Leibniz Centre for Agricultural Landscape Research (ZALF)

Amorphous silica increases the water holding capacity and the phosphorus mobility in soils - solving the two main problems of agriculture

Jörg Schaller, Benjamin S. Gilfedder, Sven Frei

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Main problems for future agriculture

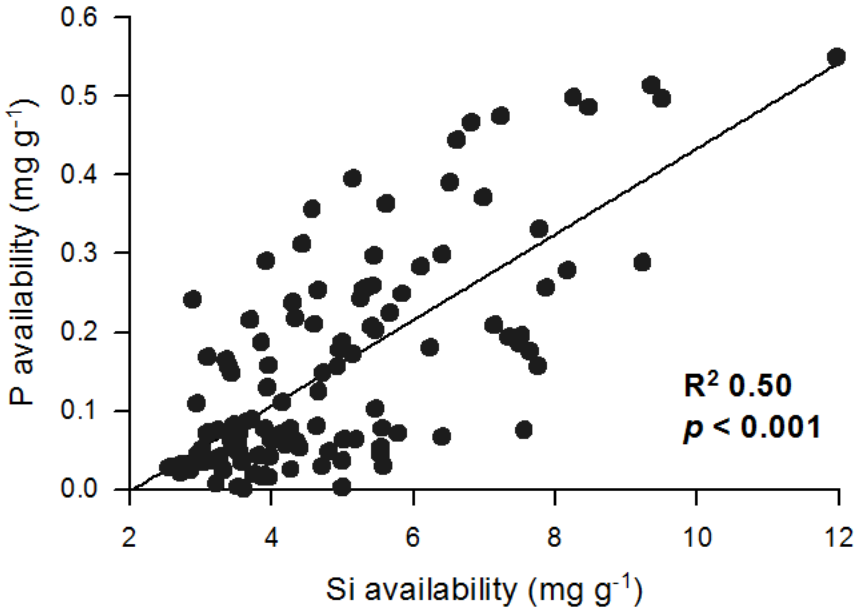
- Mineable resources for phosphorus fertilizer production decline and may be lacking at the end of the century.
- Phosphorus availability in soils is low despite high total phosphorus content (mostly unavailable).

- More frequent and longer drought periods are predicted threatening agricultural yield.
- The capacity of soils to hold water is a highly important factor controlling drought stress intensity for plants.

Increasing phosphorus availability by silica

Silica effects on P availability

Positive interdependency between P and Si availability for ~250 soils



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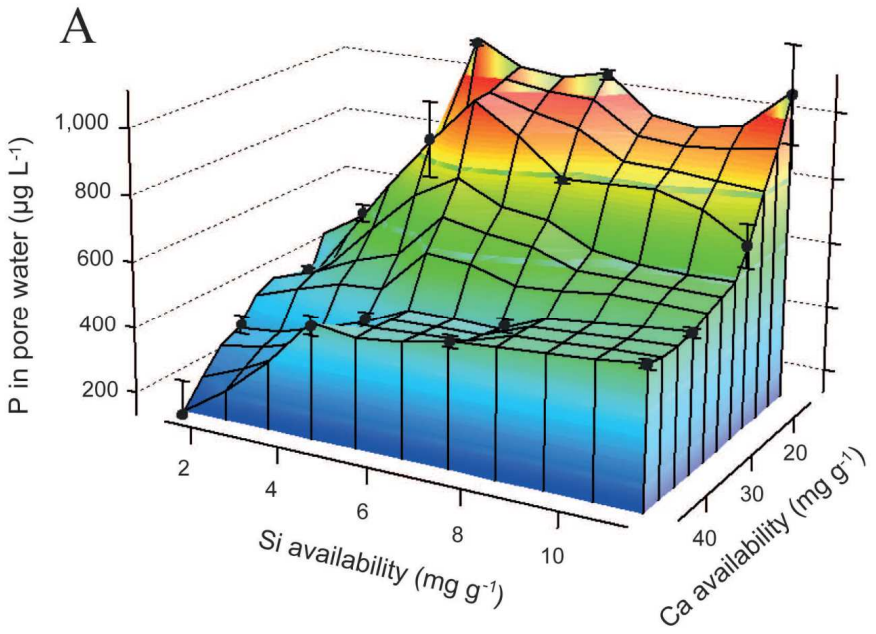
Increasing phosphorus availability by silica

