

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 second 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). The grain yield increase due to phosphorus application averaged across varieties in 2010 was 170 lbs/acre for barley (not statistically significant) and 545 lbs/acre for wheat. The grain yield increase averaged across varieties and years was 331 lbs/acre for barley and 577 lbs/acre for wheat. The barley and wheat varieties did not differ in their grain yield increase due to phosphorus fertilizer in 2010. However, based on 2 years of results, we were able to detect differences among wheat but not barley varieties in their response to P fertilizer. The yield response to P fertilizer (100 lbs P₂O₅/acre) among durum wheat varieties varied from 331 lbs/acre for Alamo to 1063 lbs/acre for Orita. Yecora rojo, a bread wheat, did not respond to P 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 5 ft x 20 ft in size. The seed was planted with a cone planter in seven rows spaced 7 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, flowering, physiological maturity, grain P, grain protein, HVAC, and light interception on Feb 12 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. Grain protein was calculated using the combustion method to obtain total N, which was multiplied by 6.25 (barley) or 5.7 (wheat) to obtain protein content and expressed on a 12% moisture basis. Flowering is defined as when about half of the heads are shedding pollen and 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. 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 and above average rainfall (Table 2). Temperatures were especially cool during the months of March, April, and May. The month of January was especially wet. Due to the cool weather, the growing season was extended by 1-2 weeks compared to normal.

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

Grain yields of Gustoe barley were not affected by phosphorus rates from 0 to 200 lbs P₂O₅/acre, whereas grain yield of Kronos durum increased linearly with P rate (Table 3). P rate also decreased time to heading; increased grain P content; and increased light interception measured on Feb 12.

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 12, 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).

The results from 2010 do not provide any evidence that barley and wheat varieties respond differently to P fertilizer. However, if the results from 2009 and 2010 are combined, we were able to detect differences among wheat but not barley varieties in their response to P fertilizer. The yield response to P fertilizer (100 lbs P₂O₅/acre) among durum wheat varieties varied from 331 lbs/acre for Alamo to 1063 lbs/acre for Orita. Yecora rojo, a bread wheat, did not respond to P fertilizer.

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References

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

Cultural information	Maricopa
Previous crop	Fallow
Soil texture	Sandy clay loam
Planting date	12/10/09
Irrigations	6 12/10, 12/21, 2/17, 3/17, 4/1, 4/15, 5/1
Nitrogen (lbs N/a)	220 12/12: 51 (46-0-0) 1/28: 24 (32-0-0) 2/25: 76 (32-0-0) 3/13: 74 (32-0-0)
Phosphorus (lbs P ₂ O ₅ /acre)	100
Pesticides	None
Harvest date	6/1 (Durum) 6/3 (Barley)

