Barley and Durum Response to Phosphorus at Buckeye, Maricopa, and Yuma, 1997

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Interpretive Summary

Soil tests were developed in the 1930's as a guideline for phosphorus fertilizer application. The phosphorus soil test for the calcareous soils in the Western U.S. is based on bicarbonate extraction and is often called the Olsen P method. Phosphorus fertilizer recommendations for small grains based on this test are remarkably similar across the Western states. Despite the availability of this test, its proven accuracy (93% in California), and its low cost ($1/acre), most farmers in Arizona apply phosphorus fertilizer to their small grains crops without the benefit of a preplant soil test. The purpose of this study was to demonstrate the effectiveness of the soil test in predicting a response to phosphorus fertilizer. At Maricopa, the soil test P was 8.1 ppm, a variable response to P fertilizer was expected, and a variable response to P fertilizer was obtained. We were able to detect a response to P fertilizer at this site with only 1 out of 4 varieties, and the response averaged across varieties was 336 lbs/acre or a 6% increase. No response to P fertilizer was obtained on a commercial farm in Buckeye where the soil test P was 22 ppm and a response was not expected. At the Yuma-Mesa site, the preplant P level was also 22 ppm, and a yield increase of 29% (1442 lbs/acre) was measured on barley even though a response was not expected. The soil on the Yuma-Mesa is 95% sand and perhaps the soil test for P needs to be adjusted for this soil type, but at the other sites tested, the current soil test recommendations for P seem to be accurate.

Introduction

Soil testing as a guideline for phosphorus fertilizer application on small grains has been recommended since 1940 (McGeorge, 1940). The current soil test procedure for phosphorus relies on bicarbonate extraction of phosphate (Olsen, 1954) rather than carbon dioxide as used earlier. Bicarbonate extractable P (Olsen P) can be determined by commercial laboratories for a price of about $10 per sample and a sample typically represents 40 acres or less of a uniform area. If we assume that the cost of collecting the sample is $10 and each sample represents 20 acres, then the total cost for preplant soil sampling is about $20 for 20 acres or $1/acre. Most farmers apply phosphorus fertilizer without the benefit of a soil test. Phosphorus fertilizer costs about $265/ton in the form of 11-52-0, and an application of 150 pounds of this fertilizer costs about $20 for the material and $6 for the application costs for a total of $26/acre. Assuming the production costs of wheat not including fixed cost is $350/acre, the phosphorus fertilizer represents about 7% of the production cost. Spending $1/acre for a soil test, to provide information on how likely a response is to phosphorus fertilizer costing $26/acre, is a wise investment. It is not likely that small grains will respond to phosphorus fertilizer unless the soil test phosphorus is low (Table 1). The phosphorus fertilizer recommendations for small grains in Arizona are similar to those of California, Eastern Washington, the Northern Great Plains, and Mexico. Research in California has shown that soil test P predicts response to fertilizer P with 93% accuracy (Mikkelsen et al., 1964). Based on a summary of soil samples tested by the UA Soils Lab between 1965 and 1984, only 19% of Arizona soils are likely to respond to phosphorus fertilizer and most soils are expected to have variable or no response to phosphorus (Doerge, 1985). The correlation between soil test P and response to P fertilizer has not been tested recently in Arizona. The purpose of this work is to demonstrate the effectiveness of basing phosphorus fertilizer on a preplant soil test.

Table 1. Phosphorus fertilizer recommendations for small grains grown in Arizona based on bicarbonate extractable phosphorus.

Preplant P level	P level description	Response to P fertilizer	Recommended P fertilizer rate
ppm			lbs P_2O_5/acre
< 6	Low	Likely	50 to 100
6 to 12	Medium	Variable	0 to 50
>12	High	Not likely	0

Procedure

Phosphorus fertilizer practices were evaluated at the Maricopa Agricultural Center and on commercial farms in Buckeye and the Yuma-Mesa. The preplant soil test at Maricopa was 8.1 ppm, which is considered medium and the response to phosphorus fertilizer was expected to be variable. The preplant soil test on the commercial farms was 22 ppm, which is considered high and a response to fertilizer P was not expected. In both cases, the farmers normally apply phosphorus fertilizer to their small grains crops. The cropping history for the locations follow.

