Effects of P Applications on Wheat Tissue Phosphate Levels and Grain Production in Graham County

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ABSTRACT

Collecting additional data to calibrate and refine current guidelines for interpreting soil and plant test values for P is an ongoing need in Arizona. An experiment was conducted at the Safford Agricultural Center during the 1987-88 crop year to evaluate the response of 'Aldura' durum wheat to P fertilizer applications on a clay loam soil testing low in available P. Maximum grain yields of more than 5,500 lbs./A were obtained by banding 40 lbs. P_2O_5/A as triple super phosphate with the seed at planting. A December 9 planting date subjected plants to cold soil temperatures early in the season (up to 80 days after planting), rendering soil P less available for plant utilization. Preplant soil P analyses predicted the yield increase observed with P fertilization (11.2%); however, economic returns were not sufficient to offset the cost of P fertilizer. The recommended preplant soil test for P proved accurate in predicting P status and stem PO_4-P tissue analyses seemed reliable in monitoring P nutrition of durum wheat. A critical nutrient range of 1200 - 2000 ppm PO_4-P is proposed for basal stem tissue sampled prior to the joint growth stage, and 1500 - 1700 ppm PO_4-P is suggested for flag leaf tissue sampled at the boot stage.

INTRODUCTION

Nitrogen (N), and to a lesser extent phosphorus (P), are the two essential nutrient elements which most often limit the production of wheat in Arizona. Preplant P soil analyses are currently used to predict if additional P may increase grain yields. Stem PO_4-P tissue tests have been used to a lesser extent than NO_3-N stem tests since P deficiencies are difficult to correct during the growing season. Also, a lack of data exists to correlate stem PO_4-P levels to yield response to P fertilization.

Any required P is normally broadcast and worked into the surface soil or banded with the seed at planting, due to the immobility of P in soils. Responses to P fertilizer with wheat in Arizona are difficult to obtain, due to marginal occurrences of soil P deficiencies. However, availability of soil and fertilizer P is reduced at cooler winter temperatures, complicating evaluations of P fertility status.

An experiment was conducted at the Safford Agricultural Center with the following objectives: 1) to determine the effect of a range of banded P fertilizer rates on durum wheat yields when grown on a soil testing just below the critical level for P; 2) to evaluate the effect of P applications on levels of stem and leaf PO_4-P; and 3) to examine the affect of P fertilizer applications on N nutrition.

MATERIALS AND METHODS

A fertility trial with 'Aldura' durum wheat was conducted on a Pima clay loam (fine silty, mixed, thermic, Typic, Torrifluvent) at the Safford Agricultural Center. Chemical properties of the surface soil (0-12 in.) were: pH, 8.1; sodium bicarbonate extractable P, 9.5 ppm; electrical conductivity, 2.9 dS/m; ammonium acetate extractable sodium, 8.0 meq/100g; free $CaCO_3$, high; and computed exchangeable sodium percent (ESP), 27.3%. Preplant

NO_3-N in the surface 12 inches of soil was determined by H_2O extraction and Kjeldahl steam distillation to be 8.7 ppm.

The rates, timing and sources of N and P fertilizers are listed in Table 1. Preplant broadcast N was hand-spread and worked into the surface 3-4 inches of soil during the seeding operation. P was banded with the seed at planting. All midseason N applications were hand broadcast on dry soil no more than 4 hours prior to irrigation.

Table 1. Rates, timing and fertilizer sources applied to 'Aldura' durum wheat grown on a Pima clay loam at the Safford Agricultural Center.

Treatment*	Preplant N as 21-0-0	Banded P as 0-45-0	Topdressings of Urea N			Total for Season	
			5-6 Leaf	Boot	Flower		
	N	P_2O_5	N	N	N	N	P_2O_5
	pounds per acre						
0% P	45	0	80	45	30	200	0
100% P	45	40	80	45	30	200	40
200% P	45	80	80	45	30	200	80

* 21-0-0 and 0-45-0 refer to ammonium sulfate and triple super phosphate, respectively.

Wheat seed was drilled on flat borders at the rate of 150 lbs./A on 9 December, 1987 and irrigated. A total of about 33 inches of water containing approximately 15 lbs. NO_3-N was applied in 6 irrigations. Rainfall during the growth period was 4.5 inches. Individual plots were 24 x 45 feet and all treatments were replicated 4 times in a split block design.