Silica effects on P availability

Positive interdependency between P and Si

- Silicon is mobilizing phosphorus
- Calcium is immobilizing phosphorus at pH 8.4



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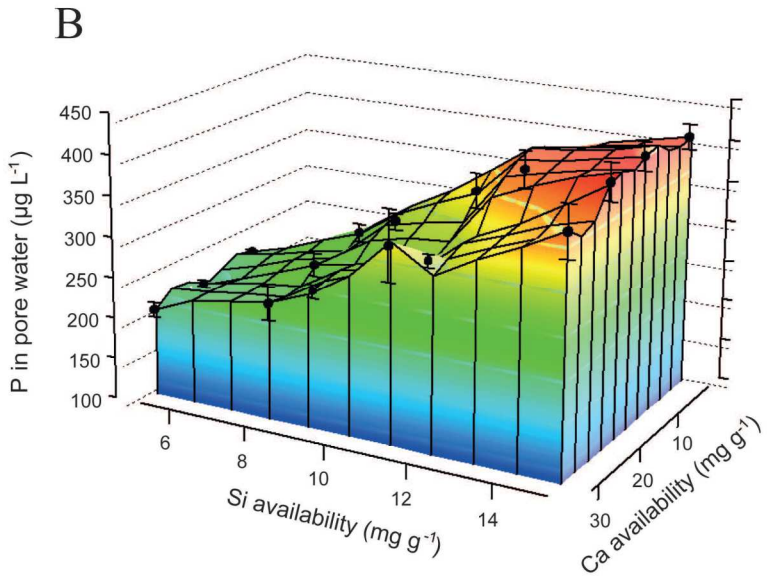
Increasing phosphorus availability by silica

Silica effects on P availability

Positive interdependency between P and Si

- Silicon is mobilizing phosphorus at pH= 5.6



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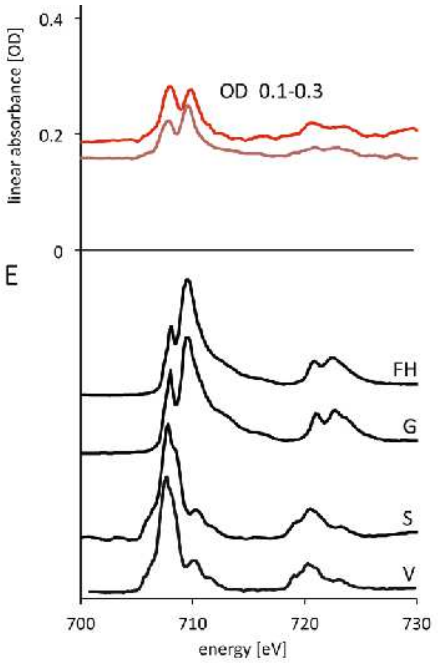
Increasing phosphorus availability by silica

XAS measurements

Positive interdependency between P and Si

- Silicon is mobilizing phosphorus from strong binding to iron by changing iron mineralogy (decreased vivianite peak referring to V in the lower figure)



