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Improved Phosphorus Fertilization Practices of Desert Lettuce

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Introduction

Lettuce produced in the desert receives large annual applications of phosphorus (P) fertilizer. Amounts of P applied to lettuce often approach and exceed 200 kg P/ha and crop recoveries of P fertilizers are generally less than 20%. While much of the added P is converted to insoluble forms in the calcareous soils of the region (Porter and Sanchez 1992; Sanchez, 2007), some of it is carried in runoff and drainage water into receiving surface waters having adverse ecological effects (Izuno et al., 1991; 1995).

Over the past two decades, desert vegetable growers have been disinclined to reduce P inputs in agricultural systems due to large crop yield and quality responses and low fertilizer costs. However, erratic fertilizer pricing over the past three years has created incentives for improved efficiency. A little over one year ago, the costs of mono-ammonium phosphate (MAP), a formulation widely used for desert vegetable production, exceeded $1,200.0 per ton. Although costs have since declined, rapid increases are anticipated as the world economy recovers and resource demand in the developing world regains momentum. World P reserves are rapidly declining and there is concern that a shortage of P fertilizers will ultimately compromise world food production (Vaccari, 2009).

In addition, P fertilizers are a major source of cadmium (Cd) and uranium (U) input to agricultural systems. Recently, maximum levels of Cd in food crops are regulated in the European Union and regulations elsewhere are likely. The contents of Cd and U in P fertilizers used in the desert approach 150 mg/kg and 200 mg/kg, respectively, and a reduction in P fertilizer inputs may be required to reduce Cd and U exposure through food.

Research conducted in areas outside the southwestern desert has shown that a number of fertilizer management practices can be used to reduce P fertilization rates required for optimal crop yield and quality (Sanchez, 1990; Sanchez and Hanlon, 1990; Sanchez et al., 1990; 1991, 1995). These practices include soil test based fertilizer recommendations and exploitation of innovative placement technologies. Thus, abundant opportunities exist for improving P fertilizer use efficiency of cool season vegetables in desert crop production systems. The objective of this project is to evaluate P fertilization practices that reduce fertilizer costs to growers without compromising production.

Methods

<u>Soil Test P Studies</u>

These experiments were conducted in grower fields over the 2008-2009 season. Originally we had 11 sites, but two were lost to commercial crews that harvested through our experiment. Therefore, only data for nine sites are reported. For seven of these sites we compared an untreated control, a starter fertilizer (10 gallons of 7.5-26-0), and the grower rate of mono ammonium phosphate (11-52-0 or MAP). In two of these sites, we only compared an untreated control to a full grower rate of MAP. The wet date and harvest dates are shown in Table 1. For all experiments we collected composite soil samples from the entire plot area pre plant and from each experimental plot at harvest. We determined P colorimetrically after sodium bicarbonate extraction.

Lettuce was seeded in elevated double row beds on 3.5 ft (1.1 m) centers and thinned at the four-leaf stage. These plots were not replicated as we are using sites for replication. The lettuce was established by sprinkler irrigation. All subsequent irrigations were by furrow. Lettuce was harvested at maturity by cutting and weighing all heads from 20 ft (6 m) of double row beds. Marketable yields were determined after grading using standard practices. Relative yields without fertilizer were calculated by dividing the observed yield without fertilization by that present through the addition of fertilizer. In a few cases where yield was higher without fertilizer, we set values to 100%.

<u>P Rate and Placement Study</u>

The study was conducted at the Yuma Agricultural Center. The treatments included P rates of 0 to 150 kg P/ha applied broadcast and disked into the soil and treatments of 0 to 100 kg P/ha applied by band within the individual beds. Individual plots were 700 ft2 (65 m2) and were arranged in a randomized complete block design with four replications. Lettuce was seeded in elevated double row beds on 3.5 ft (1.1 m) centers and thinned at the four-leaf stage. The lettuce was established by sprinkler irrigation. All subsequent irrigations were by furrow. The wet date was Sept. 23, 2009. A composite soil sample of the plot area was collected pre plant and soil samples were collected from all broadcast plots at harvest. Midribs were collected at the early cupping stage for P analysis.

Lettuce was harvested at maturity (Dec. 22. 2008) by cutting and weighing all heads from 20 ft (6 m) of double row beds. Marketable yields were determined after grading using standard practices.