Stem and leaf tissue samples were taken on 2 March at the 3-4 leaf stage, then at the joint (28 March), boot (21 April) and heading (2 May) stages of growth. The plant parts sampled were the upper leaves prior to boot and the flag leaf thereafter. The stem tissue between ground level and the seed was sampled prior to jointing and the two inches of stem just above ground level for the remaining dates. Samples were dried, ground and analyzed for PO_4-P, using a 2% acetic acid extraction and the colorimetric method of Murphy and Riley. Analysis for NO_3-N was done using a specific ion electrode. Daily average soil temperatures were recorded at 2 and 4 inch depths throughout the season.

Grain yields were estimated by harvesting a 175 sq. ft. area in each plot using a small plot combine on 22 June. A subsample of grain was dried, ground and analyzed for total ammonium plus organic N, using Kjeldahl digestion and steam distillation. Protein was estimated by using a conversion factor of 6.25%. Percent yellowberry was determined by separation of a grain subsample from each plot into vitreous and non-vitreous kernals. Bushel weights were estimated by weighing one quart of grain from each plot and 500 kernals were weighed to estimate 1000 seed weights.

RESULTS AND DISCUSSION

Applying 40 lbs. P_2O_5/A resulted in maximum grain yield at this site. Applications of P above this level did not significantly increase grain yield, but increased lodging, bushel weights and plant heights, and decreased 1000 seed weight. Grain protein and yellowberry percentages were not significantly different in all treatments (Table 2).

Table 2. Growth characteristics of 'Aldura' durum wheat receiving various P treatments.

P Rate	Grain Yield*	Grain Protein	Yellowberry	Lodging	Plant Height	Bushel Weight	1000 Seed Weight
lbs. P2O5/A	lbs./A	%	%	%	in.	lbs./bu.	gm
0	5117a#	15.9a	0a	0a	27a	61.1a	43.2a
40	5763b	15.8a	0a	2.5a	29b	61.2a	41.6b
80	6093b	15.8a	0a	10b	30c	61.8b	41.6b
LSD 0.05	537	0.3	0	2.9	0.8	0.3	1.3

* grain yields were adjusted to 10% moisture and represent clean grain weights.

means followed by the same letter within each column are not significantly different at the 5% level according to the SNK method.

Figure 1 shows the patterns of PO_4-P concentrations in wheat stems throughout the 1986-87 season (Knowles et al., 1987). Fertilizer P was both band and broadcast applied as 16-20-0 (ammonium phosphate) at a rate of 40 lbs. P_2O_5/A. Highest stem PO_4-P concentrations were achieved by banding P with the seed at planting; therefore, P fertilizer was band-applied in the 1987-88 experiment.

Figure 1. Seasonal stem PO_4-P levels measured in 'Aldura' durum wheat subjected to different application methods with 16-20-0 fertilizer (1986-87).