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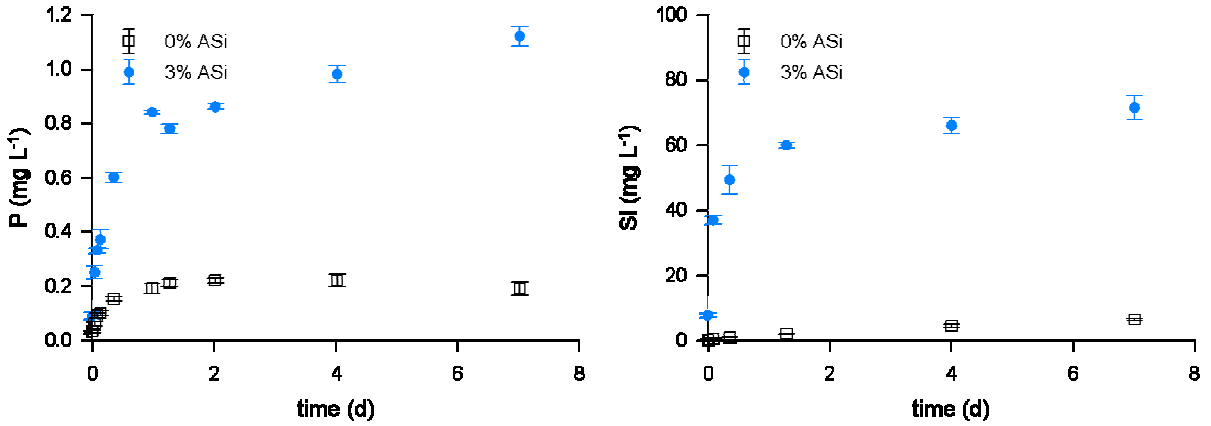
Increasing phosphorus availability by silica

Positive interdependency between P and Si mobilization



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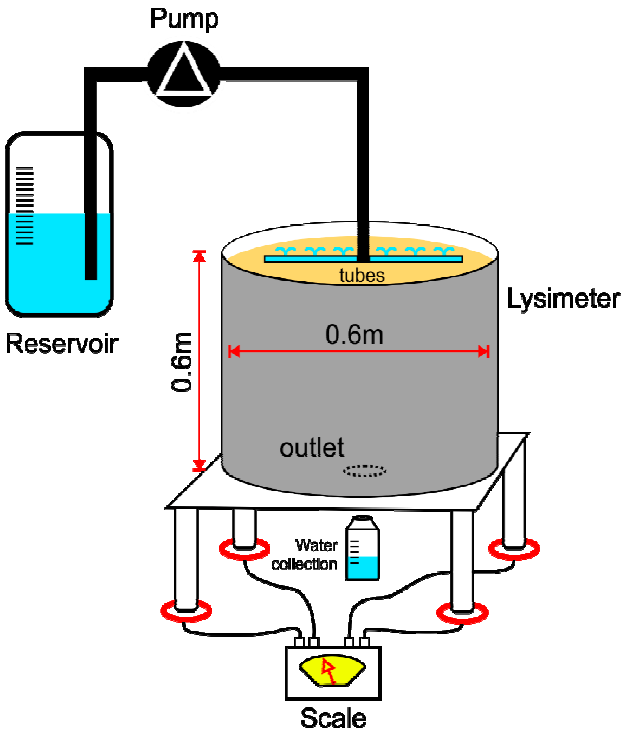
Lysimeter study using amorphous silica mixed with sand

