Changes in concentrations of oxygen, carbon dioxide and ethylene in soil solutions during waterlogging of some West Australian soils

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The 10,000 fold slower diffusion of gases im solutions than in air is a major factor contributing to the adverse effects of waterlogging on plants (1). Oxygen is considered to be the most important *gas* limiting plant growth during waterlogging (1), however other gases like C O_2 and ethylene may also be important. There are often much greater reductions im growth of plants in waterlogged soil than in deoxygenated (N2 bubbled) nutrient solution culture, though nutrient solution culture is often essential to use in physiological experiments. There are two major problems with using plants in deoxygenated nutrient solution to simulate plants in waterlogged soil. Firstly low O_2 is usually imposed instantaneously, which is unlikely in the field. This means that in nutrient solution culture experiments there is no time for plant adaptatioms to waterlogging, e.g. synthesis of enzymes for alcoholic fermentation. Secondly, bubbling solutions with N_2 will flush out gases apart from O_2, such as CO_2 and ethylene, which would normally accumulate during waterlogging.

Methods tolls

Five soils were collected from Merredin, Muresk, Meckering, Mt. Barker and Beverley in W.A. All these locations had duplex loamy soils which were prone to waterlogging. Soil was collected from the top 10 cm and incubated at 15.20?C. Samplers were used to collect soil solutions which were extracted from 5 cm beneath the surface of 1-3 kg of waterlogged soil. A soil solution sampler consisted of a 2 cm dia. sphere formed with nylon mesh (53 tun pore size) containing glass beads (3 mm dia.). A glass and Sylastic tube connected the sphere to a three way teflon stopcock at the soil surface. 02 was measured using 0.2 mL samples in a Radiometer blood-oxygen analyser (2); CO_2 was measured using 2.5 mL samples and a CO_2 electrode (3); ethylene was measured by equilibrating 0.5.5 mL solutions with a head space and assaying this using gas chromatography (2).

Results and discussion

An example of the changes in dissolved O_2 , CO_2 and ethylene gases that occur (i) in a waterlogged soil for a site at Beverley (W.A.) and (ii) in a typical glasshouse eXperiment using nutrient solution culture is given in the figure. Similar changes in dissolved gases occurred for all other topsoils, with ethylene concentrations being up to 20 ppm after I1 d waterlogging in soil from Merredin. Subsoils 0.3.0.5m deep in two locations produced less than 0.01 ppm (0.001 Pa) ethylene and had slower decreases in 02 with time. The high CO2 partial pressures which occur im solutions from waterlogged topsoils would likely have adverse effects due to root cytoplasm acidosis (see 3), while ethylene at concentrations of 0.1-10 ppm arc known to cause severe root growth inhibitions and chlorosis of many plant species (4).

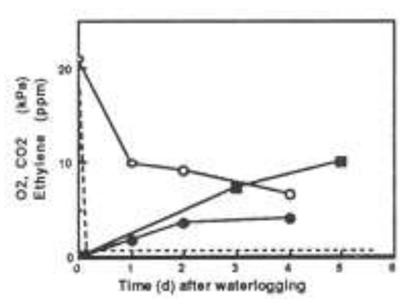

Figure. Changes in soil gases during waterlogging. Values are expressed as gas partial pressures (kPa) or ppm (%v/v) that are in equilibrium with soil solutions. Symbols (○) O_2, (●) CO_2, (■) ethylene. Soil was from Beverley, W.A., and incubated at 15?C. Dashed line shows typical 02 changes in N2 bubbled solution culture; partial pressures of CO_2 and ethylene would be equivalent to 0.03 kPa and less tham 0.00 ppm respectively.

The changes in C O_2 and ethyleme in soil samples shown here are for bulk solutions; these are indicative of the minimum changes that may occur in the microenvironment of small pore spaces in the soil. Even greater changes in dissolved soil gases of bulk solutions could occur in the field because of (i) differences in soil structure, e.g. compaction, and (ii) the additional effects of plant roots.

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