Investigating polyhalite nutrient movement through the soil

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Introduction

- Recent discoveries of polyhalite (Figure 1) ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) in the UK offer opportunities to improve yields through efficient fertilizer practice.
- The nutrient content of polyhalite, here by referred to as POLY4, has a nutrient content of 14% K_2O, 17% CaO, 6% MgO and 19% S.
- This study used conical flask extractions and leaching columns to investigate how the equivalent of several years of leaching affects the movement of nutrients through an arable, sandy loam Cambisol soil.

Methodology – *Conical flask extraction*

- POLY4 powder was mixed into acid washed sand and a Cambisol at field equivalent rates of 0, 356, 756 and 1067 kg ha^{-1}.
- Deionised water was added at equivalent rainfall amounts of 76, 152 and 758 mm.
- Buffered and unbuffered systems were treated with an ammonium salt to displace cations and assess the soil cation exchange capacity.

Figure 2 – Leaching columns setup

Methodology – *Leaching columns*

- Columns (depth 30cm) were packed with 770g of Cambisol at a density of 1.2 g cm^{-3} (Figure 2).
- Deionised water was supplied by peristaltic pump at a rate of 100mm hr^{-1} until 4500mm equivalent rainfall was leached.
- Five field equivalent treatments were replicated three times (Table 1).

Table 1 – Treatment breakdown

Fertilizer	Form (size)	Nutrient's Applied (kg ha^{-1})				
		K_2O	S	MgO	CaO	Cl
Control	-	0	0	0	0	0
Potassium Chloride (MOP)	Granules (2 – 4 mm)	100	0	0	0	80
Polyhalite (POLY4)	Powder (0.25 mm)	100	138	43	122	21
Polyhalite (POLY4)	Granules (2 – 4 mm)	100	138	43	122	21
Polyhalite (POLY4)	Crushed rock (2 – 4 mm)	100	138	43	122	21

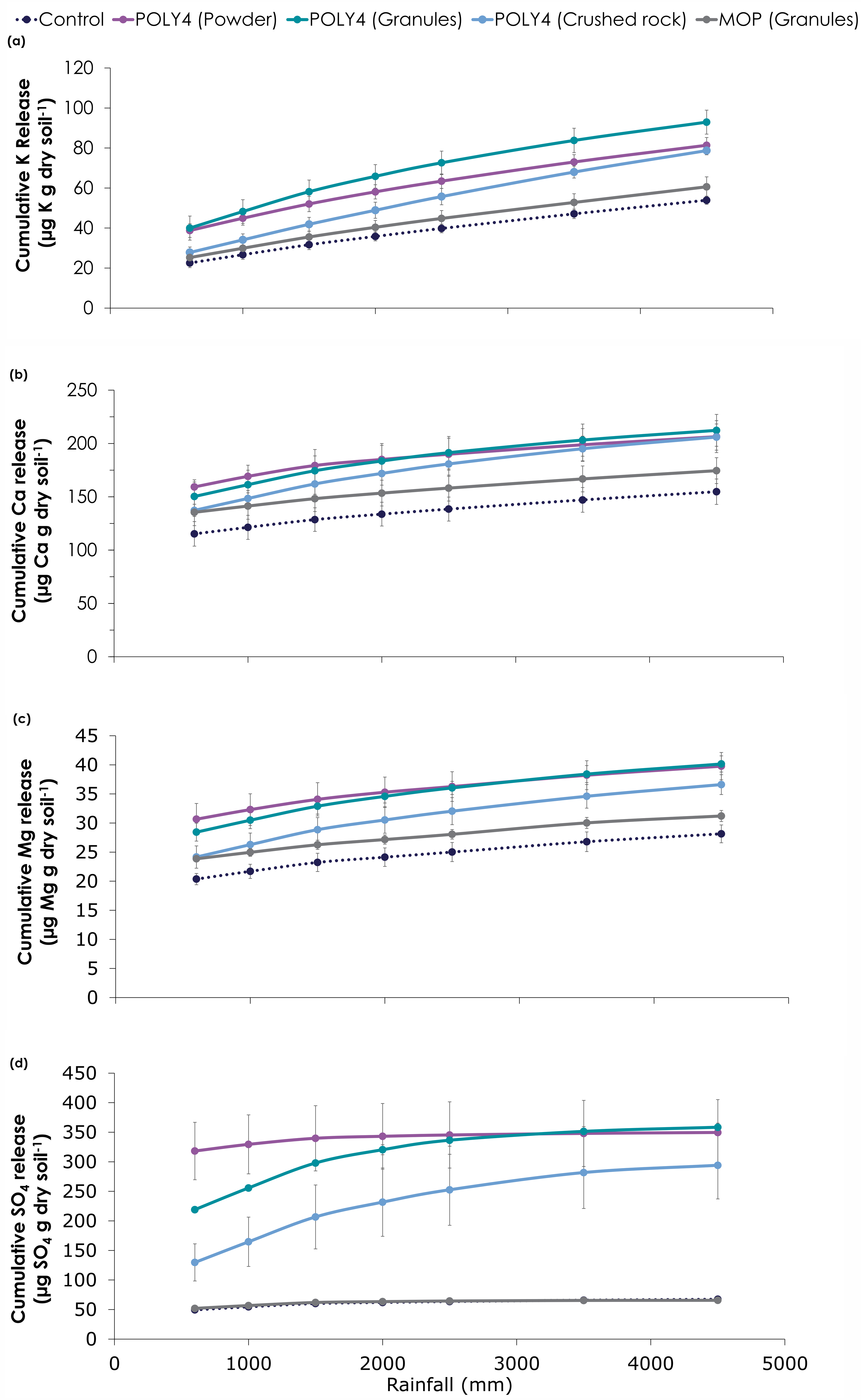

Figure 3 – Cumulative release of (a) potassium, (b) calcium, (c) magnesium and (d) sulphate. Error bars are standard deviations

Initial soil analysis: Sandy loam, pH 5.6 ($CaCl_2$) 6.3 (H_2O), organic matter 11.8%, total N 0.31%, PO_4-P 3.6 mg kg^{-1}, K 171 mg kg^{-1}, Ca 3846 mg kg^{-1}, Mg 188 mg kg^{-1}, EC 1708 uS cm^{-1} ($CaCl_2$) 70 uS cm^{-1} (H_2O)

Results

- Figure 3 shows the amount of potassium, calcium, magnesium and sulphate collected from the columns.
- At equivalent potassium amendment, POLY4 columns released more potassium over time than traditional potassium fertilizer.
- POLY4 provided other nutrients to the soil with release rates of nutrients closely matched with the individual particle surface area and form.
- Nutrient movement is complex due to ionic exchanges caused by cations, such as calcium found in POLY4, to displace other cations into solution.
- POLY4 had no influence on CEC (data not shown).

Conclusion

This study evaluated POLY4 interactions with the soil and found that nutrients are available in the rooting zone. Notably, addition of the calcium found in POLY4 appeared to interact with the soil environment through ionic substitution, which releases potassium from the soil that would be advantageous to crop production.

Figure 1 – POLY4 as crushed rock (left), granules (middle) and powder (right)