Table 2. Climatic data from AZMET for Maricopa during the 2010 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	64	66	68	73	82	90	74
	°F	Avg	65	66	70	77	85	95	76
Min Temp.	°F	2010	33	38	41	43	49	55	43
	°F	Avg	35	36	39	44	51	60	44
Ppt.	inches	2010	0.39	2.64	0.56	0.62	0.00	0.00	4.21
	inches	Avg	0.62	0.72	0.85	0.79	0.26	0.20	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	Flowering	Maturity	Grain Phos-phorus	Grain Protein	HVAC	Light inter-ception (Feb 12)
lbs/A	lbs/A	lbs/bu	inches				%	%	%	%
<u>Barley</u>										
0	5704	50.3	34.3	4/04	---	5/15	0.219	11.6	---	61
25	6438	50.2	33.5	4/01	---	5/14	0.224	11.9	---	84
50	6552	49.5	33.8	3/30	---	5/11	0.230	11.8	---	81
75	6130	50.1	34.3	3/31	---	5/13	0.245	11.6	---	90
100	5653	49.9	35.3	3/31	---	5/12	0.247	11.7	---	86
150	5623	50.3	33.5	3/31	---	5/12	0.258	11.4	---	87
200	5731	50.5	33.8	3/31	---	5/12	0.280	11.7	---	84
Avg	5976	50.1	34.0	3/31	---	5/13	0.243	11.7	---	82
P rate	NS	NS	NS	**	---	NS	**	NS	---	**
Linear	NS	NS	NS	**	---	NS	**	NS	---	**
Quad	NS	+	NS	**	---	NS	NS	NS	---	**
Cubic	NS	NS	NS	*	---	NS	NS	*	---	+
<u>Durum</u>										
0	6913	62.0	36.0	3/24	.	5/15	0.244	14.5	100	49
25	7353	62.3	36.5	3/22	3/26	5/15	0.250	14.5	100	68
50	7519	62.3	36.5	3/22	3/26	5/15	0.251	14.5	100	68
75	7474	62.5	35.5	3/22	3/26	5/14	0.276	14.8	100	73
100	7895	62.6	36.3	3/22	3/26	5/13	0.263	14.7	100	75
150	7186	62.5	35.8	3/22	3/26	5/14	0.273	14.6	100	76
200	8246	62.5	35.3	3/22	3/26	5/15	0.298	14.7	100	72
Avg	7512	62.4	36.0	3/22	3/26	5/14	0.265	14.6	100	69
P rate	*	NS	NS	**	NS	NS	**	NS	NS	**
Linear	*	NS	NS	**	NS	NS	**	NS	NS	**
Quad	NS	NS	NS	**	NS	NS	NS	NS	NS	**
Cubic	*	NS	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>										
Chico	WPB	5802	5840	39	49.7	50.3	0.6	31.7	31.8	0.2
Cochise	WPB	4906	5127	220	50.7	51.2	0.6	34.8	36.0	1.2
Gustoe	WPB	6798	6739	268	50.1	49.9	-0.2	34.0	34.5	0.5
Nebula	WPB	6492	6929	438	51.0	50.8	-0.2	37.0	37.0	0.0
Commander	WWW	6662	7160	498	49.6	49.6	0.0	33.8	35.2	1.3
Max	WWW	6035	5992	-43	49.8	49.4	-0.4	34.0	34.8	0.8
Baretta	APB	7200	6989	-211	50.4	51.2	0.8	34.2	35.2	1.0
Avg	---	6258	6397	170	50.2	50.3	0.2	34.2	34.9	0.7
LSD _{.05} *		781	781	NS	0.7	0.7	0.8	1.4	1.4	NS
Entry		**			**			**		
P rate		NS			NS			**		
Entry x P		NS			+			NS		
<u>Wheat</u>										
Alamo	WPB	6573	6492	-81	64.1	64.1	0.0	36.5	36.5	0.0
Havasu	WPB	7166	7989	823	63.8	64.5	0.7	36.2	37.0	0.8
Orita	WPB	6567	7693	999	60.2	61.3	1.1	36.0	36.5	0.5
WPB-881	WPB	6797	7123	355	62.0	62.1	0.1	37.2	36.7	-0.5
Crown	WWW	5558	6351	793	57.6	59.1	1.5	37.8	38.0	0.2
Duraking	WWW	6619	7389	770	62.2	62.2	0.0	35.7	36.3	0.7
Q-Max	WWW	4708	5399	692	58.3	59.2	0.9	37.8	37.7	-0.2
Kronos	APB	6660	7442	782	61.7	61.9	0.2	36.7	36.2	-0.5
Sky	APB	7510	8028	518	61.2	61.6	0.3	34.7	34.0	-0.7
Ocotillo	APB	6402	6922	520	62.3	62.4	0.1	37.8	38.3	0.5
Westmore	APB	7143	7479	336	62.7	63.2	0.5	36.0	36.3	0.3
Maestrале	Allstar	6004	6711	707	63.3	63.5	0.2	37.5	37.7	0.2
Yecora Rojo	Public	7100	6824	-276	63.9	63.4	-0.6	33.3	34.7	1.3
Joaquin	WPB	7367	8106	739	63.5	63.5	0.0	36.7	36.8	0.2
Avg	---	6581	7139	545	61.9	62.3	0.4	36.4	36.6	0.2
