Effects of soil physicochemical properties on the isotope composition of soil water

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Introduction

Soil water plays a central role for plant and ecosystem water relations. Understanding the role of soil water along the soil-plant-atmosphere continuum is therefore a critical task in ecological and biogeochemical research. For studying water movements in soils and during plant uptake, the stable isotope composition of soil water is becoming established as an important tool.

What remains unclear, is how the physicochemical properties of soil influence the isotope composition of soil water and if possible effects need to be accounted for in the interpretation of soil and plant water stable isotope composition in ecological or biogeochemical research. Here we present the results of an experiment, where we tested the influence of physicochemical soil properties on the isotope composition of soil water.

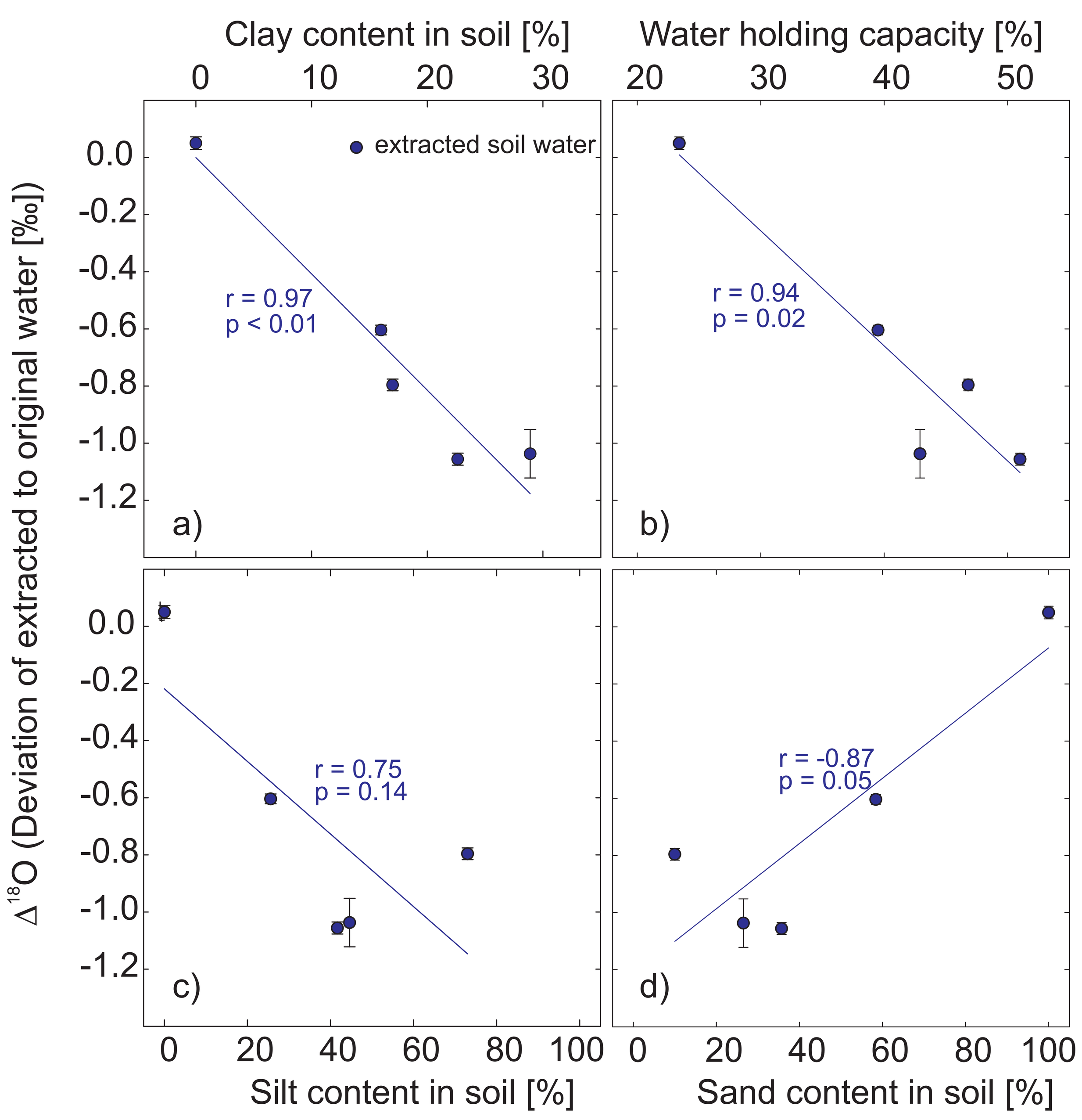

Figure 2 a-d) Effects of soil properties on SFE. The amount of deviation in $\delta^{18}O$ of extracted water is highly correlated with the clay content (r=0.97) and water holding capacity (r=0.94) of the soils and becomes less evident the higher the sand content (r=-0.87).