Setup



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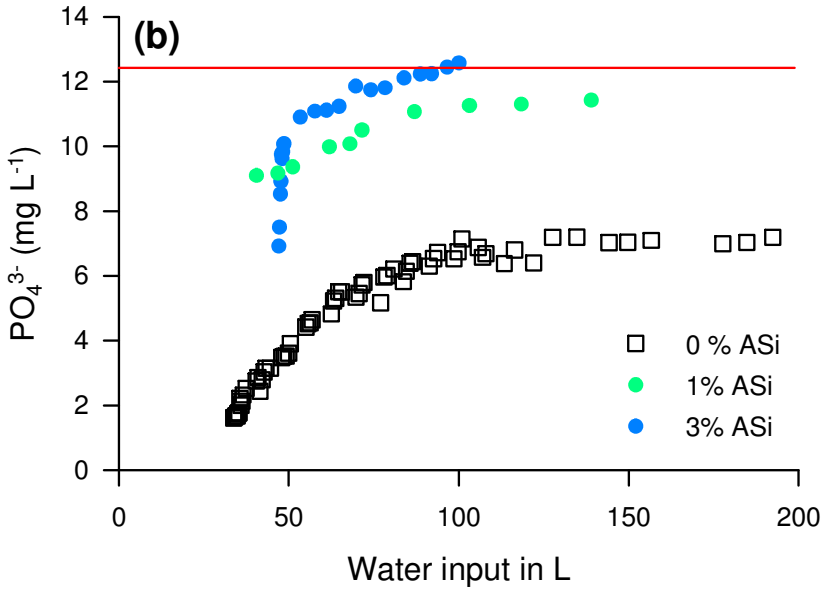
Lysimeter study using amorphous silica mixed with sand

Positive interdependency between P and Si

→ Higher P concentrations in treatments with higher amorphous silica (ASi) content

Red line indicates the P concentration of the irrigation water



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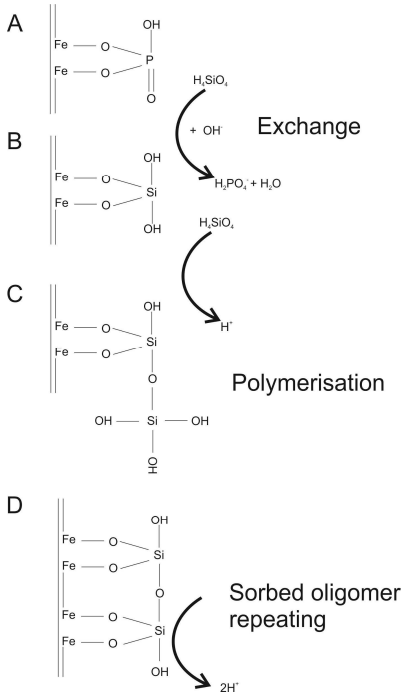
Increasing phosphorus availability by silica

Silica effects on P availability

How Si is mobilizing P

- a and b) substitution of a bidentate phosphate ligand on an iron oxide surface with the siliceous acid bidentate ligand, c and d) polymerization of the siliceous acid and sorption of the oligomer to the iron oxide surface



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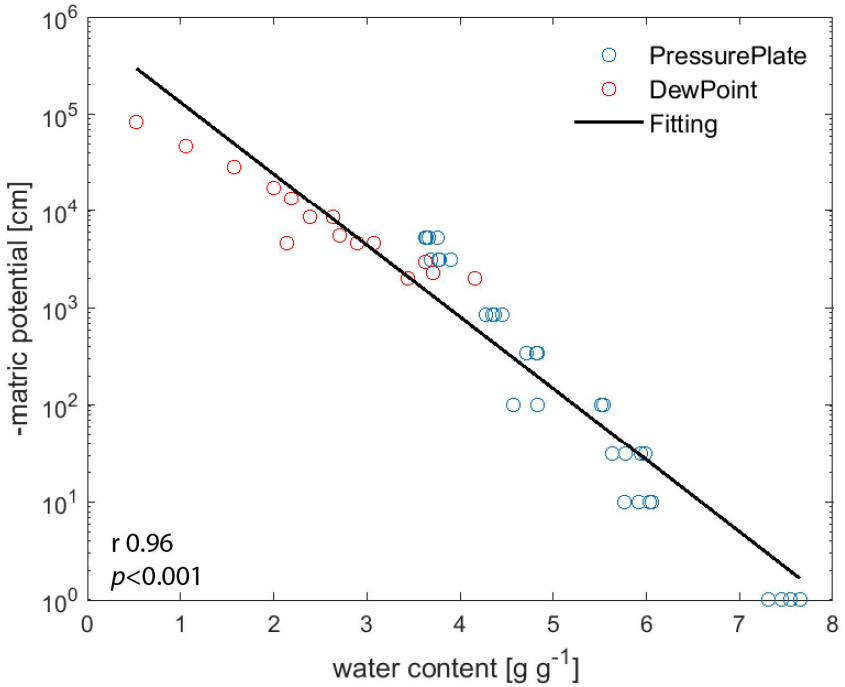
Effects of amorphous silica on soil water

