The retention and release of nutrients from polyhalite into the soil

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INTRODUCTION

Future food security could be improved by new types or sources of fertilizer that are more efficient at improving yield. Achieving efficiency whilst avoiding soil pollution will require fertilizer plans to consider all six macro-nutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sulphur). Recent discoveries of polyhalite ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) in the UK offer opportunities to improve yields through efficient fertilizer practice. This laboratory study investigated the interaction of polyhalite with the soil environment.

Figure 1: Polyhalite can be processed into chips, granules or powder

METHODOLOGY

Leaching Columns
Columns (depth 30cm) were packed with 770g of Cambisol at a density of 1.2 g cm^{-3}. Deionised water was supplied by peristaltic pump at a rate of 100 mm hr^{-1} until 4500 mm equivalent rainfall was leached. There were four treatments examined: (1) a control with 0 kg ha^{-1} polyhalite, (2) 711 kg ha^{-1} polyhalite powder, (3) 711 kg ha^{-1} polyhalite granules and (4) and 166 kg ha^{-1} potassium chloride. All amended soils received 100 kg K2O ha^{-1} with all treatments replicated three times.

Conical Flask Extraction
Polyhalite was mixed into acid washed sand and the Cambisol at rates of 0, 356, 756 and 1067 kg ha^{-1}. 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.

RESULTS – CONICAL FLASK EXTRACTION

Soil exchange parameters of polyhalite were pH independent. Results for the buffered sand system showed potassium (0.004 – 0.008 cmol kg^{-1}) and magnesium (0.008 – 0.012 cmol kg^{-1}) were increasing with the amount of added water. Calcium showed no consistent pattern with the amount of added water or polyhalite content (0.140 – 0.161 cmol kg^{-1}). Extracts from the Cambisol were higher due to the presence of nutrients in the soil. There was little variation in calcium (0.432 – 0.449 cmol kg^{-1}) and magnesium (0.06 – 0.07 cmol kg^{-1}) with any amount of water or polyhalite amendment. Potassium showed a greater level of variation (0.079 – 0.121 cmol kg^{-1}) most noticeably at higher polyhalite amendments.

Polyhalite had no influence on CEC in either sand (0.25 – 0.35 NH4-N cmol kg^{-1}) or soil (1.34 – 1.41 NH4-N cmol kg^{-1}) at any concentration or water addition. The direct dissolution of polyhalite governs the release of potassium, calcium and magnesium into soil solution resulting in ionic substitution with the soil exchange sites.

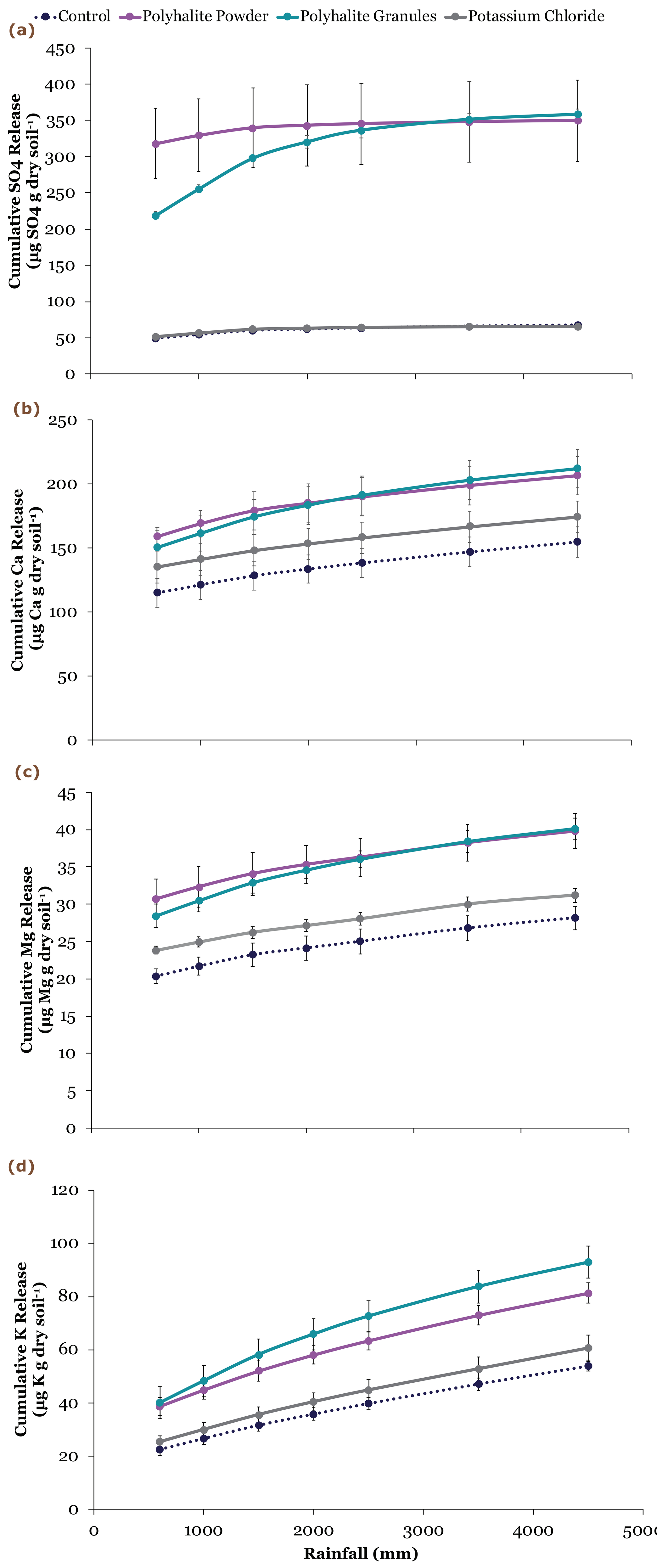

Figure 2: Cumulative release of (a) sulphate, (b) calcium, (c) magnesium and (d) potassium

RESULTS – LEACHING COLUMNS

Delivery of nutrients into the rooting zone is an efficient use of fertilizers. However, nutrient movement is complex due to ionic exchanges requiring careful planning of fertilizer use to maximise nutrient capture. Figure 2 shows the amount of sulphate, calcium, magnesium and potassium collected from the columns. Potassium chloride and control were distinctly poorer than polyhalite treatments. This can be attributed, partially, to polyhalite supplying all four nutrients. However, polyhalite contains calcium which is known to displace other cations into solution. This differentiated polyhalite treatments from potassium chloride that had equal rates of potassium applied due to leaching of existing nutrients.

CONCLUSION

Polyhalite can be supportive of improving food security and preventing soil pollution with efficient, nutrient balanced fertilizer plans. This study evaluated polyhalite interactions with the soil and found that polyhalite is an effective fertilizer. Notably, the calcium in polyhalite appears to interact with the soil environment through ionic substitution, which releases potassium from the soil that would be advantageous to crop production.

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