Buckeye

A study was conducted on H-4 farms in Buckeye on field 26-4. The previous crop was cotton, the soil type is a sandy loam, and the preplant soil P was 22 ppm. Plots 100 ft. wide (four borders) and a quarter of a mile long were established. Phosphorus was applied in four alternating strips on Jan 6, 1997 at a rate of 78 lbs P2O5/acre as 25-31-0. The experimental design was a complete block with two treatments and four replications. The control plots received nitrogen fertilizer only in the form of urea on the same date. All plots received nitrogen, therefore, at a rate of 62 lbs N/acre. Duraking durum was planted with a grain drill at a rate of 175 lbs seed/A into dry soil on Jan 12 and irrigated up the same day. A total of 4.25 acre feet of water was applied to the crop during the season as follows: Jan 12 (0.22 AF), Jan 28 (0.23 AF), Feb 12 (0.24 AF), Feb 22 (0.35 AF), Mar 7 (0.32 AF), Mar 17 (0.37 AF), Mar 27 (0.38 AF), Apr 4 (0.34 AF), Apr 16 (0.48 AF), Apr 24 (0.45 AF), May 3 (0.46 AF), and May 13 (0.43 AF). One inch of rainfall was recorded on Feb 27. Nitrogen was applied in the irrigation water as UAN32 (32-0-0) on Feb 12, Feb 22, and Apr 16 at rates of 53, 60, and 50 lbs N/A. Nitrogen fertilizer application including that at planting totaled 225 lbs N/acre. The center two borders of each plot was harvested for an area of 1.26 acres (50 ft. x 1101 ft). Grain yield was calculated from the harvested area and grain protein was determined with an NIR whole grain analyzer.

Yuma-Mesa

A study was conducted on the Yuma-Mesa. The previous crop was gourds, the soil type is a Superstition sand, and the preplant soil P was 22 ppm. Plots 16 ft. wide and 660 ft. long were established. Phosphorus was applied in five alternating strips on Nov 12, 1996 at a rate of 58 lbs P2O5/acre as 0-45-0. The experimental design was a complete block with two treatments and five replications. Nebula barley was planted with a grain drill into dry soil on Nov 12 and irrigated up on Nov 13. The entire field received 69 lbs N/acre as urea preplant. A total of 65 inches of water was applied to the crop during the season in 13 irrigations of 5 inches each. Nitrogen was applied in the irrigation water as UAN32 (32-0-0) on 8 occassions at a rate of 18 lbs N/A per application. Nitrogen fertilizer application including that at planting totaled 213 lbs N/acre. Banvel herbicide was applied at a rate of 0.25 pint/acre and MCPA was applied at a rate of 0.5 pint/acre. The insecticide dimethoate was applied at a rate of 1 pint/acre. Four 2 ft. x 2 ft areas were harvested by hand for each plot on Apr 17. The grain was threshed with a stationary thresher and grain yield was calculated. Test weight and kernel weight was measured on the harvested grain. Plant height was recorded on Apr 18.