Results and Discussion

<u>Soil Test P Studies</u>

Lettuce yield response to P varied among the sites and much of the variation could be explained by the pre plant P soil test. Sites with soil test P values less than 30 ppm generally showed a large response to P fertilizer while the probability of a yield response to P fertilizer decreased as soil test P increased above 30 ppm (Figures 1 to 3). Please note the examples for experimental sites 3 and 8. For both these sites, soils test P levels were greater than 30 ppm and yield differences among P treatments were minimal. In contrast, in sites 5 and 7, where soil test P values were less than 30 ppm, lettuce yield responses to P treatments were large. Interestingly, in many cases the starter fertilizer alone produced yields close to the full rate of broadcast MAP.

The relationship between relative yield and pre-plant soil test P across all nine field experiments are shown in Figure 3. Relative yields were as low as 20% where soil test P levels were close to 20 ppm but exceeded 90% to 100% as soil test P levels increase above 30 ppm. Overall, these data show that pre plant P soil tests can be used to guide P fertilization rates. The common practice of applying 600 kg/ha MAP, regardless of soil test P level, cannot be justified in light of the effectiveness of soil tests in assessing plant available soil P and the erratic costs of P fertilizer.

<u>P Rate and Placement Study</u>

These data show lettuce yields increased by P rate. In past studies we have found that band P placement is an effective means of improving P fertilizer use efficiency (Sanchez, 1990; 1919). However, because lettuce yields were generally maximized by a low P rate (50 kg P/ha) in this study we could demonstrate the benefits of banding in this particular experiment. Additional work aimed at evaluating P placement is in progress. Although band P placement seemed to increase tissue P a little, the differences were not statistically significant.

Literature Cited

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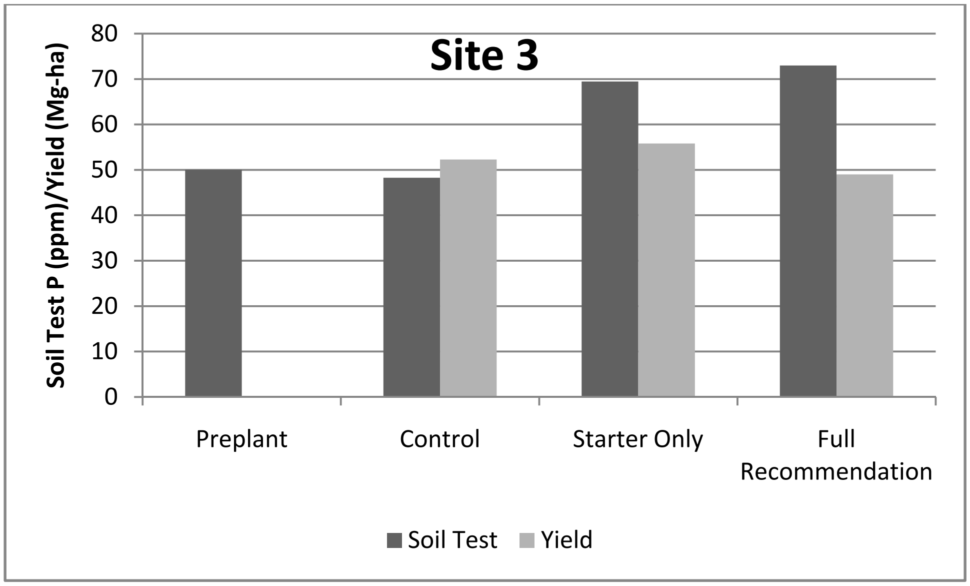
Table 1. Pre plant soil test P levels, cultivar, wet dates, and harvest dates for soil test P studies during 2008-2009.

Site	Preplant Soil Test P (ppm)	Cultivar	Wet Date	Harvest Date
1	32.4	Sun Devil	9/22/08	12/05/08
2	26.2	Nani's Best	9/23/08	12/22/08
3	50.0	Jabalina	9/24/08	12/05/08
4	68.6	Midway	10/01/08	12/18/08
5	22.7	Grizzley	10/10/08	1/15/09
6	21.7	Winter gold	10/17/08	1/16/09
7	23.5	Winter select	10/23/08	1/20/09
8	30.6	Winter select	11/01/08	2/12/09
9	23.5	Gabalan	12/15/08	4/01/09

Table 2. Lettuce yield and midrib P levels to P rate and P placement.

