UF IFAS Extension UNIVERSITY of FLORIDA

SL398

Effect of Fertilizer Phosphorus Rate on Tomato and Green Bean Yield and Growth in High pH Sandy Soils of South Florida[1]

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Introduction

This document addresses the effect of phosphorus rate on tomato and green bean yield and growth in high pH soils and discusses their relationship to both nutrition and fertilizer management. The objectives of this document are to:

- Determine the effect of fertilizer phosphorus rate on yield and growth of dominate vegetable crops in south Florida.
- Describe the impact of soil pH and soil test phosphorus concentrations on nutrient 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 soil, 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. These sandy soils are typically low in water- and nutrient-holding capacities. Many farms containing these sandy soils border the Everglades Agricultural Area and ultimately drain into the Everglades. The Everglades Forever Act mandates that landowners ensure water leaving the agricultural areas do not exceed well-defined phosphorus (P) loads. After many years of vegetable production, the sandy horizons above the spodic of many soils have increased soil pH (greater than 7.3) and are high in Ca (Morgan, Sato, and McAvoy 2009 and 2010). Under these soil conditions, fertilizer P goes into solution and is initially available for the crops. However, P in solution quickly forms water-insoluble precipitates in soil with high soil pH and high Ca concentrations (Bieleski 1973; Nair and Harris 2004). Phosphorus from P-Ca precipitates was not readily available to crop plants, 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).

Fertilizer can be a large production cost to most farmers. Unfortunately, nutrients (including P) can also be major contributors to groundwater contamination. Current best management practices (BMPs) call to avoid excess nutrient application by determining P requirements of the soil and following crop-specific recommendations based on the analysis of soil for optimum crop response to added P. The current soil test extractant for standard P recommendations by UF/IFAS is Mehlich-3 with a moderate P index of 16

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to 30 parts per million. The moderate P soil test index is considered the breakpoint for fertilizer applications, with no positive growth or yield results associated with fertilizer P applications. Thus, UF/IFAS standard recommendation would dictate no P fertilizer should be applied if a Mehlich soil text of greater than 60 parts per million is obtained.

Management strategies, such as soil testing, should be used as a BMP in vegetable production to maximize crop yields and quality, while minimizing nutrient loss to the environment. The objective of a six-year field demonstration project was to determine the effect of fertilizer P rate on increased crop P availability and yield. In this project, plant yield, biomass, tissue P concentration, and soil P concentration for vegetable crops grown under commercial conditions were determined. Crop growth and productivity in plots of selected P application rates were compared.

Methods and Materials

Field demonstrations were conducted at grower fields near Immokalee in Hendry County, Florida. Tomato (*Solanum lycopersicum* L.) and green beans (*Phaseolus vulgaris* L.) were evaluated throughout a six-year period from 2005 to 2011. Soil types at all locations were Immokalee fine sand. Phosphorus was applied in the bottom mix before bedding, and it was 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 in the first three years (Phase 1: 2005 to 2008) at 0%, 50% and 100% of grower P_2O_5 application rates (ranging from 0 to 150 pounds P_2O_5 per acre). Application rates in the second three years (Phase 2: 2009 to 2011) were standardized at 0, 60, 90, and 120 pounds per acre for tomato and 0, 60, 40, and 80 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 experimental design at each location was a split-plot design with three replications in phase 1 and four replications in phase 2. The P rate was the main plot consisting of three to six rows of 120 to 300 feet.

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. Yields were determined from two 10-ft lengths of row and weighed in the field.

Results

The effects of using alternate rates of soluble P fertilizers on yield, biomass, crop growth, P tissue accumulation, and soils based on the 27 tomato and green beans demonstrations were evaluated during the 2006–2011 growing seasons. In order to consider statistical significance, the lowest P rates resulting in the significantly greater yield, biomass, P tissue levels, and soil P were reviewed.

