Reclamation of saline-sodic soils with gypsum and sulphur

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Introduction, scope and main objectives

Saline-sodic soils have an excessive amount of sodium (Na^+) and soluble salts, and can be 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 percent and EC_e >4 dS/m. Loss of soil structure and osmotic stress in plants are some of the negative effects of salinity-sodicity, which can be treated by leaching with water and adding chemical amendments as gypsum (GY) as a source of Ca^{2+} to replace the Na^+ in the exchange complex. Sulphur (SU) as an alternative, is oxidized by microbes forming sulfuric acid to dissolve the calcite. The aim of the soil-column experiment was to evaluate the effect of GY and SU at two levels (50 percent, 100 percent) on reclamation of a saline-sodic soil from the High Valley of Cochabamba (Bolivia).

Methodology

The initial soil properties (20 cm) were: EC_e 20.5 dS/m, ESP 66.6 percent, pH 10.2, BD 1.3 g/cm^3, CEC 5.0 cmol$_c$/kg, OM 0.6 percent, clay 18.2 percent, silt 52.1 percent and sand 29.7 percent. The purity of GY was 92 percent (Ca^{2+} 18.5 percent) and 97.5 percent for SU. The GY requirement to reduce initial ESP to 15 percent was calculated through the equation of Hoffman and Shannon (2007) and for the SU was 5.38 times GY requirement (Richards *et al.* 1954). Fifteen soil columns (PVC tubes–15 cm Ø) were filled with 6.7 kg of soil (4 mm sieve) and 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) using the formula of 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 by Sumner, Rengasamy and Naidu (1998). Treatments were evaluated as factorial using LSD–Tukey adjustment.

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 percent followed by GY50 (55.2 percent), SU100 (47.1 percent), SU50 (33.4 percent) and control (26.3 percent) as sole water. GY100 and GY50 were more effective to reduce soil EC_e to 0.9 and 1.6 dS/m, respectively. SU100, SU50 and control, lowered EC_e in same magnitude (3.8–4.1 dS/m). Soil pH showed a reduction to 7.5 (SU100), 7.8 (SU50), and 8.1–8.4 (GY100, GY50, control). The evolution of Na^+_c in the leachates had higher concentration at the first lixiviation (900–1200 mmol$_c$/L) for all treatments, but from the second to fourth cycle there was a minimum increase. The EC showed similar behavior as Na^+_c in a range of 45–58 dS/m at first cycle.

Discussion

GY100 was the most effective to reduce the initial soil ESP by >98 percent and EC_e by >95 percent followed by GY50, confirming the influence of Ca^{2+} on displacing Na^+, besides the effect of washing soluble salts through lixiviation and the indirect effect of GY to improve the infiltration. SU was less efficient probably due to the insufficient incubation time and the low soil organic matter, 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 reduced at first lixiviation in >90 percent.

Conclusions

GY100 was 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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