LSD _{.05} *		735	735	NS	0.9	0.9	NS	1.1	1.1	NS
Entry		**			**			**		
P rate		**			**			NS		
Entry x P		NS			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 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 12)		
		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>										
Chico	WPB	3/28	3/25	-3	5/14	5/11	-4	48	64	17
Cochise	WPB	3/15	3/15	0	5/03	5/02	-1	60	80	20
Gustoe	WPB	3/31	3/29	-2	5/14	5/12	-2	72	80	8
Nebula	WPB	3/27	3/23	-4	5/13	5/06	-7	56	82	26
Commander	WWW	3/30	3/28	-2	5/13	5/13	1	60	79	19
Max	WWW	4/01	3/28	-2	5/17	5/13	-3	62	77	15
Baretta	APB	3/27	3/25	-3	5/11	5/07	-4	58	77	19
Avg	---	3/27	3/25	-2	5/12	5/09	-3	59	77	18
LSD _{.05} *		2	2	2	4	4	NS	15	15	NS
Entry		**			**			*		
P rate		**			**			**		
Entry x P		NS			NS			NS		
<u>Wheat</u>										
Alamo	WPB	3/25	3/22	-3	5/18	5/18	0	62	62	1
Havasu	WPB	3/24	3/22	-3	5/15	5/14	0	44	69	25
Orita	WPB	3/29	3/27	-3	5/17	5/16	-1	49	69	20
WPB-881	WPB	3/26	3/22	-4	5/15	5/15	0	68	70	2
Crown	WWW	3/30	3/27	-3	5/19	5/16	-3	41	52	11
Duraking	WWW	3/30	3/25	-4	5/17	5/17	-1	33	45	12
Q-Max	WWW	4/03	3/28	-6	5/21	5/18	-3	25	26	0
Kronos	APB	3/25	3/22	-3	5/15	5/15	0	44	65	21
Sky	APB	3/25	3/22	-3	5/18	5/17	-1	51	72	22
Ocotillo	APB	3/25	3/23	-3	5/14	5/15	1	53	67	14
Westmore	APB	3/24	3/22	-2	5/14	5/13	-1	58	65	7
Maestrale	Allstar	3/27	3/24	-3	5/14	5/13	0	51	66	15
Yecora Rojo	Public	3/23	3/22	-2	5/14	5/08	-5	56	72	16
Joaquin	WPB	3/22	3/21	-2	5/16	5/15	-1	60	58	-1
Avg	---	3/26	3/23	-3	5/16	5/15	-1	50	61	12
LSD _{.05} *		1	1	NS	2	2	3	17	17	18
Entry		**			**			**		
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>								
Chico	WPB	0.24	0.27	0.03	12.2	11.9	-0.3	---	---	---
Cochise	WPB	0.26	0.28	0.02	11.8	11.4	-0.4	---	---	---
Gustoe	WPB	0.22	0.25	0.03	11.9	12.1	0.1	---	---	---
Nebula	WPB	0.25	0.26	0.02	12.4	12.2	-0.2	---	---	---
Commander	WWW	0.24	0.26	0.02	12.4	12.3	-0.1	---	---	---
Max	WWW	0.22	0.27	0.05	12.8	12.7	-0.1	---	---	---
Baretta	APB	0.25	0.27	0.02	13.2	12.2	-1.0	---	---	---
Avg	---	0.24	0.27	0.03	12.4	12.1	-0.3	---	---	---
LSD _{.05} *		NS	NS	NS	0.8	0.8	NS	---	---	---
Entry		NS			*			---		
P rate		**			+			---		
Entry x P		NS			NS			---		
		<u>Wheat</u>								
Alamo	WPB	0.30	0.30	0.01	15.1	15.1	0.0	100	100	0
Havasu	WPB	0.27	0.31	0.04	14.8	14.6	-0.2	100	100	0
Orita	WPB	0.29	0.30	0.01	15.7	15.6	-0.1	100	100	0
WPB-881	WPB	0.27	0.31	0.04	14.5	14.5	0.0	100	100	0
Crown	WWW	0.29	0.31	0.02	15.6	15.4	-0.2	100	100	0
Duraking	WWW	0.28	0.29	0.01	14.7	14.6	-0.1	100	100	0
Q-Max	WWW	0.28	0.30	0.02	15.7	14.9	-0.8	100	100	0
Kronos	APB	0.28	0.30	0.02	14.8	15.0	0.2	100	100	0
Sky	APB	0.27	0.30	0.03	14.0	14.0	0.0	100	100	0
Ocotillo	APB	0.30	0.31	0.01	15.0	14.9	-0.1	100	100	0
Westmore	APB	0.27	0.30	0.03	15.8	16.6	0.9	100	100	0
Maestrals	Allstar	0.27	0.29	0.02	14.6	14.3	-0.3	100	100	0
Yecora Rojo	Public	0.28	0.30	0.03	14.7	15.1	0.4	100	100	0
Joaquin	WPB	0.27	0.30	0.02	14.6	14.9	0.4	100	100	0
Avg	---	0.28	0.30	0.02	15.0	15.0	0.0	100	100	0
LSD _{.05} *		NS	NS	NS	0.7	0.7	NS	---	---	NS
Entry		NS			**			*		
P rate		**			NS			NS		
Entry x P		NS			NS			NS		

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