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Foliar application of nitrate or ammonium as sole nitrogen supply in *Ricinus communis*

II. The flows of cations, chloride and abscisic acid

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SUMMARY

Following a precultivation with pedospheric nitrogen nutrition, *Ricinus* plants were supplied with nitrogen solely by spraying nitrate or ammonium solution onto the leaves during the experimental period. The chemical composition of tissues, xylem and phloem exudates was determined and on the basis of the previously determined nitrogen flows (Peuke *et al.*, *New Phytologist* (1998), **138**, 657–687) the flows of potassium, sodium, magnesium, calcium, chloride and ABA were modelled. These data, which permit quantification of net-uptake, transport in xylem and phloem, and utilization in shoot and root, were compared with results obtained in plants with pedospherically-supplied nitrate or ammonium and data in the literature. Although the overall effects on the chemical composition of supplying ammonium to the leaves were not as pronounced as in pedospherically supplied plants, there were some typical responses of plants fed with ammonium (ammonium syndrome). In particular, in ammonium-sprayed plants uptake and transport of magnesium decreased and chloride uptake was increased compared with nitrate-sprayed plants. Furthermore, acropetal ABA transport in the xylem in ammonium-sprayed *Ricinus* was threefold higher than in nitrate-sprayed plants. Additionally, concentrations of anions were more or less increased in tissues, particularly in the roots, and transport fluids. The overall signal from ammonium-sprayed leaves without a direct effect of ammonium ions on uptake and transport systems in the root is discussed.

Key words: *Ricinus communis* L., foliar N application, cations, anions, ABA, phloem transport, xylem transport.

INTRODUCTION

Nitrogen is the most important mineral nutrient for plants. On a dry matter basis the principal elements in higher plants are carbon, hydrogen, oxygen, nitrogen, potassium, sulphur and phosphorus. In autotrophic higher plants carbon is taken up from the atmosphere, whilst mineral nutrients are usually taken up by the roots. Shoot organs, however, can take up mineral nutrients as well (Raven, 1988; Pearson & Stewart, 1993; Marschner, 1995). In contrast to the above-mentioned elements, nitrogen, which is taken up at the greatest rates of all minerals, is available for plants as either the anion nitrate or the cation ammonium. The use of nitrate or ammonium as an N-source may have fundamental consequences for the growth, development and metabolism of the plants (Haynes & Goh, 1978; Runge, 1983; Pearson & Stewart, 1993; Marschner, 1995). One such consequence is the charge balance in the plants. If ammonium is taken up there is a deficiency in negative charge. Van Beusichem, Kirkby & Baas (1988) calculated an excess of cation over anion uptake in ammonium-fed *Ricinus* and the opposite effect under nitrate supply. Indeed, when ammonium was taken up, lower concentrations of cations but higher concentrations of anions were found in tissues (Allen & Smith, 1986; Arnozis & Findenegg, 1986; van Beusichem *et al.*, 1988; Pearson & Stewart, 1993; Lang & Kaiser, 1994).

A direct effect of ammonium on cation uptake systems has been assumed (Haynes & Goh, 1978; Lee & Ayling, 1993). Of particular interest are interactions between ammonium and potassium uptake (Scherer, MacKown & Leggett, 1984; Wang, Siddiqi & Glass, 1996; Smart & Bloom, 1998) and between ammonium and nitrate uptake (Lee & Drew, 1989; Jackson & Volk, 1995; Smart & Bloom, 1998). Furthermore, as a result of different ion uptake, the nitrogen source also has a profound influence on the composition of the transport fluids

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