Vegetarian Newsletter

A Horticultural Sciences Department Extension Publication on Vegetable and Fruit Crops

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Issue No. 558 June 2010

Elemental Sulfur Use for Increasing Phosphorus Availability to Lettuce in Everglades Agricultural Area Soil

By: Alan L. Wright, Yigang Luo, Nikol Havranek, David D. Sui, Ronald W. Rice, and Rongzhong Ye

Everglades Research & Education Center, Belle Glade, FL

The Everglades Agricultural Area (EAA) in south Florida was historically a seasonally-flooded wetland ecosystem but was converted to agricultural use by drainage in the early 1900s. Vegetables have been grown on these soils since that time. Early scientists at the Everglades Research & Education Center in Belle Glade observed that crops often failed to yield unless supplemented with micronutrients, especially copper, which was deficient in these soils. Further research optimized fertilizer use and management for many types of vegetable crops in the region, including sweet corn, beans, lettuce, and celery. These organic soils are typically sufficient in nitrogen and while some starter nitrogen is applied, supplemental fertilization of potassium and phosphorus, as well as manganese, iron, copper, and zinc, are regularly needed.

Subsidence of the organic soils in the region occurred soon after drainage, which led to decreases in soil depth to the underlying bedrock limestone. Some of the soils are becoming very shallow, and interaction with the underlying calcium carbonate has created conditions where particles of limestone are translocated into surface soils by tillage and evapotranspiration. The result is that the pH and nutrient retention capacity of these soils has increased, which tends to tie up nutrients, particularly P and micronutrients, in forms that are not readily available to crops.

Several options exist to remedy the situation: increase fertilization rates, optimize fertilizer placement, timing, and application method, and use of soil pH amendments. Increasing fertilization rates is effective, but adds to grower costs and may pose potential hazards to aquatic systems due to runoff or leaching of excess nutrients. Efforts are ongoing to evaluate how fertilizer placement, split application, foliar application, source material, etc., influence crop growth and yield. Another option receiving attention is the use of soil amendments to decrease pH, which has the effect of increasing available nutrient concentrations in soil. Elemental sulfur is a widely used amendment throughout the world for decreasing soil pH, and its use in the EAA is under investigation.

Prior research on these soils has demonstrated that high S rates are needed to reduce soil pH, but the results were only temporary. Contemporary results also confirmed that broadcast S application (500 lb/a) failed to increase nutrient availability or enhance crop yields (Wright, unpublished data). However, application of elemental S in narrow bands near crop rows has shown promise in increasing both nutrient availability and lettuce yield. Elemental S (wettable powder) banded at 200 lb/a showed an approximate 20% increase in romaine lettuce yield compared to unamended soil (Figure 1). Increasing the S rate above 200 lb/ac did not produce a greater yield response, although it did increase available P compared to lower S application rates and unamended soil. Thus, there appears to be some benefit of banded S application for increasing P availability and lettuce yield. This increase in P availability occurred within 2 weeks of application and was evident for 2 months. An interesting observation is that elemental S did not significantly change soil pH, yet it increased P availability. Sulfur application at 400 lb/ac decreased soil pH by 5% compared to the unamended control, but increased P availability by 100%. Thus, P was a much more sensitive indicator of S effectiveness than soil pH.

Elemental S reduces soil pH through its oxidation by soil microorganisms into sulfate (SO_4-), and this process results in the production of H^+ ions responsible for reducing pH. Since P adsorption in soil is dependent on pH, the temporary reduction in soil pH releases bound phosphates that are available for crop uptake. Meanwhile, the natural buffering capacity of the soil, mainly controlled by calcium carbonate, responds to the lower pH and acts to neutralize the soil acidity caused by elemental S oxidation. A short time after all elemental S is depleted and oxidized, the pH returns to its equilibrium point. However, the P released takes much longer to return to its equilibrium point and it remains in an available state longer until it is taken up by crops or adsorbed to soil. Thus, the benefits and effectiveness of elemental S use in the EAA are best evaluated in terms of its ability to maintain available P concentrations in soil rather than its effect on soil pH. To fully evaluate elemental S efficacy in the calcareous organic soils of the EAA, perhaps it is best to focus on changes in nutrient availability rather than on changes in soil pH, especially since soil nutrients rather than soil pH are responsible for the crop growth and yield response. Replication of this study is needed to confirm these observations. Other considerations for elemental S use in the EAA include evaluation of costs of elemental S versus yield benefits, as well as the environmental costs associated with potential sulfate losses from the EAA into the Everglades wetlands.

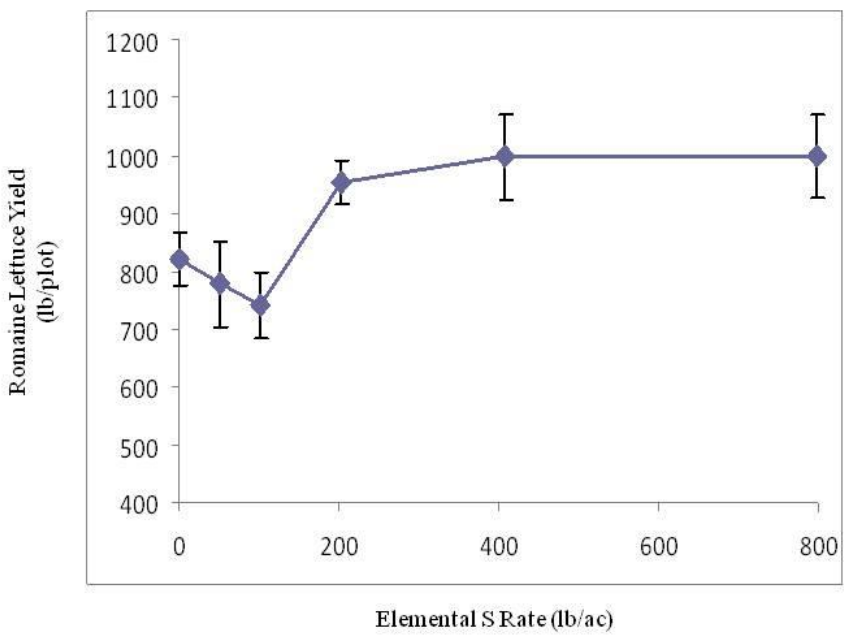

Figure 1. Response of romaine lettuce to elemental S application in Everglades Agricultural Area soil.