

Final Report

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Response of wheat and barley varieties
to phosphorus fertilizer

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Summary

Phosphorus fertilizer represents a significant portion of the cost of producing small grains. Some evidence exists that there are differences in the ability of small grain varieties to take phosphorus up from the soil and utilize this nutrient in the grain. The objective of this study is to determine if barley and wheat varieties grown in Arizona differ in their response to phosphorus fertilizer. A study was conducted for the third year at the Maricopa Agricultural Center testing the response of 7 barley and 14 wheat (12 durum wheat and 2 bread wheat) varieties to 2 phosphorus rates (0 and 100 lbs P₂O₅/acre). Averaged over varieties, the grain yield increase due to phosphorus application of 100 lbs P₂O₅/acre was 346 lbs/acre for barley and 516 lbs/acre for wheat, similar to previous years. Despite the wide range of apparent yield response (0 to over 1000 lbs/acre) of the varieties to P fertilizer, these differences were not statistically significant. Furthermore, there was no consistency in the yield response of the varieties between this year and last year. Some of the varieties that responded greatest to P fertilizer last year, responded least this year, and vice versa. Therefore, there appears to be no differences in the response of barley and wheat varieties typically grown in Arizona to phosphorus fertilizer.

Introduction

Phosphorus fertilizer costs have increased dramatically in the past few years. In small grain production, fertilizer represents a significant proportion of the cost of production. The availability of soil P can be influenced by root exudates, which are under genetic control (Rengel, 2002). Small grain varieties may differ in their response to phosphorus fertilizer due to the presence or absence of these exudates or other factors (Davies et al., 2002). Citric acid is one of the root exudates that have been identified and related to phosphorus availability. The objective of this study is to determine if wheat and barley varieties grown in Arizona differ in their response to phosphorus fertilizer. This is the second year of the study.

Procedure

A study was conducted at the University of Arizona Maricopa Agricultural Center to determine if wheat and barley varieties respond to phosphorus fertilizer differently. The soil type was a Casa Grande sandy loam with a preplant soil phosphate level of 2.0 ppm P. P fertilizer treatments were applied before planting at rates of 0 and 100 lbs P₂O₅/acre using triple super phosphate (0-45-0) as a fertilizer source. The P fertilizer was applied by hand to plots 52 inches x 20 ft in size. The seed was planted with a cone planter in seven rows spaced 6 inches apart and 20 ft long. The seeding rate was approximately 100 lbs/acre for durum varieties and 85 lbs/acre for barley varieties. The experimental design of the P x Variety Study was a split plot with varieties (7 barley and 14 wheat [12 durum wheat and 2 bread wheats]) as main plots and P rate (0 and 100 lbs P₂O₅/acre) as subplots, and replicated 6 times. A P Rate Study with a wider range of P rates (0, 25, 50, 75, 100, 150 and 200 lbs P₂O₅/acre) and a single variety (Gustoe barley and Kronos durum) was also conducted to determine if the P rate of 100 lbs P₂O₅/acre is adequate for optimum yield. Cultural practices are listed in Table 1. The following data was collected: grain yield, test weight, plant height, lodging, heading, physiological maturity, grain P, HVAC, and light interception on Feb 10 at the 5 leaf stage. Grain was harvested with a small plot combine and yields are expressed on an "as is" moisture basis. HVAC was determined from 10 g of seed. Physiological maturity is defined as when the glumes turn brown. Light interception was determined by dividing the average of six readings from a sunfleck ceptometer at ground level by

incident light level. Grain P was expressed on a 12% moisture basis. Abbreviations for the sources of varieties are: APB = Arizona Plant Breeders, WPB = Western Plant Breeders, WWW = World Wide Wheat, UC = University of California.

Results and Discussion

This growing season was characterized by below average temperature overall and below average rainfall (Table 2). Even though the overall temperature was average, February and May were colder than average and December was warmer than average. Unusually cold weather during February in particular slowed the crop growth and could have caused unseen damage, although the only damage evident was some leaf tip burn.

P rate study (6 P rates and 1 barley and 1 wheat variety):

Grain yields of Gustoe barley and Kronos durum were increased by phosphorus rates where 6 rates were applied from 0 to 200 lbs P₂O₅/acre (Table 3). P rate increased test weight, plant height, grain P, and light interception (wheat only) and decreased time to heading and maturity (barley only).

P x variety study (2 P rates and 7 barley and 14 wheat varieties)

We measured a P rate response to many variables (Tables 4-6). P rate increased yield (wheat), test weight (wheat), plant height (barley), decreased time to heading and maturity, increased light interception as measured on Feb 10 (wheat), and increased grain phosphorus concentration.

