Journal of Plant Nutrition and Soil Science 2015 vol.178 N2, pages 278-287

Oxygen and redox potential gradients in the rhizosphere of alfalfa grown on a loamy soil

Uteau D., Hafner S., Pagenkemper S., Peth S., Wiesenberg G., Kuzyakov Y., Horn R.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2015 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. Oxygen (O2) supply and the related redox potential (EH) are important parameters for interactions between roots and microorganisms in the rhizosphere. Rhizosphere extension in terms of the spatial distribution of O2 concentration and EH is poorly documented under aerobic soil conditions. We investigated how far O2 consumption of roots and microorganisms in the rhizosphere is replenished by O2 diffusion as a function of water/air-filled porosity. Oxygen concentration and EH in the rhizosphere were monitored at a mm-scale by means of electroreductive Clark-type sensors and miniaturized EH electrodes under various matric potential ranges. Respiratory activity of roots and microorganisms was calculated from O2 profiles and diffusion coefficients. pH profiles were determined in thin soil layers sliced near the root surface. Gradients of O2 concentration and the extent of anoxic zones depended on the respiratory activity near the root surface. Matric potential, reflecting air-filled porosity, was found to be the most important factor affecting O2 transport in the rhizosphere. Under water-saturated conditions and near field capacity up to -200 hPa, O2 transport was limited, causing a decline in oxygen partial pressures (pO2) to values between 0 and 3 kPa at the root surface. Aerobic respiration increased by a factor of 100 when comparing the saturated with the driest status. At an air-filled porosity of 9% to 12%, diffusion of O2 increased considerably. This was confirmed by EH around 300 mV under aerated conditions, while EH decreased to 100 mV on the root surface under near water-saturated conditions. Gradients of pO2 and pH from the root surface indicated an extent of the rhizosphere effect of 10-20 mm. In contrast, EH gradients were observed from 0 to 2 mm from the root surface. We conclude that the rhizosphere extent differs for various parameters (pH, Eh, pO2) and is strongly dependent on soil moisture. Copyright

http://dx.doi.org/10.1002/jpln.201300624

Keywords

Air-filled porosity, Hotspots, Oxygen diffusion, Rhizosphere, Soil aeration