EVALUATING THE EFFECTIVENESS OF GYPSUM AND POLYHALITE-BASED FERTILIZER POLY4 ON CHANGING SUBSOIL CHEMICAL ATTRIBUTES IN A BRAZILIAN OXISOL

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Abstract

The majority of soils in Brazil are Oxisols and Histosols. These soils are low in nutrients limiting agricultural productivity. Brazilian farmers apply gypsum ahead of planting where subsoil calcium is low and/or aluminium toxicity is present. This can improve some acid soils allowing to have deeper roots, increased nutrient availability and subsequently improved crop yield. While effective as a soil conditioner, gypsum has a low solubility (2.5 g L^{-1} at 25°C) and is often only available as powder which makes application difficult.

Polyhalite ($K_2SO_4MgSO_42CaSO_42H_2O$) contains calcium (17% CaO) and sulphur (19% S) along with potassium (14% K_2O) and magnesium (6% MgO). In a granular form, marketed as POLY4, the mineral is spreadable and has a greater solubility (27 g L^{-1}).

The trial evaluated and compared the mobility of calcium and sulphate-sulphur from gypsum and POLY4 in a clay Oxisol. Testing was done with soil columns in controlled environments receiving locally-typical water application from September 2017 to May 2018.

Results of the study showed differences in distribution of calcium (Ca), sulphate-sulphur (sulphate-S), potassium (K) and magnesium (Mg) after surface application of gypsum and POLY4.

Introduction

- The Cerrado area in Brazil has 20.5 million hectares of crops.
- Soils in this area are mostly very weathered, acidic soils with low fertility.
- Standard practice is to regularly add gypsum in order to ameliorate aluminium toxicity and promote root development. Roots that encounter high aluminium levels in the soil deliberately grow away from the high concentration areas resulting in shallow rooting.
- Potassium is delivered separately and according to commercial crop requirement.
- POLY4 delivers Ca and S while simultaneously supplying K and Mg. This might allow farmers to meet soil and crop requirements using a single material.
- The aim of this study was to evaluate the mobility of calcium and sulphate-sulphur from gypsum and POLY4 in a clay Oxisol with soil columns in a controlled environments.

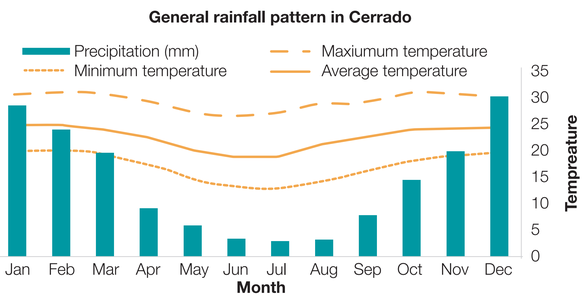
Treatments	Nutrient application rate (kg ha^{-1})			
	K_2O	CaO	MgO	S
Control	0	0	0	0
Gypsum	0	833	0	450
POLY4	700	850	300	950

Reference soil nutrient levels (0-20 cm)

OM (%)	pH	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})
2.3	5.5	25	117	450	115

Methodology

- One meter soil columns were extracted.
- Gypsum addition was based on the recommendation from Souza and Lobato (2004):
  - Gypsum requirement (kg ha^{-1}): 50 * soil clay (%);
  - POLY4 rate matches the Ca gypsum application (20% Ca).
- Both POLY4 and gypsum were incorporated at 10 cm depth.
- Deionized water was applied according to the local rainfall pattern. Equivalent monthly rainfall applied was 25 – 250 mm (see rainfall figure).

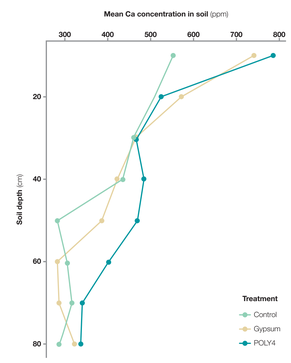


- Periodic soil solution and leachate was collected from September 2017 to May 2018 from different soil horizons (data not shown).
- Post trial soil samples were taken every 10 cm to 80 cm deep.

Results

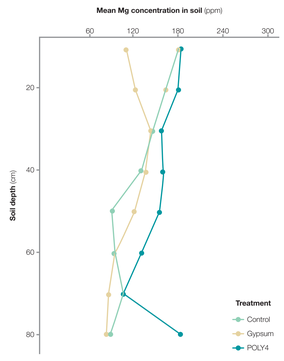
Calcium behaviour in soil

- Ca^{2+} tends to remain near soil surface since it is adsorbed to the negatively charged soil particles.
- The 30 cm horizon shows that Ca from POLY4 was released at least at a similar rate as from gypsum. POLY4 delivers Ca at a similar rate to gypsum up to 30 cm depth.
- From 45 and 70 cm higher Ca concentrations were observed with POLY4.
- Movement of Ca through the soil profile can advance soil exploration by roots and therefore an improvement in crop development.



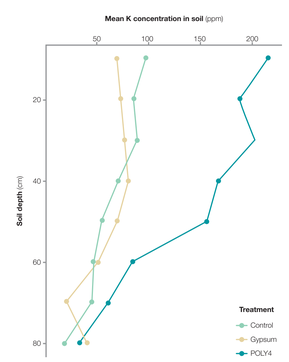
Magnesium behaviour in soil

- The higher affinity of Ca in both gypsum and POLY4 displaced Mg from soil exchange sites.
- Gypsum increased Mg concentration at 40 cm while POLY4 increased Mg concentration up to 60 cm deep.
- Similar to K, Mg provided by POLY4 entered soil solution and also moved down the soil profile, while also increasing the Mg concentration in the first 30 cm of soil at the same amount of applied Ca.



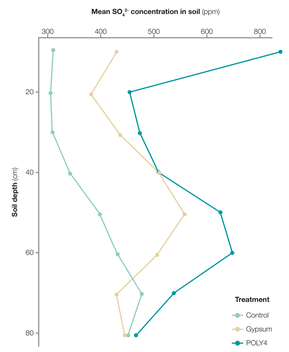
Potassium behaviour in soil

- The addition of Ca promotes ion exchange to release K from the soil into solution, supporting extended K availability throughout a cropping season.
- The K provided by POLY4 enters soil solution and moves down the soil profile providing direct supply of K, in addition to the displaced soil K.
- Throughout the trial, POLY4 supported higher K concentration in the soil up to a depth of 60 cm.
- Gypsum displaced soil K down the profile. However, without replenishing K from another source, soils treated with gypsum only will deprive crops of K at shallower depths.



Sulphate behaviour in soil

- All nutrients in POLY4 are available in sulphate form providing constant sulphate delivery.
- This sustained delivery allows sulphate to be available at shallower depths despite the sulphate anion being highly mobile.
- Higher levels of sulphate accumulated at 45-60 cm, behaving the same way as sulphate from gypsum.



Conclusions

- Calcium is delivered to greater depths with POLY4 compared to gypsum.
- Sulphate concentration is enhanced under POLY4 at both shallow and deep soil depths.
- POLY4 supplies additional potassium and magnesium. This additional nutrient supply translates into an augmented availability of these nutrients up to 60 and 40 cm, respectively.
- POLY4 directly adds nutrients to the soil solution and appears to encourage cation exchange to make adsorbed nutrients available.
- POLY4 interacts with cation exchange sites, creating conditions suitable for mobilising Al^{3+} out of the root zone.
- Greater nutrient availability at depth encourages root development and, therefore, better crop development and drought tolerance.

Notes

Source: UNESP (2018) 4000-USP-4023-16.

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