

Evaluation of New Micro Suction Cups for Sampling of Soil Solutions for Organic Acids

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Objective

Low-molecular-weight organic acids have been hypothesized to perform many functions in soil including nutrient acquisition, mineral weathering, bacterial chemotaxis and metal detoxification. Most organic acids arise from root exudation, lysis and by release from soil microorganisms. Due to the spatial heterogeneity of soil resources such as P it is most likely that the concentration of organic acids may also be highly spatially localized, e.g. around roots and microbes. Current extraction techniques (centrifugal drainage, ceramic suction cups, water extraction), however, are not able to resolve these spatial heterogeneities leading to an underestimation of soil solution organic acid concentrations [1]. Göttelein et al. [2] have developed micro suction cups (aluminium oxide ceramic, diameter 1 mm, pore size 1 µm) for sampling of soil solution in high spatial

resolution but hitherto they have been only applied for the analysis of inorganic cations and anions.

In a cooperation with EcoTech/Bonn new materials (ceramics, plastics) for micro suction cups have been tested for their ability to sample organic acid-containing soil solution. The selection criteria are:

- Impermeability for microorganisms (MOs) to prevent microbial degradation after sampling
- Low adsorption affinity for organic acids

Micro Suction Cups

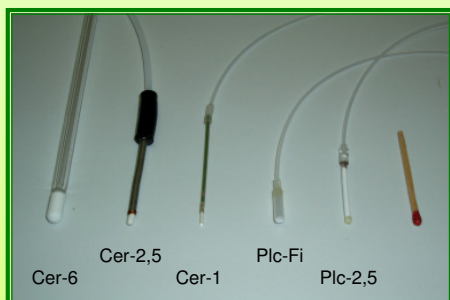


Fig. 1: Tested micro suction cups:

- Cer-6** (EcoTech): Multilayer ceramic (borosilicate), $\varnothing = 6$ mm,
- Cer-2,5** (EcoTech): Multilayer ceramic (borosilicate), $\varnothing = 2,5$ mm
- Cer-1** (according to A. Göttelein [2]): Ceramic (aluminium oxide), $\varnothing = 1$ mm
- Plc-Fi** (EcoTech): Plastic tube (teflon) closed with a 0,45 µm filter membrane
- Plc-2,5** (F.W. Meijboom, Wageningen/NL): Porous plastic tube „Rhizon 2,5 mm“, $\varnothing = 2,5$ mm

Results

1. Permeability for microorganisms (MOs)

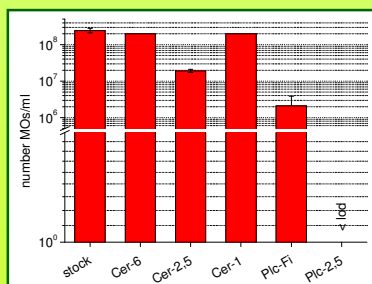


Fig. 2: Investigation of the permeabilities of the micro suction cups for MOs.

Experimental procedure: bacterial stock solution of *Pseudomonas fluorescens* ($2,5 \cdot 10^8$); vacuum 350 mbar; sampling of circa 1 ml eluate

Analysis of the eluates for MOs: dilution series of the eluates (10^{-1} , 10^{-2} , 10^{-3} and 10^{-4}); plating of the diluted eluates on agar plates (24 h incubator); counting of colonies

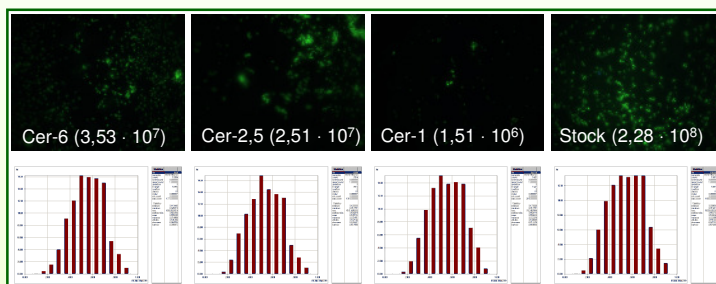


Fig. 3: **Upper row:** Fluorescence microscopic images of the MO-containing eluates colored with the green fluorescent nucleic acid dye Sytox green; in brackets: number of MOs/ml.

Lower row: Frequency distributions of the MO sizes (Identification and enumeration of MOs by digital image processing according to P. Klauth [3])

2. Adsorption affinity for organic acids

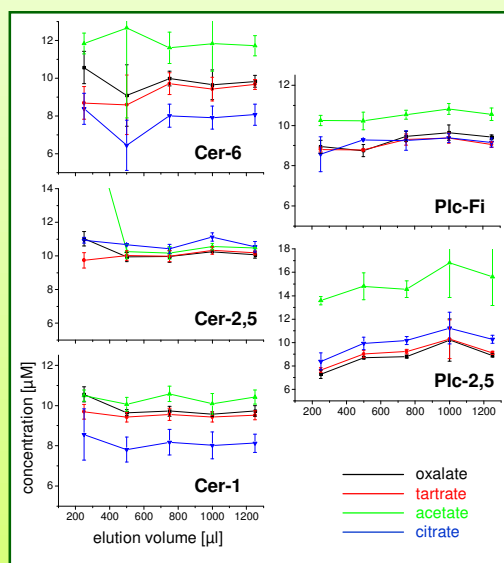


Fig. 4: Investigation of the adsorption capacities of the micro suction cups for organic acids (data points: average of two micro suction cups each).

Experimental procedure: 10 µM solution of oxalate, tartrate, acetate and citrate each; vacuum 350 mbar; sampling of 250 µl fractions

Analysis of the eluates by capillary electrophoresis: column: fused silica (75 µm x 68,5 cm, 60 cm eff.); electrolyte: 7,5 mM salicylate, 15 mM Tris, 0,5 mM DoTAH, 0,3 mM Ca(OH)₂; injection: 50 mbar/30 s; voltage: 30 kV; detection: indirect UV/232 nm;

samples: 190 µl eluate + 10 µl 200 µM NaClO₄

Summary

- Test of 5 micro suction cups made of ceramic or plastic for their abilities to sample organic acid-containing soil solution.
- Selection criteria: - Impermeability for MOs
 - Low adsorption capacity for organic acids.
- Investigation of the permeability for MOs with a bacteria solution of *Pseudomonas fluorescens*. Enumeration of the MOs in the eluates by plating and fluorescence microscopy/digital image processing.
 - ➔ Only micro suction cup **Plc-2,5** impermeable for MOs.
- Investigation of the adsorption capacities for organic acids
 - ➔ **Plc-2,5** showed a low tendency for adsorption of organic acids.

[1] Jones D L, Dennis P G, Owen A G, van Hees P A W. Plant Soil 248: 31 - 41, 2003.

[2] Göttelein A, Hell U, Blasek R. Geoderma 69: 147 - 156, 1996.

[3] Klauth P. J Microbiol Methods, in press.