Journal of Experimental Botany, Vol. 48, No. 306, pp. 75–91, January 1997

Journal of Experimental Botany

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Effects of P deficiency on assimilation and transport of nitrate and phosphate in intact plants of castor bean (*Ricinus communis* L.)

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Received 10 April 1996; Accepted 14 August 1996

Abstract

An experimentally-based modelling technique was applied to describe quantitatively the uptake, translocation, storage, and assimilation of NO_3^- and $H_2PO_4^-$ over a 9 d period in mid-vegetative growth of sand-cultured castor bean (*Ricinus communis* L.) which was fed 12 mM NO_3^- and either 0.5 or a severely limiting 0.005 mM $H_2PO_4^-$. Model calculations were based on increments or losses of NO_3^- and reduced N or of $H_2PO_4^-$ and organic P in plant parts over the study period, on the concentrations of the above compounds in xylem and phloem sap, and on the previously determined flows of C and N in the same plants (Jeschke *et al.*, 1996).

Modelling allowed quantitative assessments of distribution of NO_3^- reduction and $H_2PO_4^-$ assimilation within the plant. In control plants 58% of total NO_3^- reduction occurred in leaf laminae, 40% in the root and 2% in stem and apical tissues. Averaged over all leaves more than half of the amino acids synthesized in laminae were exported via phloem, while the root provided 2.5-fold more amino acids than required for root growth. P deficiency led to severe inhibition of NO_3^- uptake and transport in xylem and even greater depression of NO_3^- reduction in the root but not in the shoot. Accentuated downward phloem translocation of amino acids favoured root growth and some cycling of N back to the shoot.

In control plants $H_2PO_4^-$ was the principal form of P transported in xylem with young laminae acting as major sinks. At the stem base retranslocation of P in the phloem amounted to 30% of xylem transport. $H_2PO_4^-$ assimilation was more evenly distributed than NO_3^- reduction with 54% occurring in leaf laminae, 6% in the apical bud, 19% in stem tissues, 20% in the root; young tissues were more active than mature ones. In P-deficient plants $H_2PO_4^-$ uptake was severely decreased to 1.8% of the control. Young laminae were the major sink for $H_2PO_4^-$. Considerable remobilization of P from older leaves led to substantial shoot to root translocation via phloem (50% of xylem transport). Young leaf laminae were major sites of $H_2PO_4^-$ assimilation (50%), followed by roots (26%) and the apical bud (10%). The remaining $H_2PO_4^-$ was assimilated in stem and mature leaf tissues. Old leaves exhibited 'negative' net assimilation of $H_2PO_4^-$, i.e. hydrolysis of organic P exceeded phosphorylation. In young laminae of low P plants, however, rates of $H_2PO_4^-$ assimilation per unit fresh weight were comparable to those of the controls.

Key words: *Ricinus communis* L., nitrate, nitrate reduction, phosphate, phosphate assimilation, partitioning, xylem, phloem, transport, P deficiency.

Introduction

In a previous paper using the modelling techniques of Pate *et al.* (1979*a*) and Jeschke and Pate (1991*a*) the

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Abbreviations: Since dissociation of phosphate varies with pH, the term PO_4 was used. Only when addressing phosphate as an anion or in the Figures was $H_2PO_4^-$ used.