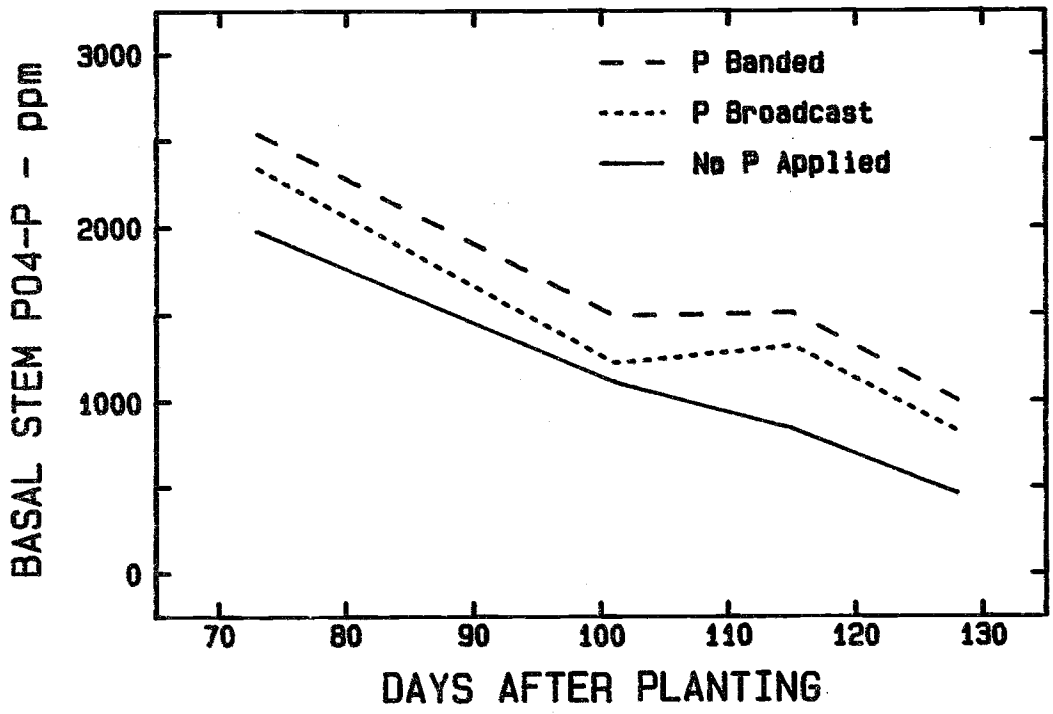
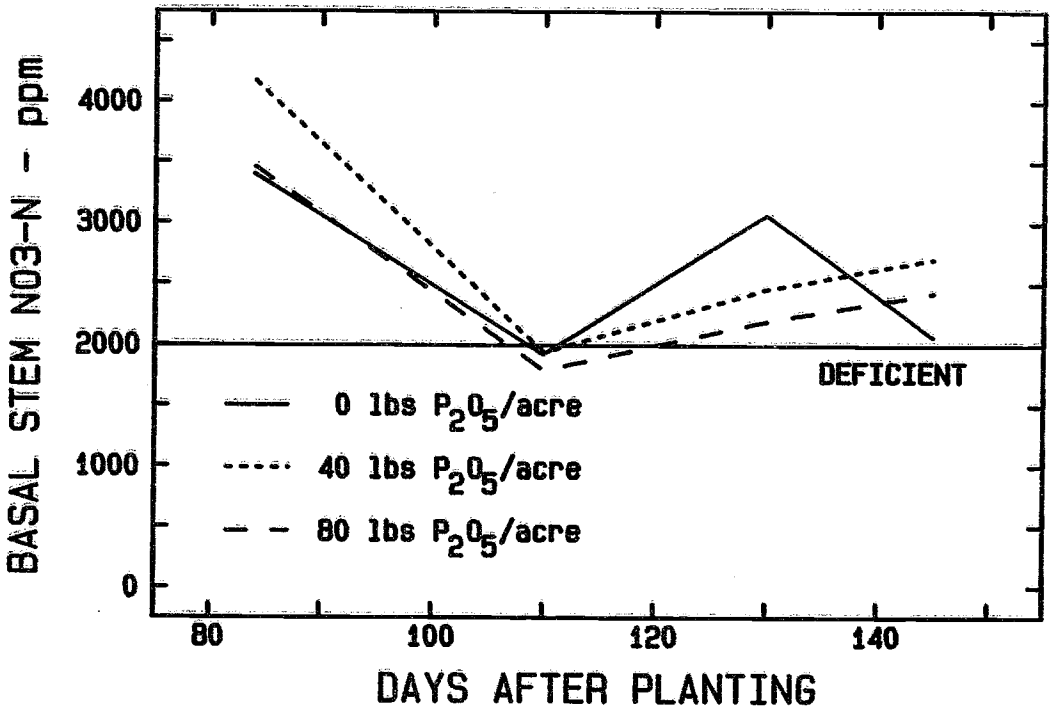


Figure 2 shows the patterns of NO_3-N concentrations in wheat stems for the 1987-88 study. The 3-4 leaf, joint, boot and heading growth stages occurred at 84, 110, 130 and 145 days after planting, respectively. Stem tissue NO_3-N concentrations indicate adequate N nutrition throughout the season. No apparent P treatment effects on stem NO_3-N levels were observed.

Figure 2. Seasonal stem NO_3-N levels measured in 'Aldura' durum wheat subjected to different P fertilizer rates (1987-88).



