Reclamation of a saline-sodic soil with gypsum and sulphur

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INTRODUCTION

Saline-sodic soils have an excessive amount of sodium (Na^+) and soluble salts, which are measured by the Exchangeable Sodium Percentage (ESP) and electrical conductivity (EC), respectively. According to the USSL classification, a saline-sodic soil has an ESP >15% and EC_e >4 dSm^{-1}. Loss of soil structure and osmotic stress in plants are negative effects of salinity-sodicity, and can be treated by leaching with water and chemical amendments as gypsum (GY) as a source of Ca^{2+} to replace the Na^+ in the exchange complex, besides Sulphur (SU). The aim of this experiment was to evaluate the effect of GY and SU at two levels (50, 100%) on reclamation of a saline-sodic soil from the High Valley of Cochabamba (Bolivia).

METHODOLOGY

The initial soil properties were: ESP 66.6%, EC_e 20.5 dSm^{-1}, pH 10.2, BD 1.3 gcm^{-3}, CEC 5.0 $cmol_c kg^{-1}$, OM 0.6%, clay 18.2%, silt 52.1% and sand 29.7%. The purity of GY was 92% (Ca^{2+} 18.5%) and 97.5% for SU. The GY requirement to reduce initial ESP to 15% was calculated through the equation of Hoffman & Shannon (2007), so for SU was 5.38 times GY (Richards *et al.* 1954). PVC tubes (15cm Ø) as soil columns (Fig 1) were filled with 6.7 kg of soil (4mm sieve), the upper layer was mixed with respective amendment/dose, following the protocol of Ahmad *et al.* (2015). The volume of distilled water for the lixiviation was defined as a pore volume (PV) according to Kahlon *et al.* (2013). After an initial soil saturation with 3/4 PV, four lixiviations were applied each of 1 PV. ESP was calculated using the formula of Sumner *et al.* (1998). Treatments were evaluated as factorial.

Fig 1. Experimental soil columns.

RESULTS

Soil ESP, EC_e and pH differed significantly (p =0.05) with respect to the interaction between amendments and doses. GY100 decreased soil ESP by 65.5%, followed by GY50 (55.2%), SU100 (47.1%), SU50 (33.4%) and control as sole water (Fig 2a). GY100 and GY50 were more effective to reduce soil EC_e to 0.9 and 1.6 dSm^{-1}, respectively (Fig 2b). Soil pH showed a reduction to 7.5 (SU100), 7.8 (SU50), and 8.1 - 8.4 (GY100, GY50, control) (Fig 2c).

