Exploring the impact of polyhalite (POLY4) application on soil sodium

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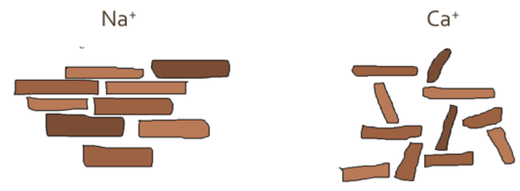
Introduction

Soil salinization affects approximately 831 million hectares of soil globally impacting the availability of land for crop production. Sodium can enter the soil system either naturally (through weathering, seawater intrusion or evapotranspiration) or as a result of human activity (water extraction, irrigation). Remediation is achieved by the application of calcium that encourages flocculation of soil particles (Figure 1), which lowers tensile strength, enabling plant roots to penetrate and facilitate soil water drainage. POLY4 ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) is an evaporite mineral that contains potassium (14% K_2O), magnesium (6% MgO), sulphur (48% SO_3) and calcium (17% CaO). The use of POLY4 in soils containing high levels of sodium is beneficial as the introduction of additional cations displaces sodium.

Figure 1 – Visualisation of how sodium and calcium affect soil structure.

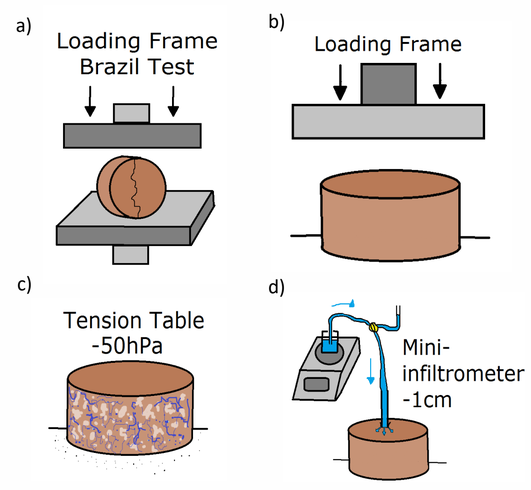


Methods

Laboratory study

- Scottish and Israeli air-dry soils were amended with POLY4 at rates of 0, 2.5, 5 and 50 t ha^{-1}.
- Ten x 3cm air-dried discs were prepared per soil for fracture testing on loading frame at 2mm min^{-1}.
- Cores (5.5cm in diameter, 4cm high) were prepared with POLY4 and gypsum (0 – 440 kg Ca ha^{-1}) for testing of sorptivity, macroporosity and infiltration (Figure 2).

Figure 2 – Schematics of laboratory methods for a) tensile strength testing; b) unconfined compression strength; c) macroporosity and d) sorptivity.



Greenhouse study

Experimental soil was saline-alkali soil, collected from Dongtai city, Jiangsu Province, China.

(1) POLY4 and gypsum powder were mixed with soil.

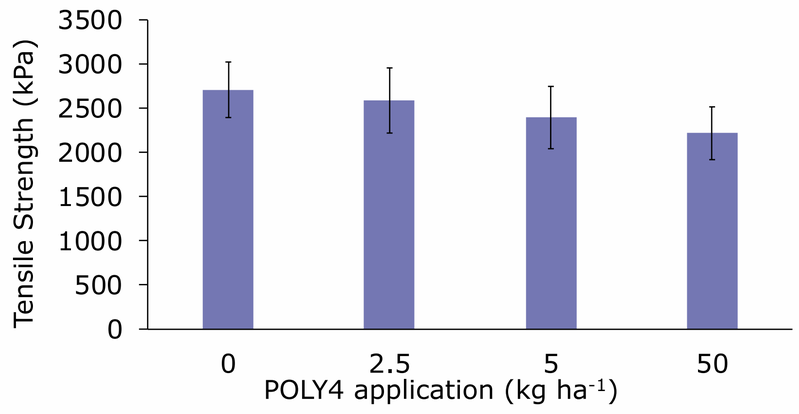
(2) First, 2.8L of distilled water was applied to soil in each pot and was maintained for 48 hours. Then the wash water was collected. Second application involved 1.0L of distilled water to soil in each pot and was maintained for 48 hours, following which the wash water was collected.

Results

Laboratory study

- Disc fracturing found that the soil tensile strength was inversely related to POLY4 application depending on soil type with waste water irrigated soils (Figure 3).
- Significant salt deposits developed on the surfaces of the cores due to the upward movements of excess salts during drying cycles, which was greater with POLY4 and was particularly prevalent in the highest application rates (Figure 4).
- Sorptivity, macroporosity and infiltration were unaffected.

Figure 3 – Soil tensile strength from tensile testing on a waster water treated soil.