The varieties responded to an application of 100 lbs P₂O₅/acre in a similar manner for all of the variables measured (Tables 4-6) except for heading in barley as determined by the significance of the entry x P interaction at the 5% probability level. If the probability level is increased to 10%, then the entry x P interaction becomes significant for several other variables (see “+” in table).

Despite the wide range of apparent yield response of the varieties to P fertilizer, these differences were not statistically significant at the standard probability level of 5% (but were at the 10% probability level). Furthermore, there is no consistency in the yield response of the varieties between this year and last year. Some of the varieties that responded greatest to P fertilizer last year, responded least this year, and vice versa. Therefore, there appears to be no differences in the response of barley and wheat varieties typically grown in Arizona to phosphorus fertilizer.

Acknowledgments

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References

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- Rengel, Z. 2002. Genetic control of root exudation. *Plant and Soil* 245:59-70.

Table 1. Cultural practices for the small grain phosphorus trial at Maricopa.

Cultural information	Maricopa
Previous crop	Fallow
Soil texture	Sandy Loam
Nominal Planting date	12/7/10
Irrigation dates (amount)	12/15 (3.21 in.)
	1/27 (3.89 in.)
	2/25 (3.59 in.)
	3/17 (3.89 in.)
	3/31 (2.39 in.)
	4/13 (5.38 in.)
	4/25 (4.08 in.)
	Total (26.43 in.)
Nitrogen dates (amount)	12/15 (50 lbs N/a) as 46-0-0
	1/28 (50 lbs N/a)
	2/25 (50 lbs N/a)
	3/17 (50 lbs N/a)
	as 32-0-0
	Total = 200 lbs N/a
Phosphorus (date, amount, fertilizer)	12/15 (50 lbs P ₂ O ₅ /a) 0-45-0
Pesticides (date)	None
Harvest date	5/26

Table 2. Climatic data from AZMET for Maricopa during the 2011 growing season compared to the long-term average.

Climate variable	Unit	Year(s)	Dec	Jan	Feb	Mar	Apr	May	Dec-May
Max Temp.	°F	2010	70	67	66	79	85	90	76
	°F	Avg	65	66	70	77	85	95	76
Min Temp.	°F	2010	38	32	34	44	54	57	43
	°F	Avg	35	36	39	44	51	60	44
Ppt.	inches	2010	0.39	0	0.4	0.05	0.32	0	1.16
	inches	Avg	0.62	0.72	0.85	0.79	0.26	0.2	3.43

Table 3. Phosphorus rate effect on grain yield and other plant characteristics for ‘Gustoe’ barley and ‘Kronos’ durum.

P rate	Yield	Test weight	Plant height	Heading	Maturity	Grain phosphorus	HVAC	Light interception (Feb 10)
lbs/A	lbs/A	lbs/bu	inches			%	%	%
<u>Barley</u>								
0	4315	50.1	24.3	4/02	5/04	0.217	---	10
25	4787	50.8	27.5	3/30	5/02	0.223	---	8
50	4963	50.8	28.0	3/26	5/02	0.221	---	23
75	4897	51.2	26.8	3/26	5/02	0.245	---	20
100	5283	51.4	27.8	3/26	4/30	0.250	---	14
150	5164	51.0	28.0	3/25	5/02	0.276	---	15
200	5487	51.6	27.5	3/25	5/02	0.258	---	17
Avg	4985	51.0	27.1	3/27	5/02	0.241	---	15
P rate	*	ns	**	**	*	**	ns	+
Linear	**	**	**	**	+	**	ns	ns
Quad	ns	ns	**	**	**	+	ns	ns
Cubic	ns	ns	+	ns	ns	*	ns	ns
<u>Durum</u>								
0	5641	62.8	33.8	3/27	5/05	0.265	100	26
25	6498	63.2	33.0	3/25	5/05	0.290	99	21
50	6715	63.1	35.3	3/23	5/05	0.270	100	33
75	6472	63.0	34.0	3/23	5/04	0.270	99	34
100	6891	63.0	34.0	3/23	5/04	0.294	100	35
150	6063	63.3	33.5	3/23	5/05	0.307	99	34
200	6997	63.3	33.0	3/23	5/05	0.297	99	35
Avg	6468	63.1	33.8	3/23	5/04	0.285	99	31
P rate	*	*	*	*	ns	*	ns	ns
Linear	*	**	ns	*	ns	**	+	*
Quad	ns	ns	+	*	ns	ns	ns	ns
Cubic	*	ns	ns	*	ns	ns	ns	ns

Table 4. Grain yield, test weight, and plant height of barley and wheat varieties as affected by phosphorus fertilizer rates of 0 and 100 lbs P₂O₅/acre. "Response" refers to the difference between the phosphorus rates. The wheat varieties are durums except for Yecora Rojo and Joaquin, which are bread wheats.