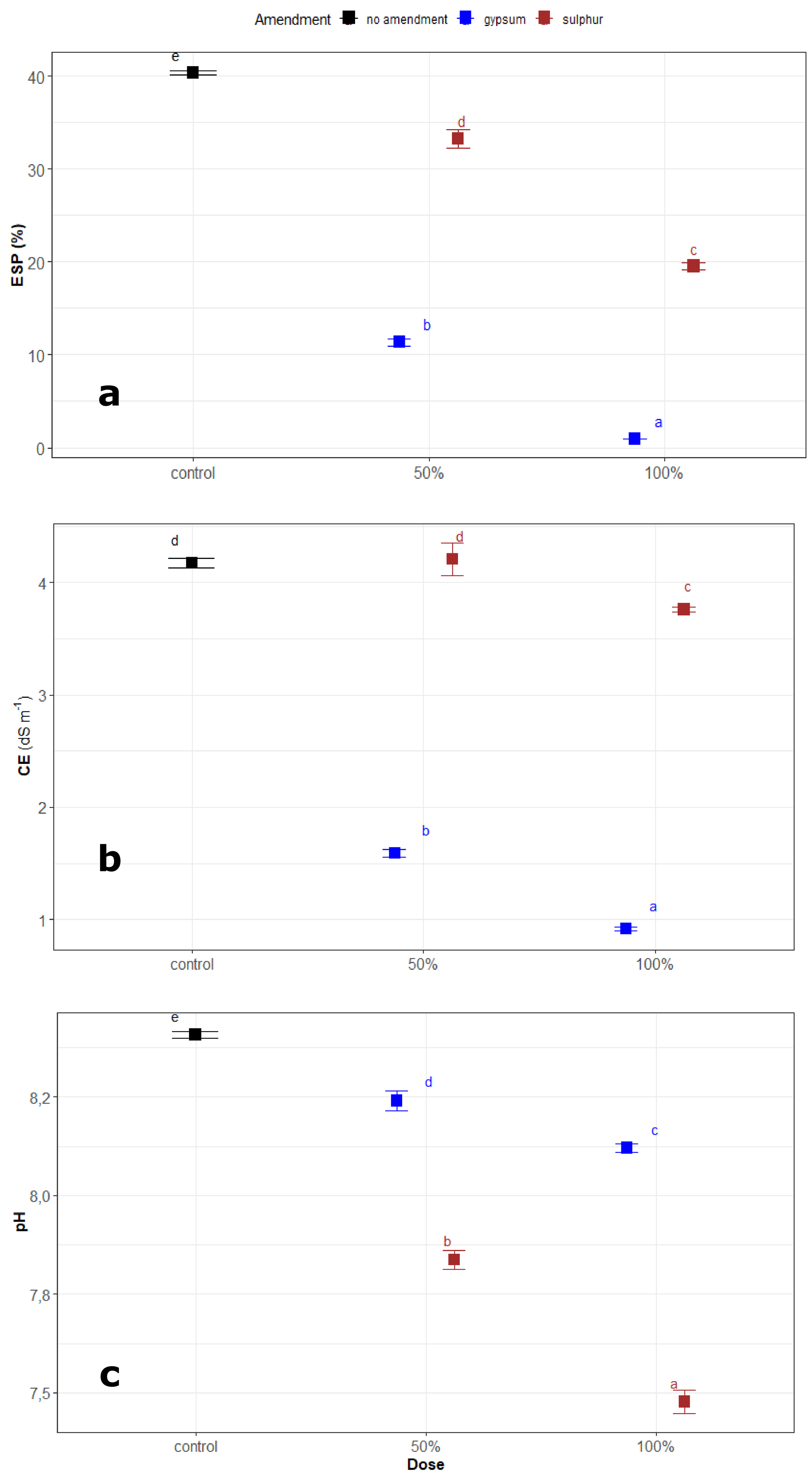

Fig 2. Soil ESP (a), EC_e (b) and pH (c), for the interactions between chemical amendment (gypsum, sulphur) and dose (50, 100%). Means with different letters are significantly different (Tukey, P<0.05). The bars indicate the SE.

The evolution of Na^+_c in the leachates was higher at the first lixiviation (900 -1200 $mmol_c L^{-1}$) for all treatments except control, but from the second to fourth cycle there was a minimum increase (Fig 3a). The EC showed similar behavior as Na^+_c in a range of 45 - 58 dSm^{-1} at first cycle (Fig 3b).

DISCUSSION

GY100 was more efficient to reduce the initial soil ESP by >98% and EC_e by >95%, followed by GY50, confirming the influence of Ca^{2+} on displacing Na^+, also for washing soluble salts through lixiviation, besides the indirect effect for improving the infiltration. SU was less efficient, probably due to the short incubation time and the low soil OM, but was more effective to improve soil pH maybe due to the acidic counteracting effect. Results agree with those obtained by Qadir *et al.* (1996), Tavares *et al.* (2011), Manzano *et al.* (2014) and Ahmed *et al.* (2016). Evolution of Na^+_c and soluble salts in the leachates was congruent with soil amelioration. The salinity-sodicity was considerably decreased at the first lixiviation in >90%.