P rate	P Placement	Midrib P (%)	Lettuce Yield (Mg/ha)
0	---	0.40	29.7
50	Broadcast	0.40	44.0
100	Broadcast	0.45	49.1
150	Broadcast	0.43	44.5
25	Band	0.43	30.4
50	Band	0.49	46.3
75	Band	0.42	46.8
100	Band	0.43	49.3
Stat.			
P rate (PR)		NS	L**Q**
P Placement (PP)		NS	*
PR X PP		NS	NS



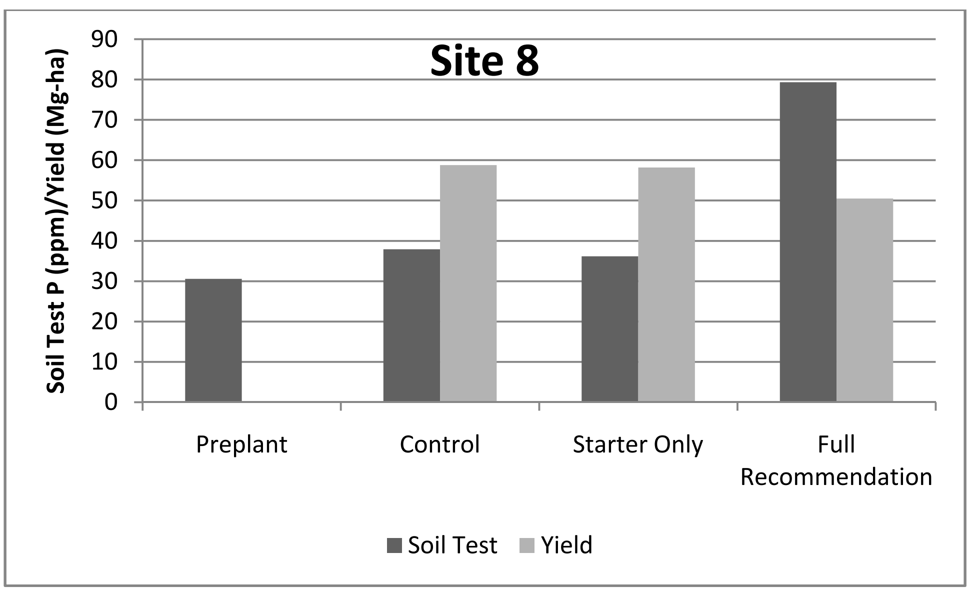
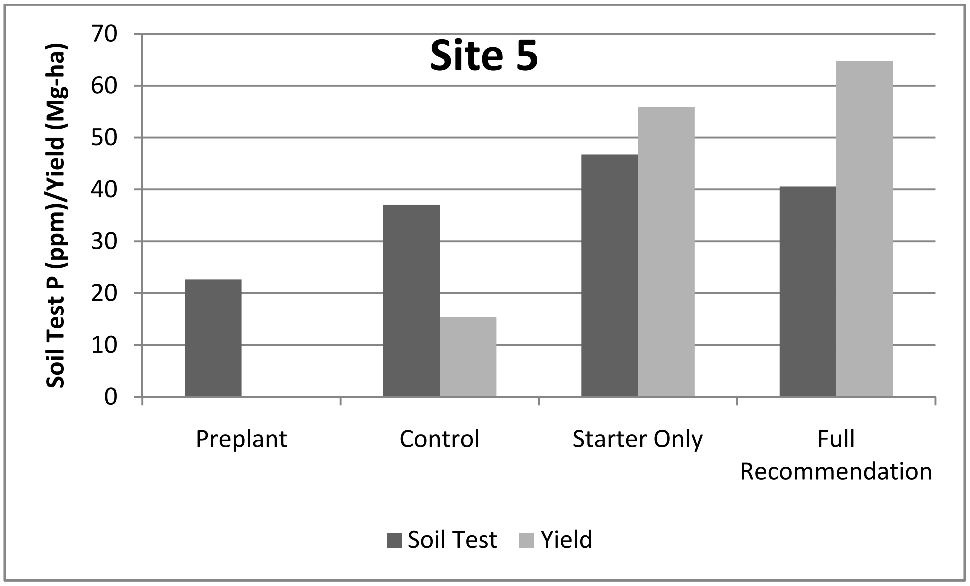


Figure 1. Pre plant soil test P level and soil test P levels and lettuce yields for three treatments at harvest for two sites with minimal yield differences.



