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CO_2 High Partial Pressure in the Rhizosphere Affect Mineral Nutrition of Plants: an Approach to the Mechanisms Involved

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Summary

A high CO_2 partial pressure (pCO_2) is known to strongly affect mineral nutrition of plants. Interaction of high pCO_2 with ion mobilization and migration processes are somewhat more documented (1) than the interaction of high pCO_2 with ion absorption mechanisms, with which we deal here. The plasma membrane of cortical root cells is fitted with an ATP-driven H^+ pump which transports H^+ ions out of the cytoplasm, into the cell wall. H^+ excretion results in a gradient of H^+ electrochemical potential through the plasma membrane and this is used by other transport systems as a shared energy source (chemiosmotic theory). Furthermore, operation of the H^+ pump may shift the membrance surface pH towards a value lower than the pH in the bulk medium, probably because cell walls limit rate of H^+ diffusion towards the medium. This surface pH shift may be estimated by using acetic acid influx as a pH probe (2). The local pH shift increases the H^+ electrochemical gradient and is involved in the energetic coupling of ion uptake (3). At constant bulk pH, the surface pH shift no longer occurs when the buffering power of the absorption solution is high enough, probably because the buffer (e.g. Hepes-Tris) accelerates the diffusion of H^+-equivalents towards the medium. Such an effect was expected for the buffering system CO_2/HCO_3^-. We studied this hypothesis in conditions allowing the independant control of both the pH of absorption solution and the pCO_2 in the air bubbled through the solution. Increasing pCO_2 inhibited acetic acid and phosphate absorption, nitrate accumulation, and stimulated potassium absorption. These effects were similar to those induced by Hepes-Tris and may be ascribed to the observed attenuation of the surface pH shift (4). In summary, the acidification of the cell surface by the H^+ pump improves the

efficiency of the H^+-cotransports by favouring local H^+ cycling, and high pCO_2 impedes this cycling by enhancing the transport of the excreted H^+ in the medium. Starting from this work, interactions between high pCO_2 and root mineral nutrition may be addressed to at the membrane transport level with the help of a mechanistic model.

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