Improving P Fertilization Efficiency for Desert Durum

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Over the past two decades, desert 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) input to agricultural systems. Recently, maximum levels of Cd in food crops are regulated in the European Union and regulations elsewhere are likely. The content of Cd in P fertilizers used in the desert approach 150 mg/kg and a reduction in P fertilizer inputs may be required to reduce Cd exposure through food. For these reasons there is an urgent need to evaluate practices that result in improved P fertilizer use efficiency.

In Arizona, Durum wheat is grown over a wide range of soils having a wide range of cropping histories. In some instances the crop grown in rotation with wheat are field crops having a low P fertilizer requirement, such as cotton. In other instances wheat is grown in rotation with vegetable crops, which receive very large applications of P fertilizer. A reliable pre plant soil test should represent some reliable index of plant available P.

Over the past century a number of P soil test procedures have been proposed. Several excellent reviews on P soil testing have been published by others (Thomas and Peaslee, 1973; Kamprath and Watson, 1980; Fixen and Grove, 1990; Kuo, 1996; Sanchez, 2006). Most early soil tests were developed empirically based on simple correlations between extractant and some measure of crop P response. However, based on the P fraction method developed by Chang and Jackson (1957) inferences have been made concerning the extractant mode of action. It is generally assumed that water or dilute salts characterize solution P or the intensity factor while acids, complexing solutions, or alkaline buffer solutions generally characterize the quantity factor. Tests based on water extraction often correlate well with P uptake for shallow rooted fast growing vegetable crops. However, soil tests capable of better characterizing the labile fraction and or capacity factor generally produce more reliable results for field crops. The sodium bicarbonate ($NaHCO_3$) soil test for P generally correlates well with crop response on calcareous soils in the Western United States (Olsen et al. 1954).

Ultimately soil test P levels must be converted to crop P fertilizer recommendations. A useful starting point is the determination of critical soil test level or the soil test P level above which there is no response to P fertilizer. Using the double calibration approach described by Thomas and Peaslee (1973) information on how much fertilizer is required to achieve the critical concentration would result in a P fertilizer recommendation. In reality most soil testing laboratories make recommendations over a large geographical area and across many diverse soil types. Under most situations quantitative information on how soil test P levels change with P fertilizer additions across a range of soil types rarely exist. Due to this uncertainty, most soil testing laboratories make P fertilizer recommendations based on probability of response using class interval grouping such as low, medium, and high. Crops produced on a soil testing very low or low have a very high probability of responding to a moderate to high rates of P fertilizer. Crops produced on soils classified as medium frequently respond to moderate rates of fertilizer, and typically crops produced high P testing would not respond to P fertilization.

Preliminary evidence in Arizona indicates that wheat seldom responds to P fertilization when soil test P levels by sodium bicarbonate exceed 13 mg/kg (Ottman, 2004). Current recommendations are to apply up 50 lbs P_2O_5 per acre (25 kg P/ha) when soil tests are medium (7 to 12 mg/kg P) and up to 100 lbs P_2O_5 per acre (50 kg P/ha) when soil tests are low (<7 mg/kg). Traditionally most growers have not made P fertilizer applications based on soil tests but rapidly increasing fertilizer costs has created an incentive for using soil tests to contain growing costs. However, additional data is needed to verify and revise these recommendations across a wide range of conditions in Arizona.

Materials and Methods

We selected a site that had not been cropped to produce for a year in hope of finding a location with low residual soil P. The site was a field located at the Yuma Agricultural Center. The treatments were P rates of 0, 25, 50, 75, 100, 125, 150, 175, 200, and 225 kg P/ha. Because mono ammonium phosphate (MAP or 11-52-0) is the typical P source used in the area it was used in these experiments. The P fertilizers were broadcast and disked into the soil before planting. The plots were 10 ft (3 m) wide by 50 ft (15.2 m) long. The experimental design was randomized complete block with 4 replications. The wheat (cv. Havasu) was seeded and irrigated January 30, 2009. N fertilizer as UN 32 (20 gallons/acre) was applied with irrigations on February 26, March 18, and April 2, 2009. The grain was harvested May 27, 2009 using a Hagie small plot harvester and that collected from each plot was weighed. Soil samples were collected after harvest and soil test nitrate-N and soil-test P were determined. Data were subjected to analysis of variance using an appropriate statistical model.

Results and Discussion

There were visual differences during the early growth stages which carried through to significant yield differences at the higher fertilizer rates at maturity (Table 1). This surprised us because the lowest soil test P levels in this experiment were 24 ppm P. Previous studies have indicated durum wheat generallydoes not respond to supplemental P when soil tests exceed 15 ppm.

We used 11-52-0 as the P source because this is the P fertilizer commonly used in the region. Because of the experimental design we employed we cannot rule out the possibility of an N response to the ammonium in this fertilizer. We used a total of 224 kg N/ha as UN32 split in three water run applications and we did not anticipate the N associated with the 11-52-0 would be important. This may have been a mistake. It seems that most producers in the area used up to 300 kg N/ha based on basal stem nitrate-N monitoring to avoid grain protein issues. Rates of N applied with the 11-52-0 ranged from 12 kg N/ha at the low P rate (25 kg P/ha) to 108 kg N/ha at the high P rate (225 kg P/ha). This additional N may have been important during early growth. We did collect grain samples from all plots for protein analysis but these data were not complete as of the writing of this report. Soil-nitrate-N levels at harvest were generally low and there were no differences among treatments.

We plan to repeat this study during 2010 but we will modify our experimental design to remove potential confounding effects of N and P fertilizer responses.

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Table 1. Yields of lettuce to rates of P fertilizer applied as MAP.

P Rate (kg/ha)	**Wheat Yields (lbs/A)**
0	4736
25	4565
50	4878
75	4594
100	5076
125	5644
150	5473
175	5105
200	5870
225	5671
Stat.	**L****

Table 2. Soil Test nitrate-N and sodium bicarbonate P soil test at harvest.

P Rate (kg/ha)	**Soil Nitrate-N (mg/kg)**	**Soil Test P (mg/kg)**
0	5.1	24
25	3.4	28
50	9.7	27
75	5.1	26
100	5.1	28
125	5.1	26
150	5.1	36
175	9.7	27
200	7.8	39
225	5.1	32
Stat.	**NS**	**L***