Maricopa

Field 117 at the Maricopa Agricultural Center was used for this study. The soil type at this location is a Casa Grande sandy loam. The field was in sudangrass the previous summer. Preplant soil phosphate was 8.1 ppm. Before planting, phosphorus fertilizer in the form of 0-45-0 was spread by hand at rates of 0, 20, 40, 60, 80, 100, and 120 lbs P_2O_5/acre to plots 16 ft. by 25 ft. Urea was also applied at this time at a rate of 80 lbs N/acre. The fertilizer was worked into the soil with a spring tooth harrow. Seed was planted with a grain drill into dry soil on December 4, 1996, and a germination irrigation was applied on December 6. Gustoe and Mucho barley and Kronos and WestBred 881 durum were planted in 12 ft wide strips at a seeding rate of 110 lbs/A for the barley and 130 lbs/A for the wheat in a split plot design with varieties as main plots, fertilizer rates as subplots, and replicated four times. The plots were trimmed to 21 ft. with a rototiller. The plots were irrigated on December 6, January 31, February 26, March 19, April 1, and April 18. Urea was topdressed on January 30 at a rate of 50 lbs N/acre. UAN32 was applied in the irrigation water at a rate of 25 lbs N/acre on February 26 and April 1. Whole plants of Kronos were sampled from four 2 ft^2 areas on Jan 23, Feb 18, and March 18 at the 5 leaf, 2 node, and late heading stages, respectively. These samples were dried in an oven at 65 degrees C, weighed, and total above ground yield calculated. Total phosphorus was also determined in the samples, and P uptake calculated by multiplying yield by P concentration. Heading, anthesis, and physiological maturity dates were noted. The plots were harvested with a small plot combine on May 21 (barley) and May 23 (durum) from a 5 ft wide x 21 ft long area. Grain yield was calculated on an "as is" moisture basis and test weight, kernel weight, and plant height were also measure at harvest. No lodging occurred. Kernel weight was determined from 10 g of hand picked seed.

Results and Discussion

We were not able to detect an influence of P fertilizer on grain yield or grain protein at the Buckeye location (Table 2). The soil P level at this location of 22 ppm is well above the critical level where a response to P fertilizer is expected. We measured a yield increase at the Yuma-Mesa due to P fertilizer of 1442 lbs/acre, or a 29% increase (Table 2). This result was surprising since the initial soil test level was high (22 ppm) and we could not see any apparent differences in growth through visual observation. The only explanation we can devise for the yield response at the Yuma-Mesa despite high soil test P is due to the sandy nature of the soil at this site.

The influence of phosphorus fertilizer rate at Maricopa on total plant yield of Kronos at the 5 leaf, 2 node, and heading stages is presented in Table 3. We were not able to detect on influence of phosphorus fertilizer on total plant yield at the three stages sampled. Phosphorus fertilizer, however, did increase the concentration of P in the plant as measured at the 5 leaf and heading stages, and on P uptake, the product of yield and P concentration. We never visually observed any differences in growth or appearance among the plots during the season. At harvest, however, we did measure an increase in grain yield due to phosphorus fertilizer for most of the rates over the control for Gustoe and for all the varieties averaged together (Table 4). The average response to P fertilizer was 336 lbs of grain per acre, or a 6% increase. Only 20 lbs of P_2O_5 per acre was required on average for maximum yield.

The results of our work demonstrates the effectiveness of using a soil test as a guide for P fertilization, but recommendations may have to be adjusted for sands such as on the Yuma-Mesa.

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Table 2. Phosphorus rate effects on yield and plant characteristics at Buckeye and the Yuma-Mesa.

Location	Soil test P	Variety	Phosphorus rate	Yield[a]	Grain protein	Test weight	1000 Kernel weight	Plant height
	ppm		lbs P_2O_5/A	lbs/A		lbs/bu	grams	inches
Yuma-Mesa	22 (high)	Nebula	0	5013	—	54.9	45.0	30
		(barley)	58	6455	—	55.6	46.7	29
	Statistical significance (5%)			Yes	—	No	No	No
Buckeye	22 (high)	Duraking	0	6562	12.4	—	—	—
		(durum)	78	6629	12.7	—	—	—
	Statistical significance (5%)			No	No	—	—	—

Table 3. Total plant yield, phosphorus concentration, and phosphorus uptake for Kronos durum at three sampling dates at Maricopa.

