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Sulfur efficiency application on soybean in two types of Oxisols

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Abstract
To assess the effect of Sulphur on soybean yield and to establish critical levels of $S\text{-}SO_4^{2-}$ available in Typic Haplorthox and Typic Eutrorthox soils, respectively. The experimental design was randomized blocks with five S rates. The maximum estimated yields on average for the two years were obtained with application of 49.9 and 63.0 kg ha^{-1} in the Typic Haplorthox and Typic Eutrorthox soils, with $S\text{-}SO_4^{2-}$ concentrations in the 0–20 cm depth of 16.9, and 19.3. In turn, at the 21–40 cm depth, the S concentrations were 49.5, and 74.2 kg ha^{-1}.

INTRODUCTION

The adoption of varieties having high productive potential, besides needing suitable management techniques, requires application of fertilizers and soil correctives to increase the yields of various crops. However, the use of concentrated fertilizers can cause symptoms of deficiency of some nutrients, such as sulfur (S). In the case of soybean, Brazil's leading agricultural export (Fageria et al. 2011), fertilization with this element is of great importance because of this crop's higher demand than grasses (Jamal et al. 2010) – 6.0 kg of S for each 1.0 t ha^{-1} of soybean produced, and the fact that 90% of tropical soils, especially those in Cerrado regions, have sub-critical concentrations. For soybean, the definitions of the sufficient levels of $S\text{-}SO_4^{2-}$ in the soil in tropical and subtropical conditions were established based on only a few experiments (TPS 2011). These studies show, as expected, that crops grown in soils with low OM and clay concentrations are more likely to respond to application of sulfate fertilizers. The objective of this study was to determine the relationship of the S rates and concentration of $S\text{-}SO_4^{2-}$ available in the soil at depths of 0–20 cm and 21–40 cm with the productivity of soybean in two types of soil (Typic Haplorthox and Typic Eutrorthox) in the subtropical region of Brazil.

MATERIALS AND METHODS

Two experiments were conducted under field conditions in two consecutive years, in the municipalities of Londrina (23°18'36" LS and 51°09'46" LW), in a Typic Eutrorthox, and Ponta Grossa (25°05'42" LS and 50°10'43" LW), in a Typic Haplorthox, located in the Paraná State, Brazil. Six months before sowing, the 0–20 cm layer of the fields was fertilized by broadcast with incorporation with dolomitic limestone. The experimental design was randomized blocks with five S rates (0, 25, 50, 75 and 100 kg ha^{-1}) and four replicates, applied in the form of elementary S with 98% purity. After physiological ripening in both years, the plants in the five central rows of each plot were harvested to determine the grain yield (kg ha^{-1}) and 100-seed weight. Then soil samples from each treatment were collected at the 0–20 cm and 21–40 cm depths to determine the available $S\text{-}SO_4^{2}$. The data on soybean yield, 100-grain weight and concentrations of $S\text{-}SO_4^{2-}$ available in the two soil types were tested for normality and then submitted to analysis of variance and F-test for statistical significance of treatments effects. The regression analysis were performed at the 5% probability level.

RESULTS AND DISCUSSION

In the first planting year, before application of the treatments at the 0–20 cm depth, the concentrations of $S\text{-}SO_4^{2-}$ available in the two soils were above the sufficiency level of 10 mg kg^{-1} recommended by TPS (2011) for soybean grown in tropical soils with clay content above 400 g kg^{-1}. Even considering the average uptake and exportation of 15 kg of S for each metric ton of grain produced, in the control plot (without S) after the first and second growing years the concentration of available $S\text{-}SO_4^{2-}$ remained above the adequate, while at the 21–40 cm depth it was at or slightly below the sufficiency concentration of 35 mg kg^{-1}. Even with application of S only before the first planting, the concentrations of $S\text{-}SO_4^{2-}$ in the 0–20 cm and 21–40 layers of both soil types cm remained above 10 mg kg^{-1} and 35 mg kg^{-1}, respectively. At the 21–40 cm depth, the $S\text{-}SO_4^{2-}$ concentrations were always higher than those in the 0–20 cm depth. The presence of high OM content in the surface layer reduces the adsorption of $S\text{-}SO_4^{2-}$ by oxides, increasing the quantity of negative charges with the elevation of the pH with the release of the adsorbed sulfates (Raij 2011). The concentrations of available $S\text{-}SO_4^{-2}$ (0-20 and 21-40 cm) were significantly influenced by the S rates, with a linear increase in the areas sampled ($\hat{y} = 11.50 + 0.114x$, $R^2 = 0.68$ and $\hat{y} = 28.76 + 0.169x$, $R^2 = 0.88$). Even with broadcast application, at the 21–40 cm depth the angular coefficient was greater than at the 0–20 cm depth, indicating the presence of vertical movement of the element in the soil profile. The soybean yields from the two soil types were significantly increased with the application of S (Figure 1). On average over the two years, the application of 49.9 kg ha^{-1} of S in the Typic Haplorthox and 63.0 kg ha^{-1} of S in the typic Eutrorthox resulted in the highest estimated yields, corresponding to 3,031.6 kg ha^{-1} and 2,925.7 kg ha^{-1}, respectively, while on average for the two soils the rate was 56.4 kg ha^{-1} of S for estimated productivity of 3,022.6 kg ha^{-1}. Considering that at the 0–20 cm and 21–40 cm depths, the critical available S-SO_4^{2-} levels are 10 mg kg^{-1} and 35 mg kg^{-1} for tropical and subtropical soils with more than 400 g kg^{-1} of clay (TPS 2011), the concentrations of 16.9 mg kg^{-1}(typic Haplorthox), 19.3 mg kg^{-1} (typic Eutrorthox) in the 0–20 cm layer in both years to obtain maximum estimated potential yield (Figure 2) are well above that indicated as adequate (TPS 2011). The same result was observed in the 21–40 cm layer, with higher estimated yields obtained with S-SO_4^{2-} concentrations of 49.5 and 74.2 mg kg^{-1}, respectively. Regardless of the soil type, cultivar and year of evaluation, the 100-grain weight was not influenced by the treatments.