Research questions

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- Is the composition of soil water influenced by soil physiochemical properties
- Which soil properties influence the observed fractionation on water

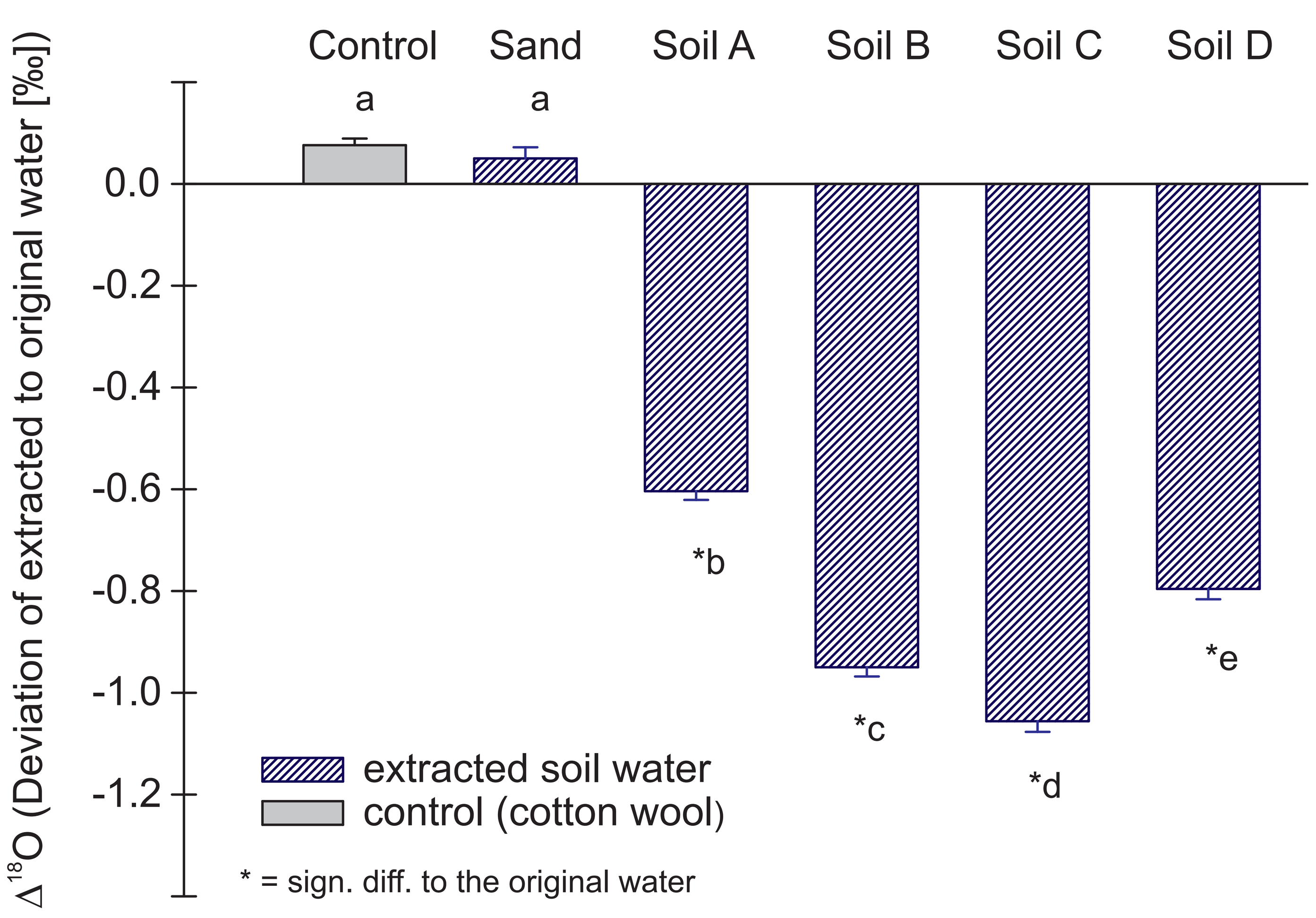

Figure 1) Difference between $\delta^{18}O$ of cryogenically extracted soil water and the original water, that we used to irrigate.

Results

- Water extracted from soils was depleted in its isotope composition relative to the water we used to wet up the soils (Figure 1).
- The SFE is correlated with the clay content and thus the water holding capacity of soils (Figure 2).
- The effects of soil fractions (grain size) on SFE were independent of soil type (Figure 3).
- Results are independent of extraction time. We obtain the same results after 5 hours extraction time. (data not shown).

