalization during nitrate assimilation. The internal nitrogen percentage vary only slightly (2–5% on a dry weight basis; Marschner, 1986) in well-grown plants. Limited nitrogen supply causes reduced growth and morphological changes (Clarkson and Hanson, 1980; Marschner, 1986).

The level of nitrogen supply also affects the translocation, allocation and distribution of assimilates and nutrients in the whole plant. In *Triticum aestivum*, growth and the translocation of C and N was influenced by different levels of nitrate (Lambers *et al.*, 1982). Fetene *et al.* (1993) followed the distribution of labelled assimilates after a $^{14}CO_2$-pulse in *Urtica dioica* fed with three levels of nitrate. Duarte and Larsson (1993) induced two distinct relative growth rates in *Pisum sativum* by applying different relative nitrate addition rates, which influenced the translocation of nutrients, including nitrogen. The level of nitrate also changed the partitioning of nitrate reduction between shoot and root in *Prunus persica* (Gojon *et al.*, 1991) and in *Nicotiana tabacum* (Rufty *et al.*, 1990).

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