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Effects of Sulfur Fertilization Rates and Irrigation Programs on Tomato Growth and Yields

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There has been a renewed interest in S deficiencies because of the reduction in atmospheric depositions from the institution of clean air referendums across the world. A study was conducted from Feb. to June 2008 to determine the influence of S fertilization rates and irrigation programs on tomato (*Solanum lycopersicon* L.) growth and yield. The experiment was arranged as a split-plot with six replications, where irrigation program was the main plot and S rate was the sub-plot. The irrigation programs were 3528, 5292, and 7056 gal of water per acre per day. The S rates were 0, 25, 50, 100, 150, and 200 lbs S per acre. Irrigation program increased vigor early in the season before fruit set, but did not continue to influence visual vigor ratings as the fruit were set. At the first harvest of tomatoes, the rate of 25 lb/acre S increased yield by 1.3 ton/acre over the non-treated control. Increasing the S rate beyond 25 lb/acre S had less yield than 25 lb/acre S, but more than the non-treated control.

Sulfur is essential to the production of cysteine, and methionine amino acids in plant metabolism. It has been shown to play an important role in yield and quality of crops (Heeb et al., 2006; Pavlista, 2005; Rhoads and Olson, 2000). In the past, S was generally supplied indirectly through other fertilizers, such as superphosphate and deposition from the atmosphere. But during the past two decades, as the composition of fertilizers changed (high analysis and sulfur-free), crop production intensified, and SO_2 emissions decreased, S deficiencies have become a serious problem (Ceccotti et al., 1997). Crop plants obtain their S requirement from a number of sources: soil, crop residues, manures, irrigation waters, rainfall, the atmosphere, and soil amendments and fertilizers (Tabatabai, 1984). Also, sites without access to mineral-bound S sources may have sufficient S dissolved in soil water and shallow groundwater bodies available to plant roots (Eriksen et al., 1998). Yet, the S concentration of all irrigation waters used through the North American continent is unknown, and there has been little research reported that related the S content of irrigation waters to the requirement for S in a fertilizer program (Olson and Rehm, 1986). It has also been suggested by some that irrigation water in Florida, which can be aquifer or surface waters, has a rotten-egg smell commonly associated with S. This may often lead to the belief that S in the irrigation water is a S source for crop production.

Tomato production in Florida is typically on deep Spodosols (fine sand) with low organic matter (>2%) and therefore inherently low in organic and inorganic S. Previous studies on tomato and S have found that S sources (ammonium sulfate, ammonium thiosulfate, ammonium nitrate sulfate, potassium sulfate) were similar effect on tomato yield (Santos et al., 2007; Susila, 2001). Elemental S is a less expensive S fertilizer source when compared to other sources of S that contain nitrogen. Yet, limited information exists on using elemental S and irrigation programs to improve tomato yield and S content in Florida. Elemental S can be an ideal S source because it has high analysis of S insoluble in water and is stable in damp and humid conditions, yet it has to be oxidized to SO_4-S for plant uptake (Solberg et al., 2003).

It has been suggested that to achieve high yields and to minimize S leaching, rates of fertilizer S should be recommended on the basis of available soil S and crop requirement (Scherer, 2001). Therefore, the goal of this study was to investigate irrigation program and S rates on Florida sandy soils and to determine their effect on fresh market tomato growth and yield.

Materials and Methods

Two field studies were conducted at Gulf Coast Research Education Center on a Myakka fine sand (sandy siliceous hyperthermic Aeric Alaquods) for two seasons (Mar.–July 2008 and Aug–Dec. 2008). All crop management was conducted according to current recommendations for tomato (Olson et al., 2008). Soil was fumigated with 50:50 (v:v) methyl bromide to chloropicrin mixture at 170 lb/acre using metalized polyethylene mulch on 14 Feb. 2008. Tomato seedlings ('Tygress') were transplanted on 6 Mar. 2008 and 28 Aug. 2008, 21 d after soil fumigation into raised beds (8 inches high and 28 inches wide). The experimental design was a split block with six replications. This design allows for more precision to be given to the factor that is the sub-plot. Therefore, the main plot was irrigation and the sub-plot was S rate (0, 25, 50, 100, 150, and 200 lb S per

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acre). Sulfur rates were applied pre-bedding for the raised beds as elemental S (0–0–0–90S). All other nutrients were at rates recommended based on soil test results (Olson et al., 2008) using a 6–2–8 (N–P–K) liquid fertilizer.