Very large water holding capcity of amorphous silica (more than 700%)



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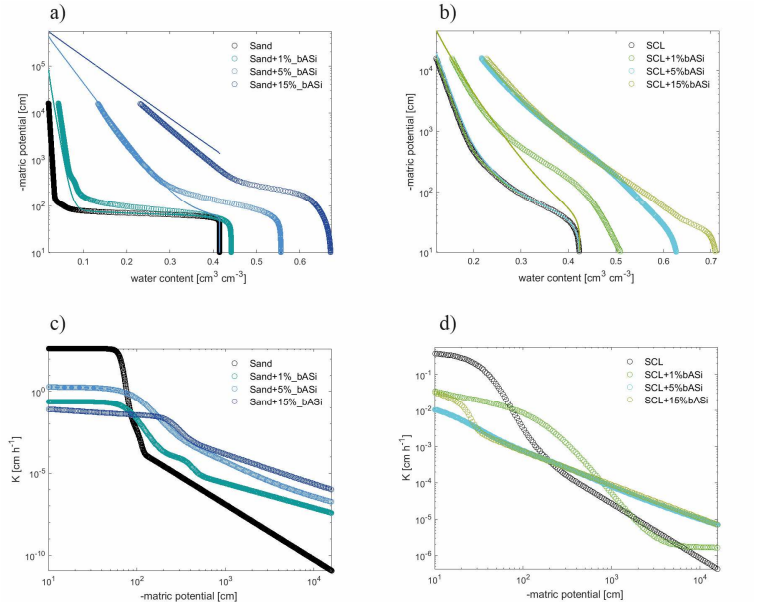
Effects of amorphous silica on soil water

Amorphous silica increases water holding capcity at any any water potential for both soils used (pure sand and sandy clay loam – SCL)



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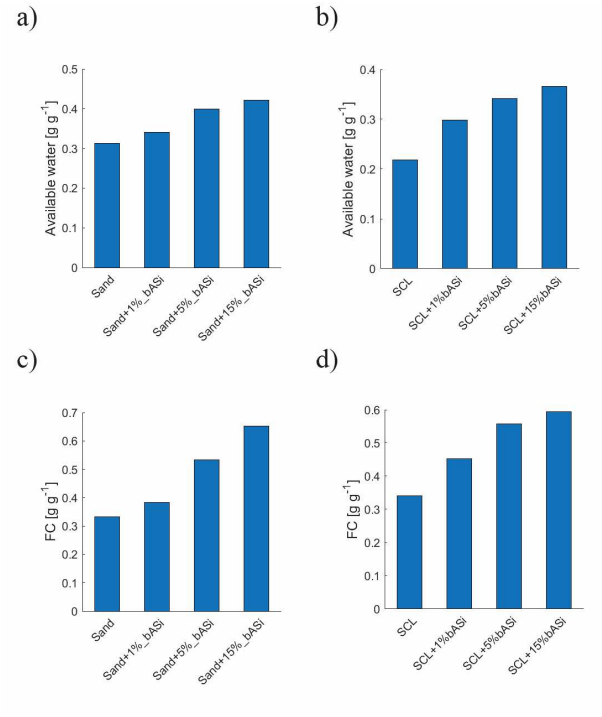
Effects of amorphous silica on soil water

Plant available water and field capacity (FC) were strongly increased by amorphous silica for both soils (pure sand and sandy clay loam – SCL)