Entry	Source	Grain Yield			Test Weight			Plant Height		
		Phosphorus								
		0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response
		lbs/A			lbs/bu			inches		
		<u>Barley</u>								
Commander	WWW	5566	5867	301	47.3	47.6	0.0	26.5	25.8	-0.8
Max	WWW	4656	5194	539	48.8	49.5	0.7	26.8	27.0	0.3
Baretta	APB	3985	5383	1398	50.0	50.6	0.6	24.8	27.3	2.5
Chico	WPB	3990	4807	817	47.9	47.2	0.4	21.5	23.5	2.0
Cochise	WPB	4011	3992	-20	49.1	49.7	0.7	22.8	24.8	2.0
Gustoe	WPB	4571	4827	256	48.6	48.8	0.2	24.3	25.5	1.3
Nebula	WPB	4975	4104	-871	48.3	46.5	-1.8	27.3	29.8	2.5
Avg	---	4536	4882	346	48.6	48.6	0.1	24.8	26.2	1.4
LSD _{.05} *		1085	1085	ns	1.2	1.2	ns	1.7	1.7	ns
Entry		*			*			**		
P rate		+			ns			**		
Entry x P		ns			+			+		
		<u>Wheat</u>								
Crown	WWW	4485	5330	846	59.8	60.6	0.8	36.3	34.8	-1.5
Duraking	WWW	4672	5659	987	62.6	63.4	0.8	31.0	31.3	0.3
Q-Max	WWW	4103	5410	1307	59.0	60.3	1.2	35.5	35.3	-0.3
Kronos	APB	5069	4811	-257	63.0	63.1	0.1	33.5	33.0	-0.5
Sky	APB	5265	5658	393	61.0	61.5	0.5	30.3	31.5	1.3
Havasu	WPB	4802	5002	200	64.1	64.3	0.2	33.5	33.3	-0.3
Orita	WPB	4250	5123	873	61.7	62.3	0.7	30.0	31.5	1.5
WPB-881	WPB	4746	4892	145	61.6	61.6	0.0	34.0	34.3	0.3
Alamo	WPB	4119	5166	1047	63.6	64.0	0.4	34.3	34.5	0.3
Maestrале	Allstar	4603	4616	14	63.4	63.5	0.1	37.3	35.0	-2.3
Westmore	APB	4772	5190	418	62.0	62.0	0.0	33.5	33.8	0.3
Ocotillo	APB	4270	4888	619	62.3	62.3	0.0	35.3	36.5	1.3
Yecora Rojo	UC	2715	3290	575	64.0	63.3	-0.7	26.3	26.8	0.5
Joaquin	WPB	4005	4069	63	63.8	63.8	-0.1	32.3	32.5	0.3
Avg	---	4420	4936	516	62.3	62.5	0.3	33.1	33.1	0.1
LSD _{.05} *		686	ns	ns	0.7	0.7	ns	2.0	2.0	ns
Entry		+			**			**		
P rate		**			**			ns		
Entry x P		+			+			ns		

* LSD_{.05} = least significant difference between means within a column with a 5% or less probability the difference is due to chance.

Table 5. Heading, physiological maturity, and light interception of barley and wheat varieties as affected by phosphorus fertilizer rates of 0 and 100 lbs P₂O₅/acre. "Response" refers to the difference between the phosphorus rates. The wheat varieties are durums except for Yecora Rojo and Joaquin, which are bread wheats.