Figures 3 and 4 show the patterns of PO_4-P concentrations in wheat stems and upper leaves, respectively, throughout the 1987-88 season. Stem PO_4-P levels are similar at the boot and heading growth stages, but are significantly different at the 3-4 leaf and joint stages. Greatest concentrations of stem P occurred prior to jointing. Leaf PO_4-P levels were significantly different at the 3-4 leaf and boot growth stages; however, greatest concentrations occurred in the flag leaf at boot. Additionally, 30 plants were sampled from each plot during the 1986-87 study, partitioned at the boot stage into basal stems, lower leaves and flag leaves, and analyzed for PO_4-P. Highest PO_4-P concentrations were observed in the flag leaves, followed by the lower leaves and basal stems, respectively (data not shown). Basal stem tissue seems to indicate P nutritional status best prior to jointing, while the flag leaf is a better indicator thereafter. Perhaps these observations suggest accumulation of P in stem tissue prior to jointing, then translocation of P to the younger flag leaf tissue by the boot, stage then ultimately to the grain.

Figure 3. Seasonal stem PO_4-P levels measured in 'Aldura' durum wheat subjected to different P rates of 0-45-0 fertilizer (1987-88).

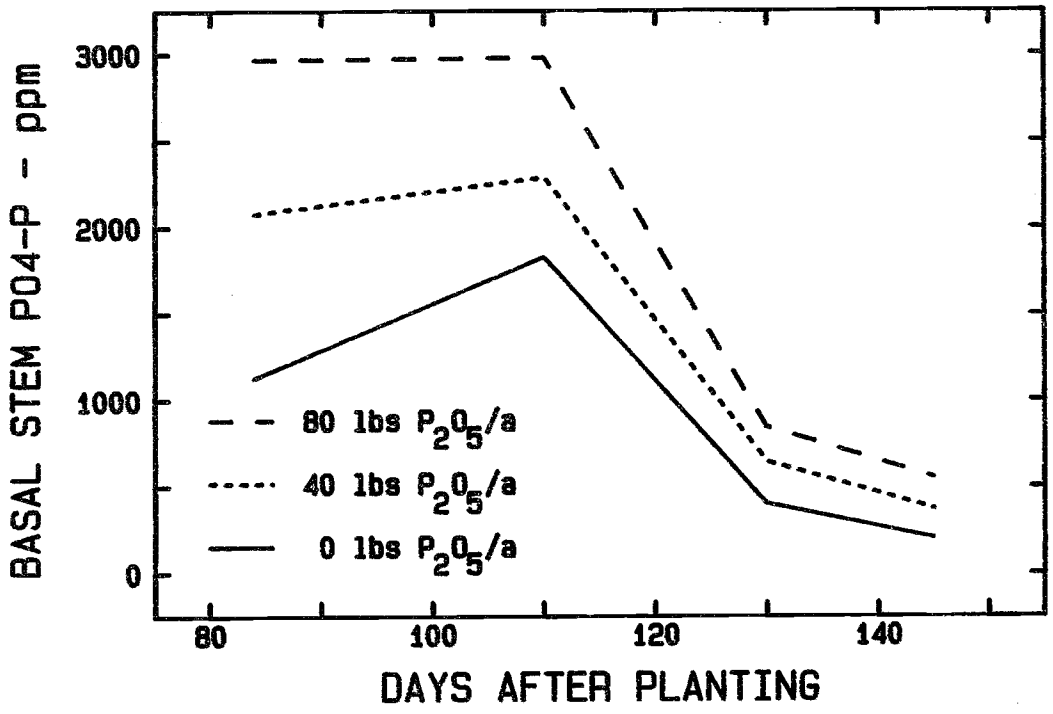
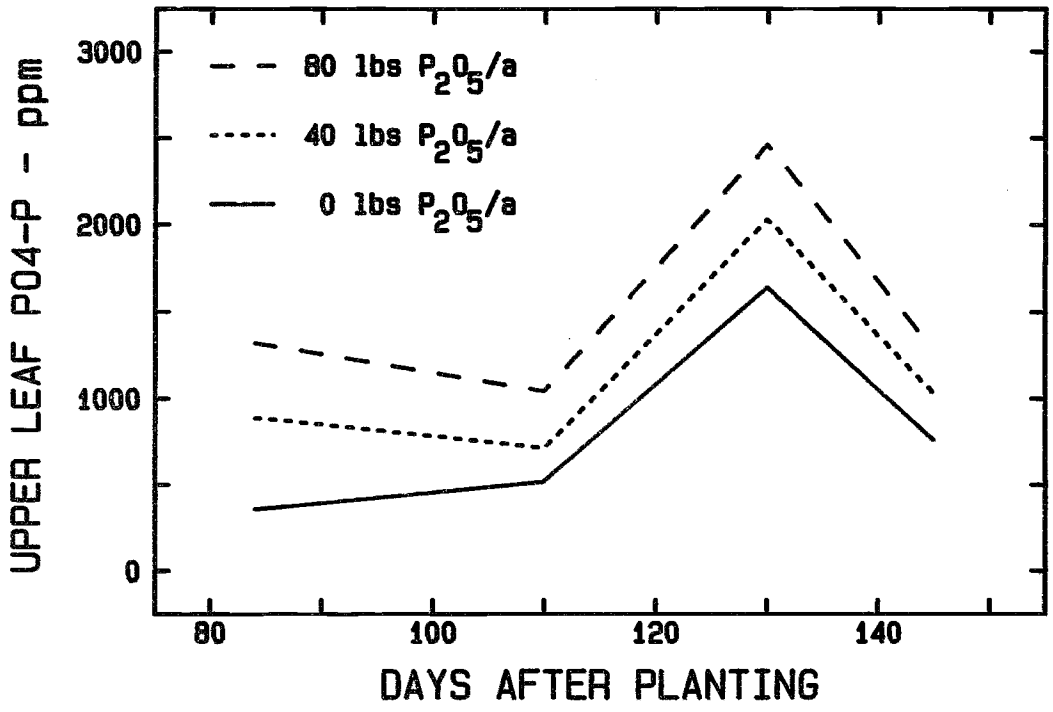