Greenhouse study

- Applied on a mass basis, POLY4 treated pots post-leaching produced higher amounts of sodium than gypsum-treated pots.
- This result showed the potential for POLY4 to remediate soils with high levels of sodium (Figure 5).

Figure 4 – Amended cores with increasing calcium application from left to right. Images taken when cores are field capacity.

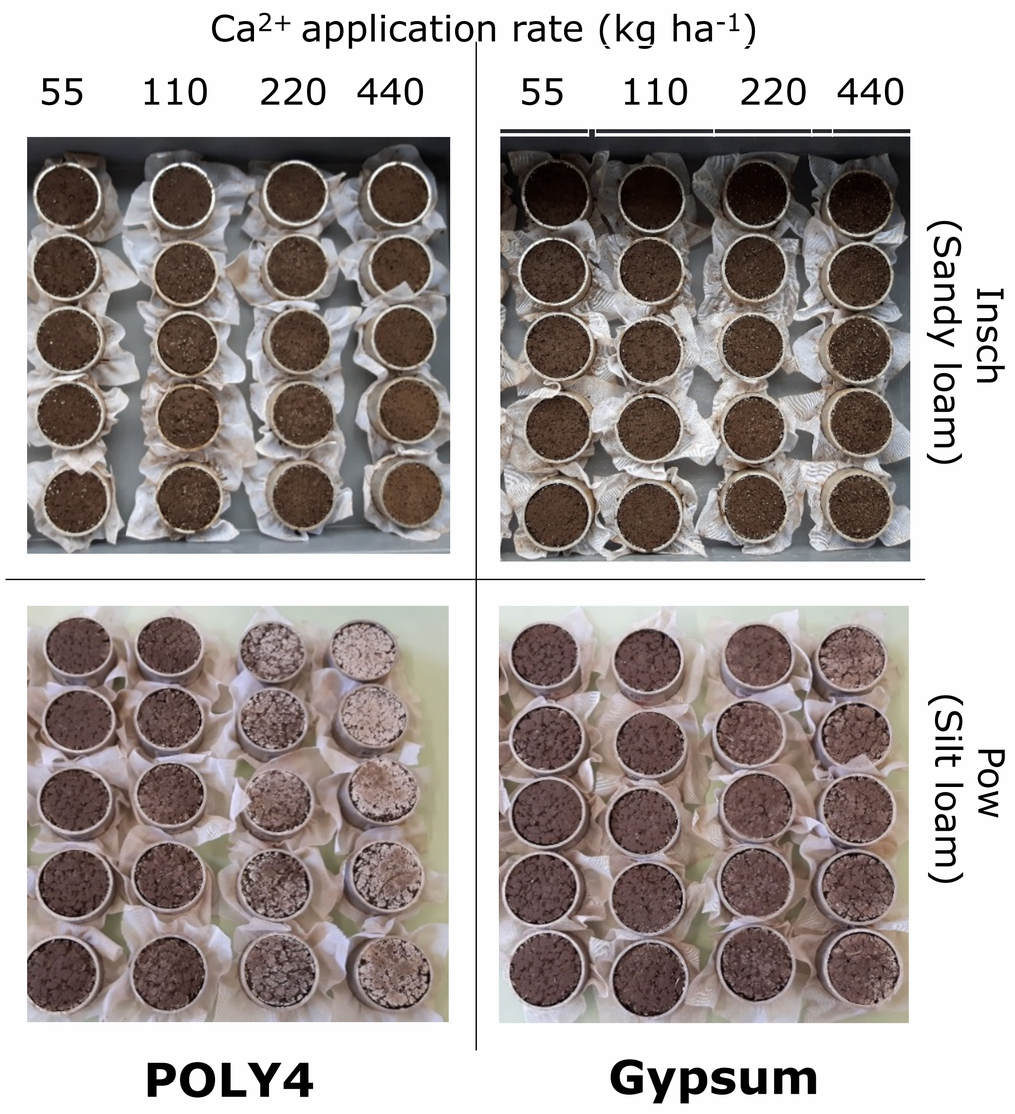


Figure 5 – Total leaching from pots treated with POLY4 and gypsum.

Conclusion

- ✓ Soils containing high levels of exchangeable sodium often limit plant growth.
- ✓ Remediation using calcium makes sodium available for washing out of the soil.
- ✓ In laboratory-based testing, POLY4 showed improvements in soil structure for soils irrigated with waste water.
- ✓ Salt deposits formed with increased POLY4 application demonstrating availability for sodium to be removed by water.
- ✓ In a greenhouse trial, POLY4-amended pots leached more sodium than gypsum-amended pots.