Entry	Source	Heading			Physiological Maturity			Light Interception (Feb 10)		
		Phosphorus								
		0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response
% of incident										
<u>Barley</u>										
Commander	WWW	4/01	3/30	-2	5/05	5/05	0	14	14	0
Max	WWW	4/03	4/02	-2	5/14	5/09	-5	27	15	-12
Baretta	APB	3/28	3/26	-2	5/03	5/01	-2	15	20	4
Chico	WPB	4/03	3/25	-9	5/04	5/03	-2	13	21	8
Cochise	WPB	3/22	3/19	-3	4/29	4/25	-4	20	31	11
Gustoe	WPB	4/03	3/28	-6	5/04	5/03	-1	21	24	3
Nebula	WPB	3/30	3/21	-8	5/03	4/30	-3	11	26	15
Avg	---	3/31	3/26	-5	5/04	5/02	-2	17	22	4
LSD _{.05} *		2	2	2	3	3	ns	ns	ns	ns
Entry		**			**			ns		
P rate		**			**			+		
Entry x P		**			ns			ns		
<u>Wheat</u>										
Crown	WWW	4/03	3/30	-4	5/10	5/05	-5	20	29	9
Duraking	WWW	4/03	3/28	-6	5/07	5/04	-3	11	39	27
Q-Max	WWW	4/03	4/01	-2	5/08	5/07	-1	20	18	-2
Kronos	APB	3/29	3/21	-8	5/04	5/02	-2	22	27	5
Sky	APB	4/03	3/25	-9	5/08	5/07	-1	18	34	16
Havasu	WPB	3/31	3/26	-5	5/05	5/03	-2	18	27	10
Orita	WPB	4/03	3/28	-6	5/04	5/05	1	24	26	3
WPB-881	WPB	4/03	3/27	-8	5/05	5/03	-2	20	32	12
Alamo	WPB	4/03	3/29	-5	5/05	5/05	0	32	26	-6
Maestrals	Allstar	4/03	3/28	-6	5/05	5/04	-1	23	28	5
Westmore	APB	4/01	3/25	-7	5/04	5/03	-2	20	26	7
Ocotillo	APB	4/03	3/26	-8	5/06	5/05	-1	15	27	12
Yecora Rojo	UC	3/30	3/26	-4	5/04	5/02	-2	19	35	17
Joaquin	WPB	3/30	3/25	-5	5/04	5/02	-2	27	33	6
Avg	---	4/02	3/27	-6	5/06	5/04	-2	21	29	9
LSD _{.05} *		3	3	ns	3	3	ns	16	16	ns
Entry		**			**			ns		
P rate		**			**			**		
Entry x P		+			ns			ns		

* LSD_{.05} = least significant difference between means within a column with a 5% or less probability the difference is due to chance.

Table 6. Grain phosphorus, grain protein, and percentage of kernels “hard and vitreous and of amber color” (HVAC) of barley and wheat varieties as affected by phosphorus fertilizer rates of 0 and 100 lbs P₂O₅/acre. “Response” refers to the difference between the phosphorus rates. The wheat varieties are durums except for Yecora Rojo and Joaquin, which are bread wheats.

Entry	Source	Grain Phosphorus			Grain Protein			HVAC		
		Phosphorus								
		0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response	0 lb/A	100 lb/A	Response
		%			%			%		
		<u>Barley</u>								
Commander	WWW	0.23	0.23	0.01	---	---	---	---	---	---
Max	WWW	0.22	0.26	0.03	---	---	---	---	---	---
Baretta	APB	0.24	0.25	0.01	---	---	---	---	---	---
Chico	WPB	0.24	0.27	0.03	---	---	---	---	---	---
Cochise	WPB	0.23	0.26	0.03	---	---	---	---	---	---
Gustoe	WPB	0.25	0.25	0.00	---	---	---	---	---	---
Nebula	WPB	0.24	0.28	0.04	---	---	---	---	---	---
Avg	---	0.24	0.26	0.02	---	---	---	---	---	---
LSD _{.05} *		0.03	0.03	ns	---	---	---	---	---	---
Entry		+			---	---	---	---	---	---
P rate		**			---	---	---	---	---	---
Entry x P		ns			---	---	---	---	---	---
		<u>Wheat</u>								
Crown	WWW	0.26	0.29	0.03	---	---	---	100.0	100.0	0.1
Duraking	WWW	0.27	0.28	0.02	---	---	---	99.9	100.0	0.0
Q-Max	WWW	0.25	0.28	0.03	---	---	---	99.9	98.6	-1.3
Kronos	APB	0.24	0.25	0.01	---	---	---	99.7	99.5	-0.2
Sky	APB	0.27	0.31	0.04	---	---	---	99.9	99.8	-0.1
Havasu	WPB	0.24	0.26	0.02	---	---	---	99.9	99.9	0.0
Orita	WPB	0.24	0.28	0.04	---	---	---	99.8	99.9	0.1
WPB-881	WPB	0.27	0.29	0.02	---	---	---	99.9	99.9	-0.1
Alamo	WPB	0.27	0.28	0.01	---	---	---	99.5	99.9	0.4
Maestrade	Allstar	0.24	0.26	0.03	---	---	---	99.8	100.0	0.3
Westmore	APB	0.28	0.29	0.01	---	---	---	100.0	100.0	0.1
Ocotillo	APB	0.28	0.32	0.04	---	---	---	100.0	99.8	-0.3
Yecora Rojo	UC	0.23	0.26	0.03	---	---	---	100.0	100.0	0.0
Joaquin	WPB	0.25	0.29	0.04	---	---	---	99.6	99.8	0.2
Avg	---	0.26	0.28	0.03	---	---	---	99.8	99.8	-0.1
LSD _{.05} *		0.03	0.03	ns	---	---	---	ns	ns	ns
Entry		*			---	---	---	ns		
P rate		**			---	---	---	ns		
Entry x P		ns			---	---	---	ns		

* LSD_{.05} = least significant difference between means within a column with a 5% or less probability the difference is due to chance.