The following variables were collected: soil samples before fumigation, 5 and 13 WAT in Season 1, and 4 and 15 WAT in Season 2 for soil S and pH. Dried soil samples were sent to a commercial analytical lab in Camilla, GA, for SO_4 determination by turbidimetric method. Plant tissue samples for S were collected 5 and 13 WAT in Season 1, and 4 and 11 WAT in Season 2. Dried and ground tissue samples were sent to a commercial analytical lab in Camilla, GA, for total S determination by ICP. Soil samples were held at 40 °F and tissue samples at 0 °F until shipment to the commercial lab for analysis. Soil moisture was monitored every other week for 5 d using a time domain reflectometry probe (TDR). Tomato fruit were harvested 12 and 13 WAT in Season 1, and 11 and 14 WAT in Season 2 at the mature green stage, and graded according to size: extra large, large, and medium round tomatoes (5 × 6, 6 × 6, and 6 × 7, respectively).

Statistical analysis was conducted to determine variability and similarity of results. The statistical analysis used analysis of variance to determine significance of treatments and regression models were fitted to significant data using SigmaPlot (Systat, 2008).

Results and Discussion

There were no interactions found between irrigation program and S rates for any variable collected. Soil SO_4-S and soil pH were not influenced by either irrigation program or S rate. As stated by Solberg et al. (2003), elemental S fertilizers require oxidation time to plant-available SO_4-S. The oxidation of elemental S is highly dependent upon soil conditions that are favorable to soil microbe metabolisms which are involved in the S cycle. The increase in irrigation rate unexpectedly did not influence soil SO_4-S or soil pH. This suggests that soil C or soil substrates may be the limiting factor of S oxidation in Florida sandy soils.

There was a seasonality effect of S applications on leaf S concentration. Leaves collected in Season 1 were influenced by S rates (Fig. 1), which ranged from 0.54% to 0.57% S dry weight basis. These levels are within range for leaf S for tomatoes as stated by Olson et al. (2008), and also within the range of those reported in previous studies (Susila, 2001). Early tomato yield was also influenced by S rates only (Fig. 2). Increasing S applications from 0 to 25 lb/acre improved early yield by 1.3 ton/acre over the non-treated control. This is equivalent to one hundred 25-lb boxes more per acre in early yield with adding 25 lb/acre than not adding any S. These results were similar to those reported by Santos et al. (2007), and Susila (2001), where S applications increased in yield of tomatoes.

Irrigation program did not influence soil S concentration, soil pH, S concentration within tomato leaves, or early yield. This suggests that irrigation water may not meet the S needs of tomatoes when grown with drip irrigation. It is possible that the form of S present within the irrigation water needs to be oxidized by microbes. An increase in tomato leaf S and early yield were found with the addition of elemental S to the fertilizer regime. Based upon these results, for tomato production S should be incorporated into the fertilizer regime to maximize early yield production of fresh market tomato.

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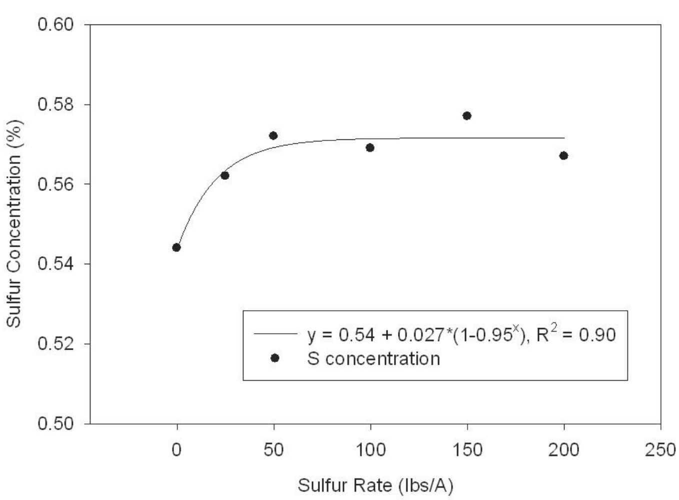

Fig. 1. Influence of elemental S rates on tomato leaf S concentration in Season 1.

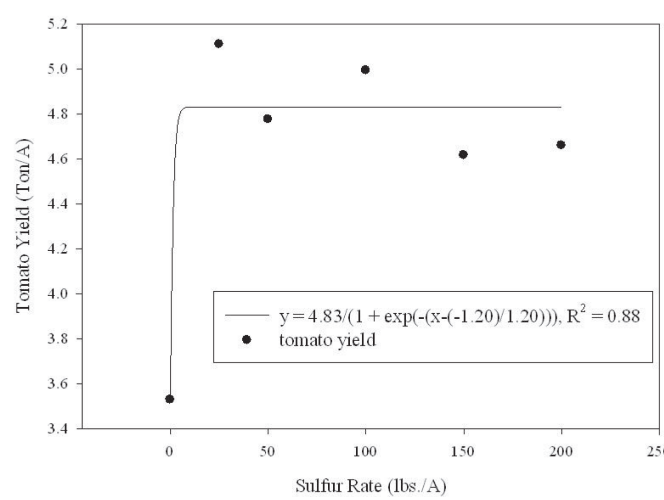

Fig. 2. Influence of elemental S rate on early yield of fresh market tomato both fall and spring seasons combined.

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