Managing High pH Soils for Crop Production

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Introduction

The Everglades Agricultural Area (EAA) in south Florida consists primarily of Histosols that were drained in the early 1900s and converted to sugarcane and vegetable cropping. These soils contain low P and micronutrient concentrations that require supplemental fertilization. Underlying these organic soils is limestone (Fig. 1), and due to the conversion of land use from seasonally-flooded wetlands to agricultural use, oxidation has occurred at 1.5 cm yr^{-1}. The depth of the soil has declined considerably to the point of causing significant interaction with the underlying bedrock leading to elevated concentrations of limestone mixed into the surface soil (Fig. 2). Cultivation of these drained peatlands, specifically the use of tillage and extensive soil preparation (Fig. 3), has resulted in incorporation of bedrock $CaCO_3$ into soil, which has increased the pH from the historic 5.0-5.5 to approximately 7.0-7.5 today. Subsequently, these soil pH increases have decreased P and micronutrient availability to crops and necessitated new fertilizer management practices or use of soil pH amendments.

Everglades wetlands of south Florida are traditionally P limited and sensitive to small increases in P loading. Reducing P export from the EAA is critical to fulfilling the emerging interests of protecting water quality and restoring south Florida ecosystems. Due to the increases in pH and the decreasing depth to bedrock of soils in the EAA, use of S application to counteract the rising pH may increase in the future. Therefore, a better understanding of how S influences pH and P distribution and availability is the objective of this study.

Results

Elemental granular S (90%) was applied to Dania muck (euic, hyperthermic, shallow Lithic Haplosaprist) at rates of 0, 112, 224, and 448 kg S ha^{-1} to the furrow and covered after planting. Soil samples were collected before planting and fertilizer application and then throughout the year, corresponding to approximately 0, 2, 6, 9, and 13 months after planting, respectively.

Overall, S application within the range of 0 to 448 kg S ha^{-1} did not significantly reduce soil pH. Labile P is commonly considered the most biological available form of P and consistently represented the smallest fraction of total P throughout the growing season, decreasing from 1.1% to 0.3% from 2 to 13 months. Labile P was significantly higher in soils receiving 448 kg S ha^{-1} (13 mg P kg^{-1}) compared to soils receiving 112 (6 mg P kg^{-1}) and 224 kg S ha^{-1} (6 mg P kg^{-1}). Phosphorus concentrations in the Fe-Al bound fraction displayed a clear declining pattern during the growing season. Phosphorus stocks in the Ca-bound fraction were much higher than those of labile and Fe-Al fractions, contributing 28-35% of the total P as a result of high Ca concentrations in the soil. Residual P was the most abundant P fraction for all sampling times, accounting for 47-51% of the total P. Sulfur application at 448 kg S ha^{-1} promoted P accumulation in labile P and Fe-Al-P fractions, suggesting increased P availability to crops and as well as potential increased risk of P export.

Sulfur application also had effects of enzyme activities in the short-term. The S application effect on phosphatase activity was significant, yet the effect was only observed at 2 months after S application. Glucosidase activity significantly increased at 2 months, averaging 15, 56, 58, and 99 mg MUF kg^{-1} h^{-1} for the increasing S application rates. Microbial biomass C and N were not altered as a result of S amendment, but did fluctuate during the growing season dependent on temperature patterns. Microbial biomass P increased significantly at 2 months at the highest S rate (177 mg kg^{-1}), which was about 3 times higher than for lower S application rates. Soil oxidation rates, and N and P mineralization, did not differ between soils receiving variable S application rates.

Conclusions

Application of elemental S at 448 kg S ha^{-1} increased P availability at 2 months, which subsequently stimulated some enzyme activities and simultaneously promoted labile P to be immobilized in microbial biomass. However, these effects were temporary and not observed beyond 2 months. Organic P was the major form of P in this soil, averaging 63% of total P, while the Ca-P fraction dominated the inorganic pools, contributing 32% of total P. Total P concentrations in the surface soil decreased significantly at the end of growing season as a result of considerable reduction in inorganic P, especially labile P and Fe-Al-P, which comprised of the majority of available P for crops. Under current crop production, organic P in this soil is susceptible to oxidation and a potential source for P loss. Application of S at rates up to 448 kg S ha^{-1} introduced limited effects on reduction in soil pH, yet it promoted P accumulation in labile and Fe-Al bound fractions, which increased P availability and as well as the risk of P export from these two fractions. The pool of Ca-P was relatively stable under current S application guideline and rates. Higher S rates than currently recommended may overcome the soil's buffering capacity and consequently release large amounts of P from the Ca-bound pool and pose an environmental hazard, so it must be well evaluated.

Figure Captions

Fig. 1. Only about 2 feet of soil remain at some sites within the Everglades Agricultural Area as a result of years of oxidation.

Fig. 2. Subsidence has increased calcium carbonate levels in the soil surface.

Fig. 3. Tillage and crop management practices also contribute to the rising pH in these Histosols.