Figure 4. Seasonal leaf PO_4-P levels measured in 'Aldura' durum wheat (1987-88).



Although a yield response to P was measured in 1988, the slight yield increase warranted an economic analysis. Adjusted economic returns calculated in Table 3 assume the cost of P_2O_5 derived from 0-45-0 is .67/lb. and a grain price of $7.00 per cwt. No significant differences were observed for economic returns with the addition of P fertilizer.

Table 3.Estimated adjusted economic returns for P fertilizer treatments to 'Aldura' wheat.

P Rate	Estimated P Cost*	Adjusted Economic Return
lbs. P_2O_5/A	$/A	$/A
0	0	358.16a#
40	27	376.44a
80	54	372.53a
LSD 0.05	-----	37.61

* assumes P is banded with the seed at planting as 0-45-0.

means followed by the same letter are not significantly different at the 5% level according to the SNK method.

The preplant soil P test of 9.5 ppm P indicated the soil tested just below the critical level for P (10 ppm P). A statistically significant yield increase of 11.2% resulted from the application of P fertilizer at 40 lbs. P_2O_5/A; however, economically no increase in net income occurred. This supports the current interpretation of preplant soil test P values.

REFERENCES

1. Knowles, T., T. Doerge, M. Ottman and L. Clark. 1987. Effects of N and P applications on wheat stem nitrate and phosphate levels, and grain production in Graham County. 1987 Forage and Grain Report, p. 134-39.

2. Power, J.F., D.L. Grunes, G.A. Reichman et al. 1964. Soil temperature and phosphorus effects upon nutrient absorption by barley. Agron. J. 56:355-59.

Stem and leaf tissue PO_4-P concentrations prior to heading increased with P fertilization in both crop years. Based on PO_4-P levels observed in 1987 and 1988, a critical nutrient range of 1200-2000 ppm PO_4-P is proposed for basal stem tissue sampled prior to the joint growth stage, and 1500-1700 ppm PO_4-P for the flag leaf sampled at boot. Perhaps grain P analyses could be considered thereafter.

Apparent differences exist in the seasonal patterns of stem tissue PO_4-P concentrations throughout both years. An earlier planting date in 1988 subjected wheat plants to cooler temperatures early in the season, slowing maturity and utilization of soil P. Figure 5 shows weekly average soil temperatures at a 2-4 inch depth for Safford in 1987 and 1988. Earlier work proposed the lower threshold temperature of 52°F for optimal soil and fertilizer P absorption by barley (Power et al., 1964). In 1987 soil temperatures reached the 52°F level about 50 days after planting (23 days prior to the 3-4 leaf stage), but required about 80 days (3-4 leaf) in 1988. Cool temperatures delayed the period of optimal P absorption since soil and fertilizer P were less readily available. It seems growing practices such as earlier planting dates, which subject durum wheat to extended cold soil temperatures, may require the application of fertilizer P.

Figure 5. Seasonal weekly average soil temperatures for Safford Agricultural Center for durum wheat planted 23 December 1986 (1987) and 9 December 1987 (1988).