Yield

Tomato

Results from 13 tomato demonstrations were available for analysis. Yields statistically increased with P application rates for only half of the demonstrations. Yields generally plateaued at rates lower than the grower-typical rates or the rate assuming low soil P (approximately 120 lbs/acre). On average, the optimum total relative yield was observed between 60 and 90 pounds of P_2O_5 per acre (Figure 1). Yields in five of 13 demonstration sites statistically increased with P application rates. When statistically higher yields were observed, they were generally with rates lower than the grower-typical rates or rates assuming low soil P (approximately 120 lbs/acre). The statistically significant highest total or the total extra-large yields were found in six sites at 90 and 60 pounds of P_2O_5 per acre of soluble fertilizer.

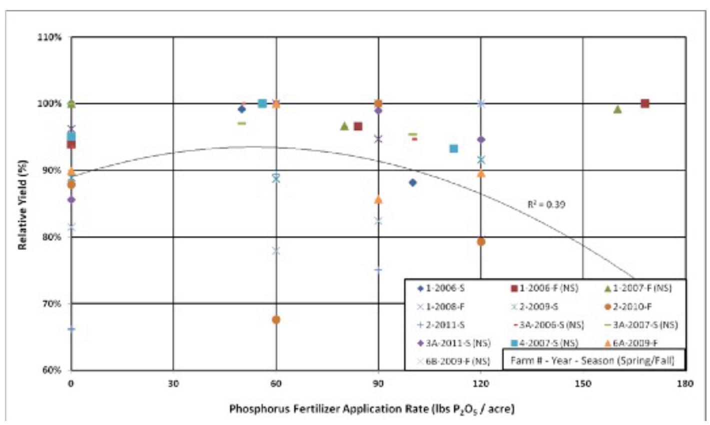

Figure 1. Percent of Maximum Yield for Tomato.

Green Bean

Results from 14 green bean demonstrations were available for analysis. Yields statistically increased with P application rates for only five of the demonstrations. In those cases, highest yields or large pod yields were observed with P rates greater than zero (Figure 2). Two sites were substantially affected by cold temperatures, and results are not representative. The average application rates resulting in the statistically significant highest total and large pod yields were 40 and 50 pounds P_2O_5 per acre.

For all demonstrations covered in this project, soil P at planting was measured at or greater than high levels based on the Mehlich-1 extractant (31 ppm P).

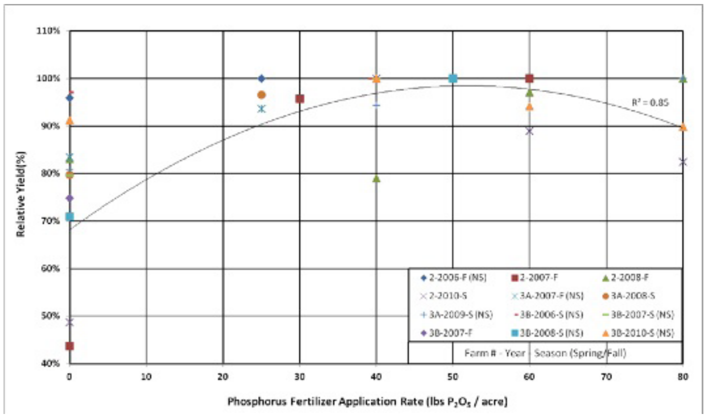

Figure 2. Percent of Maximum Yield for Green Beans.

Biomass Production

TOMATO

Eight of the 13 representative demonstrations had statistically significant total biomass results. The rates resulting in statistically highest total biomass varied from site to site from 0 to 90 pounds of P_2O_5 (Figure 3). When biomass was separated into component plant parts, significantly higher leaf biomass was observed with a varied range of application rates. The average lowest soluble fertilizer P rate required to produce the significantly highest total biomass or leaf biomass was at a rate of 60 and 90 pounds of P_2O_5 per acre, respectively.