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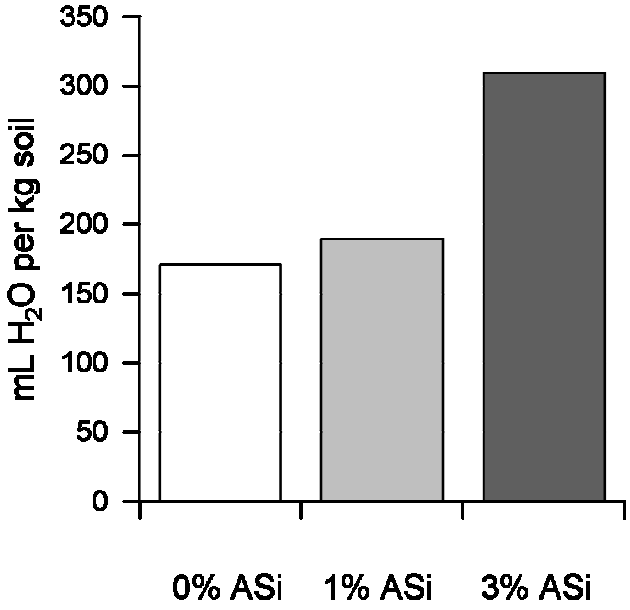
Lysimeter study using amorphous silica mixed with sand

Increased water holding capacity by amorphous silica (ASi)



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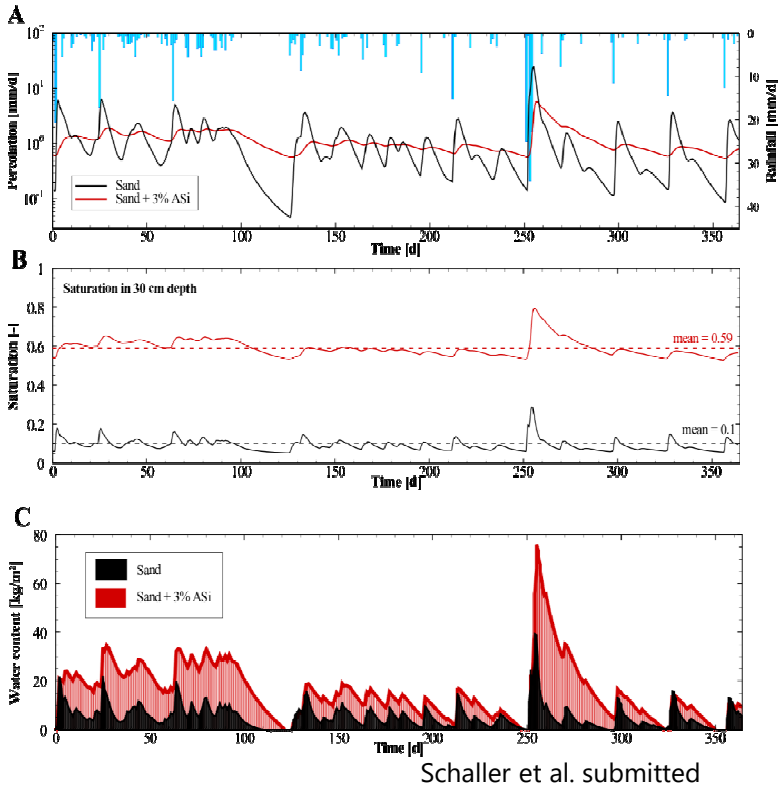
Effect of ASi on modelled soil water budget

A) Applied rainfall rates for the yearly simulation scenario (November 1st 2017 to October 31th 2018) and the modeled percolation rates for the pure sand and the sand with 3% ASi. B) Simulated water saturation at 30 cm depth. C) Simulated water uptake in kg per unit area for the sand and sand with 3% ASi.



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Silica effects on soil phosphorus and water status

- Amorphous silica increased soil phosphorus availability
- Amorphous silica decreases phosphorus retention during percolation
- Amorphous silica increased soil water holding capacity

- Amorphous silica may be used to solve the two main problems of agriculture