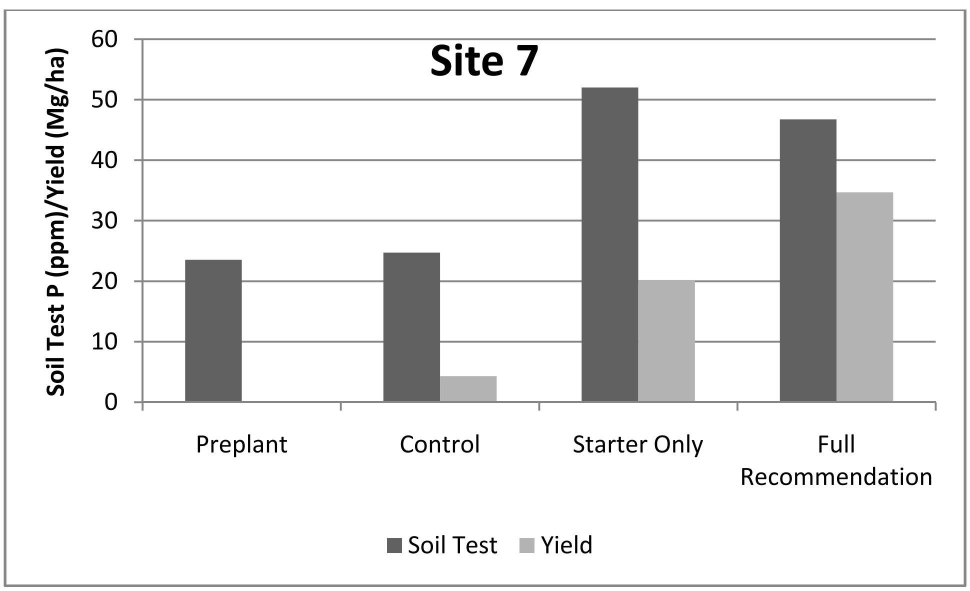


Figure 2. Pre plant soil test P level and soil test P levels and lettuce yields for three treatments at harvest for two sites with large yield differences.

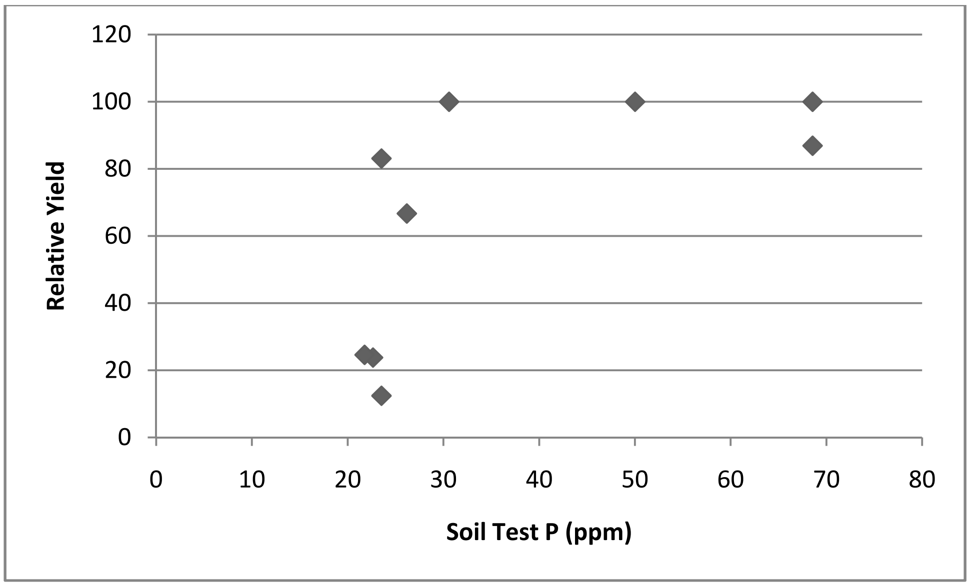


Figure 3. Relative yield response (without P fertilizer) by pre plant soil test P level.