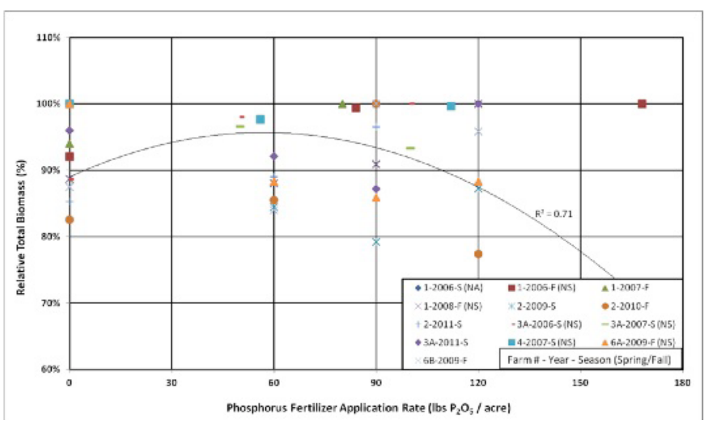

Figure 3. Percent of Maximum Biomass for Tomato.

GREEN BEANS

The total biomass in six of the 14 demonstration sites was significantly greater in sites at a rate of 25 pounds of P_2O_5 per acre (Figure 4).

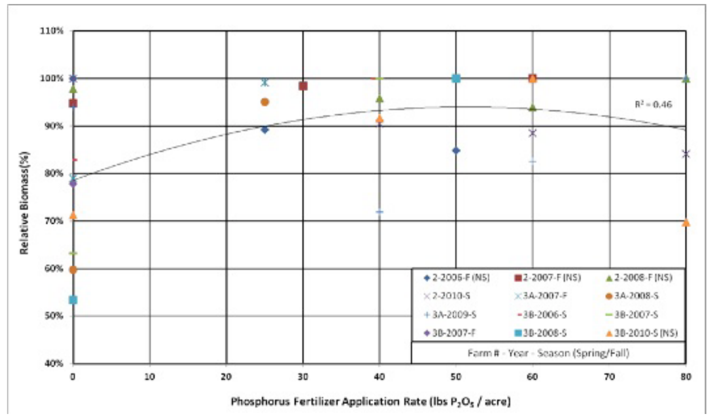

Figure 4. Percent of Maximum Biomass for Green Beans.

Soil Phosphorus Concentration at Harvest

Based on the Mehlich-1 extractant, statistically highest soil P levels at harvest were observed at application levels of 50 pounds P_2O_5 per acre and higher for tomatoes. For green beans, which use lower application rates, no consistent results were obtained.

TOMATO

At harvest, soil at 10 of the 13 fields recorded statistically higher soil P levels in plots receiving 50 pounds of P_2O_5 per acre or higher. On average for the representative sites, significantly higher soil P was observed at approximately 120 pounds of P_2O_5 per acre. It would appear as the effect of varying P application rates during the individual growing seasons can, but does not always, statistically affect soil P levels at harvest despite pre-plant conditions.

GREEN BEANS

Only three of the 14 representative demonstrations did not have statistically significant differences in soil P at planting, but one of these resulted in statistically significant soil P at harvest with a rate at 25 pounds of P_2O_5 per acre. Of the four sites with significant differences in soil P at planting, three reported no statistical significant differences at harvest or maintained the differences observed at planting.

P Tissue Levels

For both tomato and green beans, average tissue P accumulation during crop life was comparable at rates ranging from 60 to 120 pounds of P_2O_5 per acre. Leaf P concentrations met the sufficiency levels (0.2 to 0.4 ppm) at all application rates.

Conclusions

In a demonstration project, statistically higher yields were sometimes obtained with phosphorus application, despite soil P levels greater than the 60 parts per million thresholds for fertilizer P application. Tomato yields appear to have increased with increased P application rates in soils with Mehlich-1 soil P test results at planting in the range of 30 to 200 parts per million, suggesting the Mehlich soil P extracted during the demonstration project was still at the moderate- to low-P index. Although optimum yield responses vary from site to site, a preliminary finding was that fertilizer P may need to be applied to crops grown on soils with pH greater than 7.0 and high calcium at Mehlich-1 soil test P result of 200 parts per million or less. Total tomato relative yield appears to increase with P_2O_5 applications up to 80 pounds per acre within 123 to 146 parts per million pre-plant soil P levels and with P_2O_5 applications up to 40 P_2O_5 pounds per acre for pre-plant soil P levels greater than 147 parts per million.

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