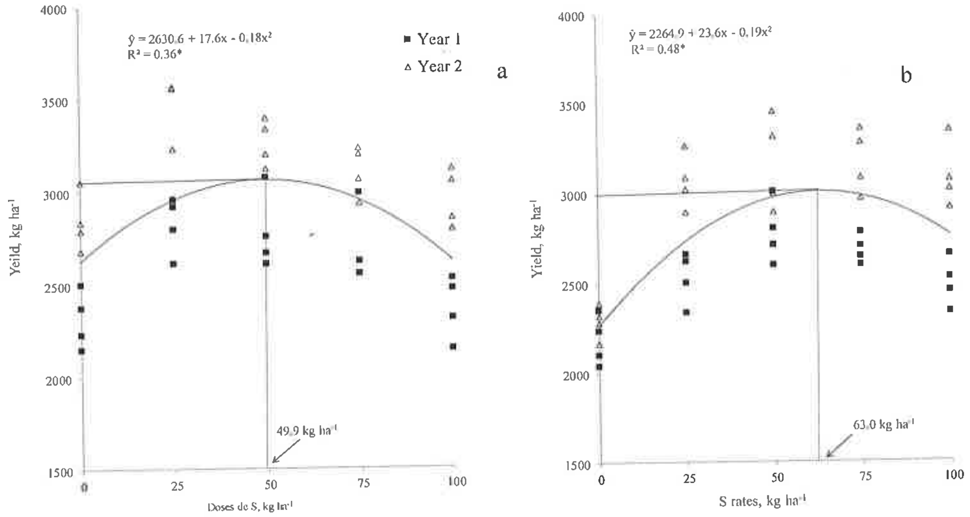

Figure 1. Soybean grain yield in a Typic Haplorthox (a) and Typic Eutrorthox (b) in two years of harvest and S rates applied (kg ha^{-1}). * Significant at 5% probability.

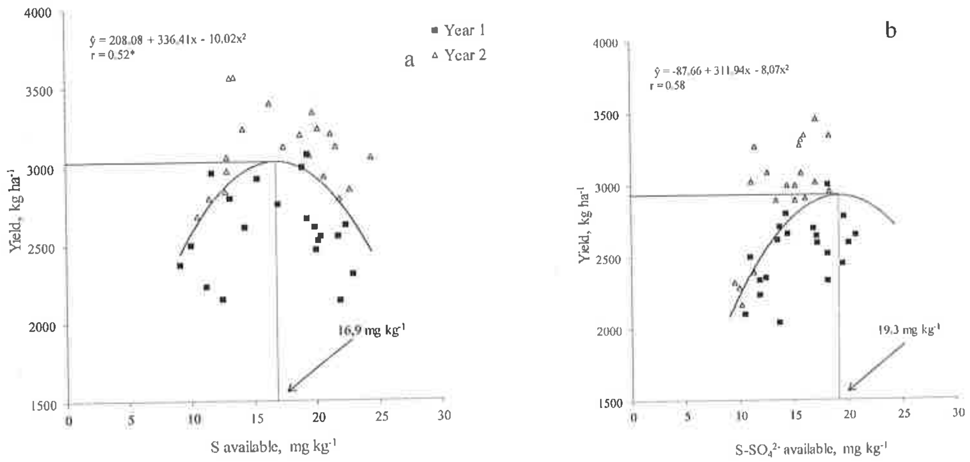

Figure 2. Soybean grain yield in a Typic Haplorthox (a) and Typic Eutrorthox (b) in two years of harvest in response of concentrations of S-SO_4^{2-} (mg kg^{-1}) applied in the soil. *Significant at 5% probability.

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