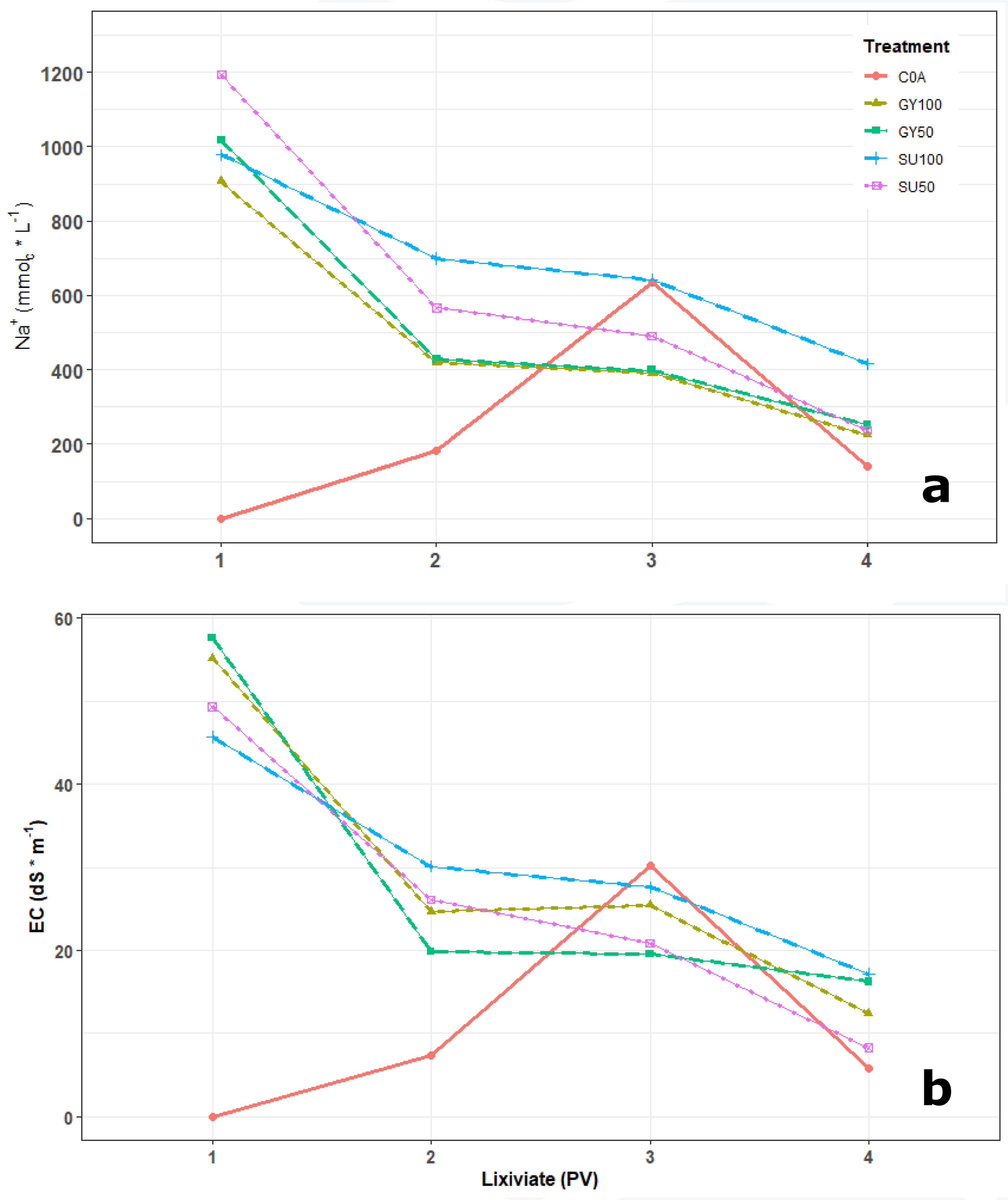

Fig 3. Evolution of Na^+_c (a) and EC (b) at each lixiviation for the interactions between chemical amendment (gypsum, sulphur) and dose (50, 100%)

CONCLUSIONS

GY100 was the most effective to improve soil ESP and EC_e also reaching the thresholds from the classification, followed by GY50 > SU100 > SU50. SU was more efficient to decrease the pH. Up to two lixiviations might be sufficient to remediate the soil.

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