Effect of Reduced Soil pH with Sulfur on Available Soil Phosphorus in High pH Sandy Soils of South Florida[1]

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Introduction

This document addresses the effect of moderating soil pH by using sulfur amendments in high pH soils and discusses their relationship to both nutrition and fertilizer management. The objectives of this document are to:

- Determine the effect sulfur amendments have on lowering soil pH and the length of time moderation can be expected to continue.
- Describe the impact of sulfur application on nutrien management and crop phosphorus availability.

The target audience for this series dealing with citrus nutrition includes Certified Crop Advisers; citrus, vegetable and sugarcane producers; fertilizer dealers; and other parties interested in crop fertilization practices.

Soils in south Florida are sandy mineral soils, predominantly Spodosols, and have low organic matter. These soils also have low nutrient retention capacity above the Bh or spodic horizon, which is typically less than one meter below the soil surface. After many years of vegetable production, the sandy horizons above the spodic of many soils have increased soil pH (greater than 7.3) and high Ca (Morgan, Sato, and McAvoy 2009 and 2010). Under these soil conditions, fertilizer P goes into a solution and is initially available for crops. However, P in a solution quickly forms water-insoluble precipitates in soil with high pH and high Ca concentrations (Bieleski 1973; Nair and Harris 2004). These P-Ca precipitates do not form in soils with lower soil pH (less than 7), even in the presence of high Ca concentrations (Gartley and Sims 1994). Phosphorus from P-Ca precipitates was not readily available to crops, and the P reduced its leaching potential because it dissolved very slowly in water and only in water with low soluble P concentrations (Graetz and Nair 1995). Thus, once formed, P from P-Ca precipitates may take many years to dissolve into the soil solution (Rhue and Everett 1987).

The objective of our field demonstration project was to determine the effectiveness of lowering soil pH as a best management practice (BMP) to increase P availability and reduce fertilizer P applications. Specifically, the projects assessed plant uptake from existing soil P on marketable yield and assessed quality of the crops by lowering soil pH. In this project, plant biomass, tissue P concentration, soil pH, soil P concentration, and yield for vegetable crops grown under commercial conditions were determined. Crop growth and productivity in plots of selected P application rates and pH levels were compared with plots receiving selected rates of S in the planted row.

Methods and Materials

Four demonstrations were conducted at two grower fields near Immokalee in Hendry County, Florida. Three tomato (*Solanum lycopersicum* L.) crops were planted on October

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29, 2008, March 4, 2009, and November 24, 2009, and one green bean (*Phaseolus vulgaris* L.) was planted on February 9, 2010. Soil types at all locations were Immokalee fine sand. Phosphorus and elemental S were applied in the bottom mix before bedding, and they were incorporated in the soil during the pre-bedding and bedding operation. Treatments were applied by adjusting the P_2O_5 content of the bottom mix to provide P at 120, 90, 60, and 0 pounds per acre for tomato and to provide 80, 60, 40, and 0 pounds per acre for green beans. Approximately 20% of the total N and K were applied in the bottom mix, and the remaining 80% was applied in the top mix. The top mix was applied in grooves on the right and left shoulders of plant beds as they were formed. The top mix did not contain any fertilizer P. For soil pH moderation in the bottom mix, elemental S was applied to plots with S at 500, 250, and 0 pounds per acre, which restricted the soil volume receiving S in the bed of soil and protected it from runoff by the polyethylene mulch. All treatments received N at 225 pounds per acre and K at 280 pounds per acre. The experimental design at each location was a split-plot design with four replications. The P rate was the main plot that consisted of six rows by 120 to 300 feet, and the S treatment was the subplots that were spaced evenly over the length of each set of six rows.

Soil samples were taken from each plot before bed preparation at 30-day intervals after planting. The soil pH of each sample was determined using water extraction at a ratio of 1 part soil to 10 parts water. Soil P concentration was determined using Mehlich-1 soil extraction. Starting 30 days after planting, plant dry biomass was determined by collecting the aboveground tissue from plants on 10 feet of row and drying it before calculating its weight. This was done in 30-day intervals. Yields were determined from two 10-ft lengths of row and weighed in the field.

Results of Soil pH Moderation Studies

Data were reviewed to determine if sulfur addition at planting affected soil pH during the life of the crop, which resulted in the statistically highest yields than for non-amended soils (no S treatments).

When statistically similar yields were obtained with amended and no S treatments, data were reviewed to determine if these yields were obtained at lower P_2O_5 rates for the amended soils. General trends indicated that soil pH returned to nearly equal to those prior to sulfur application within 60 days after planting. Dry plant biomass significantly increased with S application rates at 30 days after planting compared with the non-amended plots. Specific yield, growth (biomass), and soil P observations at the end of the season for tomato and green bean crops with sulfur amendment treatments are provided below:

Tomato: One of the sites was substantially affected by freezing temperatures, and results were not representative. For the remaining two demonstrations, statistically similar highest yields were obtained in the amended soils and non-amended soils. Thus, the P_2O_5 rate to achieve these highest yields was not lower in the amended soils. The highest biomass levels were statistically similar across amended and non-amended soils. For plant biomass, these levels were generally observed at the same P_2O_5 rates, despite amendment. The statistically highest soil P levels were all associated with the 100 and 75 pounds per acre P_2O_5 rate, despite the level of sulfur amendment.

Green bean: For the single green bean demonstration, statistically similar highest yields were obtained at the zero P_2O_5 rate in amended soils as with the 40 pounds per acre P_2O_5 rate in soils that were not amended, indicating improved P uptake with lower soil pH. Statistically similar highest plant biomass was observed with no P applied for non-amended soils sand with 40 pounds of P_2O_5 pound per acre rate. There were no statistically significant differences between soil P for amended and non-amended soils, indicating no effect of soil pH on soil P at the end of the season.

Conclusions

Results from only two tomato and one green bean demonstrations were available for observing the effect of lowering soil pH with sulfur on phosphorus availability. Lowering of soil pH increased biomass initially (30 days after planting) but did not increase biomass or yield at the end of the growing season. These results can be explained by the effects of sulfur on soil pH during the life of the crop. While adding sulfur to the soil clearly lowered soil pH less than 7 and allowed for greater availability of P left in the soil from previous crops, pH moderation lasted only 30 to 60 days. At harvest, the pH amended soil P was not significantly lower than the non-amended block soil P, and the P_2O_5 rates resulting in statistically highest soil P levels were the same. Statistically, similar highest green bean yields were obtained with lower P rates when soils were amended (no P applied) than with 40 pound of P_2O_5 per acre in non-amended soils.

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