Material & Methods

Soil wetting and water extraction

Four soil samples, differing in their properties, and pure quartz sand were dried at 105 °C for 36 hours. 10 g of each soil (n=4) was filled into a gas proof exetainer and was re-wetted with 3g water (30 % mass) of known isotope composition. After the samples were shaken for 24 hours, water was extracted again for 1.5 h with cryogenic water distillation (30 mTorr ~ 40 mbar Vacuum). The extracted water was analyzed for ^{2}H and ^{18}O on an isotope ratio mass spectrometer and compared to the original added water.
To test if the observed effect is an artifact of extraction time, two soil samples (A,B) were wetted up to their corresponding field capacity and extracted as described before, but for 5 hours.

Soil separation

200g samples (adequate amount for ultrasonic energy output) from soils A and B were divided into 33g in 250mL conical flasks and suspended in 200mL of water. The soil suspensions were then disrupted in an ultrasonic bath for 6.5 minutes each. The disrupted soils were then initially wet-sieved through a 1mm sieve to remove large particles and then subsequently wet-sieved through 0.4mm, 0.25mm and 40µm sieves. The remaining soil suspension was allowed to sediment for 12 hours and then filtered through fluted filter paper. Soil fractions were dried, re-wetted and extracted as described before.

Conclusion

Physiochemical properties of soils can affect the isotope composition of water. This fractionation effect becomes more distinct under dry conditions. Soil texture seems to be the main driver of the observed fractionation effect. If these results will be confirmed by other experiments, the SFE will have strong implications on soil-water related studies, such as plant-water relations.

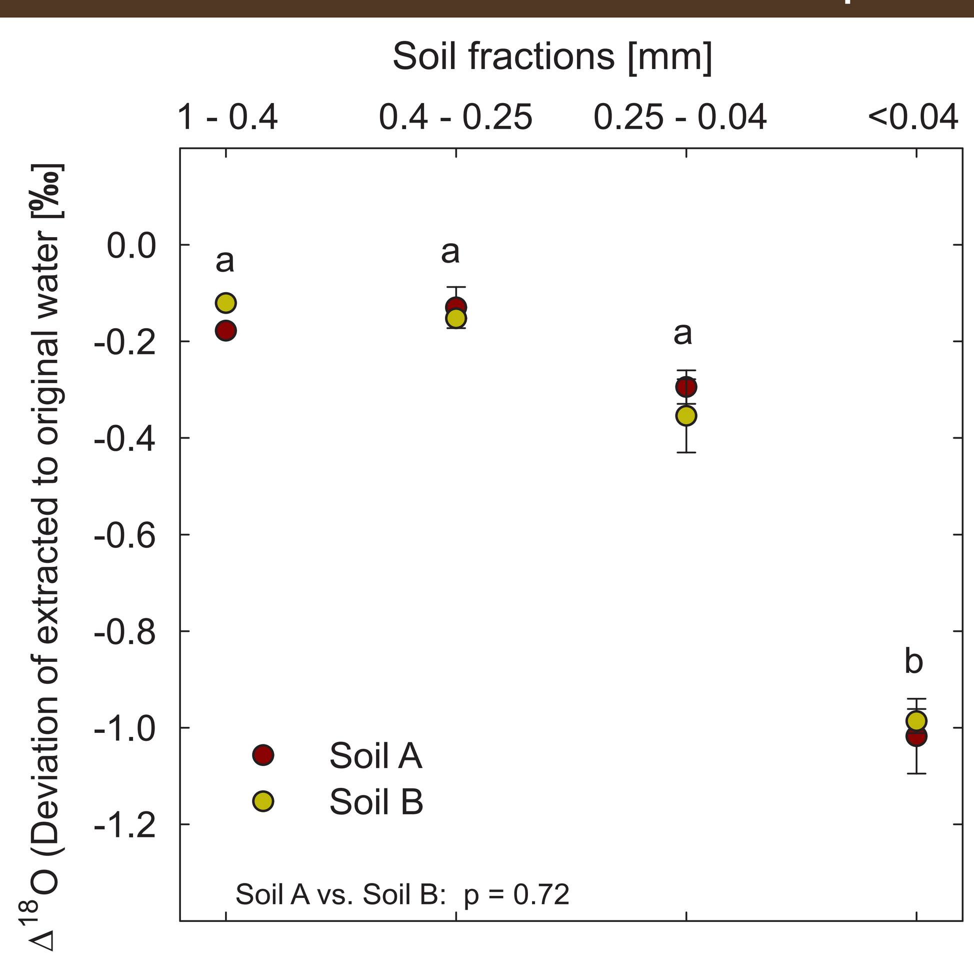

Figure 3) Difference in $\delta^{18}O$ of cryogenically extracted water to the original water, added to dried soil fractions (grain size) samples. Two different soil samples were separated into 4 fraction ranges with different sieves (1, 0.4, 0.25, 0.04 mm). The initially difference in the SFE of soil A and soil B (p=0.01; see Figure 1) disappeared (p=0.72), however between the soil fractions a difference in the fractionation strength could be observed.