Journal of Experimental Botany, Vol. 50, No. 337, pp. 1365–1372, August 1999

Journal of Experimental Botany

The characterization of inhibition of net nitrate uptake by salt in salt-tolerant barley (*Hordeum vulgare* L. cv. California Mariout)

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Received 3 November 1998; Accepted 21 April 1999

Abstract

Barley seedlings (*Hordeum vulgare* L. cv. California Mariout) grown hydroponically for 14–19 d without addition of NaCl were used for describing the effects of salt application on net nitrate uptake and for the calculation of kinetic parameters. The addition of NaCl, KCl, $CaCl_2$, and Na_2SO_4 to the uptake solution in the experiments led to similar inhibition of nitrate uptake, only at low and very high salt concentrations were ion-specific effects found. The same decrease in nitrate uptake can also be achieved by sorbitol or betaine at corresponding osmolalities. Thus, it was concluded that the inhibition of uptake was caused mainly by the osmotic effects of salts. Differences in the mechanisms of inhibition were detected between the two systems of nitrate uptake (high affinity system: HATS, and low affinity system: LATS). The HATS was inhibited non-competitively by NaCl, an apparent K_i of 60 mol m^{-3} was calculated using a Dixon-plot. Fitting an equation assuming a non-competitively inhibited HATS by computer program to the raw data resulted in an apparent K_i of about 37 mol m^{-3}. In contrast, the LATS was affected in a complex way: up to 60 mol m^{-3} NaCl the affinity was increased, which led to a stimulation of nitrate uptake at low nitrate concentrations (<2 mol m^{-3}). An inhibition of the LATS became obvious at concentrations above 3 mol m^{-3} nitrate (for all applied salt concentrations) or with 100 mol m^{-3} NaCl (throughout the whole nitrate range). Related plots of the data pointed to a competitive effect.

Key words: Barley, *Hordeum vulgare* L., net nitrate uptake, high affinity transport system (HATS), low affinity transport system (LATS), salt, inhibition, apparent kinetic parameters.

Introduction

The growth and physiological reactions of higher plants are affected by salinity in many ways. One effect is that in a salinized rhizosphere the uptake of mineral nutrients is inhibited, including uptake of nitrogen which is quantitatively the most important mineral for plants.

The rate of nitrate uptake was shown to be lowered by both NaCl and Na_2SO_4, but nitrate reduction was affected less in barley (Aslam *et al.*, 1984). The inhibitory effect of salinity was diminished by adding calcium to the solution (Ward *et al.*, 1986). The different effects of osmotic stress caused by NaCl or polyethylene glycol on nitrate metabolism in ryegrass has been investigated (Ourry *et al.*, 1992). The kinetics of nitrate uptake in non-salinized and salinized wheat seedlings have been compared (Hawkins and Lewis, 1993; Botella *et al.*, 1994). In these papers, however, nitrate uptake was treated as a single mechanism over a wide range of nitrate concentration (up to 10 or 1 mol m^{-3} nitrate, respectively). However, the uptake of nitrate into the roots of plants is mediated by at least a biphasic system (Rao and Rains, 1976; Doddema and Telkamp, 1979; Siddiqi *et al.*, 1990; Aslam *et al.*, 1992; Peuke and Jeschke, 1998; for a review see Peuke and Kaiser, 1996). In the low nitrate concentration range one system with a high affinity following Michaelis–Menten characteristics operates. With increasing external nitrate concentrations a second system contributes to uptake, but the nature of this system is

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Abbreviations: HATS, high affinity transport system; LATS, low affinity transport system; K_i, inhibitor constant; V_{max}, maximal activity; K_m, Michaelis-Menten constant; FW_R, fresh weight of the root.