	Jan 23 (5 leaf)			Feb 18 (2 node)			Mar 18 (heading)		
P rate	Yield	P conc.	P uptake	Yield	P conc.	P uptake	Yield	P conc.	P uptake
lbs/A	lbs/A	%	lbs/A	lbs/A	%	lbs/A	lbs/A	%	lbs/A
0	546	0.49	2.6	2331	0.40	9.2	4049	0.24	9.5
20	533	0.50	2.6	2178	0.40	8.7	3864	0.24	9.1
40	425	0.54	2.3	2376	0.48	11.4	4007	0.23	8.9
60	612	0.56	3.4	2632	0.45	11.7	4520	0.29	13.2
80	509	0.51	2.6	2481	0.51	12.6	4627	0.29	13.2
100	520	0.59	3.0	2430	0.53	12.7	4049	0.29	11.7
120	577	0.63	3.6	2478	0.58	14.4	4758	0.30	14.0
$LSD_{.05}$	NS	.06	0.9	NS	NS	NS	NS	.05	3.1

Table 4. Phosphorus rate effects on yield and plant characteristics for barley (Gustoe and Mucho) and durum (Kronos and WPB 881) at Maricopa.

Variety	Phosphorus rate	Yield[a]	Test weight	1000 Kernel weight	Plant height	Heading	Anthesis	Physio-logical Maturity
	lbs P_2O_5/A	lbs/A	lbs/bu	grams	inches			
Gustoe	0	4024	52.9	41.8	27	3-22	3-22	4-21
(barley)	20	4999	52.9	39.0	25	3-22	3-22	4-21
	40	4958	52.4	37.9	27	3-22	3-22	4-21
	60	4667	51.9	36.7	28	3-22	3-22	4-21
	80	5030	52.0	38.2	25	3-22	3-22	4-21
	100	4781	53.0	38.3	25	3-22	3-22	4-21
	120	4522	53.3	38.8	24	3-22	3-22	4-21
Mucho	0	5300	53.5	49.3	25	3-06	3-08	4-12
(barley)	20	5466	54.7	49.7	25	3-06	3-08	4-13
	40	5217	53.8	47.5	26	3-06	3-08	4-12
	60	5404	53.6	47.3	25	3-06	3-08	4-12
	80	5186	53.4	47.6	28	3-06	3-08	4-12
	100	5379	54.0	48.7	31	3-06	3-08	4-12
	120	5611	54.1	49.4	27	3-06	3-08	4-13
Kronos	0	6959	61.6	52.6	35	3-12	3-22	4-27
(durum)	20	6990	60.8	52.9	34	3-12	3-22	4-27
	40	6897	61.4	53.8	34	3-12	3-22	4-27
	60	7312	60.9	55.8	33	3-12	3-22	4-27
	80	7146	61.1	53.7	35	3-12	3-22	4-27
	100	6835	61.2	52.6	35	3-12	3-22	4-27
	120	7540	61.9	57.5	34	3-12	3-22	4-27
WPB 881	0	6067	60.5	52.3	35	3-14	3-23	4-28
(durum)	20	6731	60.6	52.2	36	3-15	3-24	4-28
	40	6410	61.0	50.3	35	3-15	3-23	4-28
	60	5628	61.5	52.3	32	3-15	3-24	4-28
	80	6316	62.0	53.1	35	3-15	3-24	4-28
	100	6617	60.8	51.9	35	3-15	3-23	4-28
	120	6545	61.0	52.4	34	3-15	3-24	4-27
Average	0	5588	57.1	49.0	30	3-13	3-18	4-22
	20	6046	57.2	48.5	30	3-13	3-19	4-22
	40	5870	57.1	47.4	30	3-13	3-18	4-22
	60	5761	57.0	48.0	30	3-13	3-19	4-22
	80	5919	57.1	48.2	31	3-13	3-19	4-22
	100	5937	57.2	47.9	31	3-13	3-18	4-22
	120	6054	57.6	49.5	30	3-13	3-19	4-22

[a] The least significant yield difference at the 5% probability level ($LSD_{.05}$) is 637 lbs/A for Gustoe, 294 lbs/A for the average, and a signficant difference was not detected for the remaining varieties.