Effects of Residual and Fertilizer Phosphorus on Durum Wheat Production and Wheat Stem Phosphate Levels

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ABSTRACT

Collecting additional data to calibrate and refine current guidelines for interpreting soil and plant test values is an ongoing need in Arizona. An experiment was conducted at the Safford Agricultural Center during the 1987-89 crop years to evaluate the response of 'Aldura' durum wheat to a range of residual soil and fertilizer P levels. Maximum grain yields exceeding 5,500 lbs./A were obtained by banding 50 lbs. P_2O_5/A as triple superphosphate with the seed at planting in 1988. Residual P from phosphorus fertilizer applications up to 80 lbs. P_2O_5/A had no significant effect on grain yields of the succeeding wheat crop. Basal stem PO_4-P tissue analysis seemed reliable in monitoring P nutrition of durum wheat during the vegetative growth period. Observed critical levels of PO_4-P in basal stem tissue for durum wheat at the 3-4 leaf, joint and boot growth stages were 2000, 1200 and 500 ppm, respectively.

INTRODUCTION

Nitrogen (N), and to a lesser extent phosphorus (P), are the two 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 stem NO_3-N tests since P deficiencies are difficult to correct during the current growing season. Also, a lack of data exist to correlate stem PO_4-P levels to yield response to P fertilization.

Yield responses of durum wheat to P fertilizers were modest in 1987 and 1988 at the Safford Agricultural Center (Knowles et al., 1987, 1988). This has been attributed to marginally deficient soil P levels and to temperature interactions. The importance of residual soil P has been implied by initial findings, but to date has not been adequately studied. A two year study was conducted at the Safford Agricultural Center to investigate: 1) the effect of a range of residual and fertilizer P levels on durum wheat yields; and 2) the effect of P applications on stem tissue PO_4-P levels.

MATERIALS AND METHODS

The two phases used in this experiment were: 1) to establish field plots with a range of residual soil P; and 2) to quantify the response of durum wheat to both residual soil P and fertilizer P.

This experiment was conducted on a Pima clay loam (fine silty, mixed, thermic, Typic Torrifluvent). The chemical characteristics of this site were; pH, 8.1; electrical conductivity, 2.9 dS/m; and computed exchangeable sodium percent (ESP), 27.3%. On 9 December, 1987, 'Aldura' wheat was drilled into flat basins at the rate of about 150 lbs./A and irrigated. Three levels (0, 40 and 80 lbs. P_2O_5/A) of P fertilizer were banded with the seed at planting in a split block design with 4 replications. Individual plots were 24 x 45 feet in size. Triple superphosphate (0-45-0) was used as the source of P.

The plots were harvested on 22 June 1988, using a plot combine. The soil in each plot was then sampled to a 12-inch depth to permit analysis of residual soil P. Soils were air dried, ground to pass a 2-mm mesh screen and analyzed for P content using a 0.5 M sodium bicarbonate extraction (Olsen's P).

For the 1988-89 crop season, each original plot was split, resulting in two 12 x 45 foot subplots. The experimental area was uniformly seeded to 'Aldura' durum wheat on 7 December 1988, using similar seeding rates and irrigation techniques as in the preceding year. One subplot within all the main plots was designated as a -P subplot and received no additional P fertilizer. The other +P subplots received a uniform application of 50 lbs. P_2O_5/A banded with the seed at planting as triple superphosphate. A uniform application of 175 lbs. N/A was broadcast-applied to all plots in split applications of 45, 60, 45 and 25 lbs. N/A at the preplant, 5-6 leaf, boot and flowering growth stages, respectively.

A total of about 26 inches of water, containing approximately 20 lbs. NO_3-N, was applied in 5 irrigations. Rainfall during the growth period was 1.7 inches. Stem tissue samples were taken on 22 February at the 4 leaf stage, then at the joint (24 March) and boot (10 April) stages of growth. For the remaining dates, the stem tissue between ground level and the seed was sampled prior to jointing; then the two inches of stem just above ground level was sampled. Samples were dried, ground and analyzed for PO_4-P content, using a 2% acetic acid extraction and the colorimetric method of Murphy and Riley.

Grain yields were estimated by harvesting a 175 sq. ft. area in each plot, using a plot combine with a 7 ft. swath on 14 June. A subsample of grain was dried, ground and analyzed for Kjeldahl-N, using an automated CNS analyzer. Protein was estimated by multiplying the total N concentration by a conversion factor of 6.25. Bushel weights were estimated by weighing one quart of grain from each plot and 500 kernels were weighed to estimate 1000 seed weights.

RESULTS AND DISCUSSION

Table 1 shows preplant soil test values for both NO_3-N and $NaHCO_3$-extractable P, plus fertilizer rates applied to field plots from 1986-89. Nitrogen fertilizer applications increased soil NO_3-N reserves over the 3-year period studied. Likewise, the application of 40 lbs. P_2O_5/A in 1986 increased the soil P test level from 8.0 to 9.5 ppm in 1987. Applications of 40 and 80 lbs. P_2O_5/A in 1987-88 resulted in residual soil P levels of 9.3 and 11.5 ppm, respectively. Residual soil P levels dropped from 9.5 to 6.3 ppm (1988-89) in plots not receiving P fertilizer additions at the 1987 planting. Durum wheat grain yield response to P fertilizer applications increased steadily from 1986-89.

Figure 1 shows the effect of both residual P (from 1987) and fertilizer P (in 1988-89) sources on 'Aldura' durum wheat grain yields. Letters appearing above each bar denote significance at the 0.05 level. Significant yield increases occurred when 50 lbs. P_2O_5/A was banded at planting, with soils ranging in extractable P content from 6.3 to 11.5 ppm in the +P plots. The residual effect of phosphorus fertilizer applications in the preceding year had no significant effect on grain yields in 1988-89 (-P plots). Perhaps larger P application rates were necessary in 1987 in order to support a wheat crop over the 1988-89 season. Additionally, a significant yield increase occurred in plots where soil tested at 11.5 ppm P, which is just above the critical level for the Olsen P soil test (10 ppm).

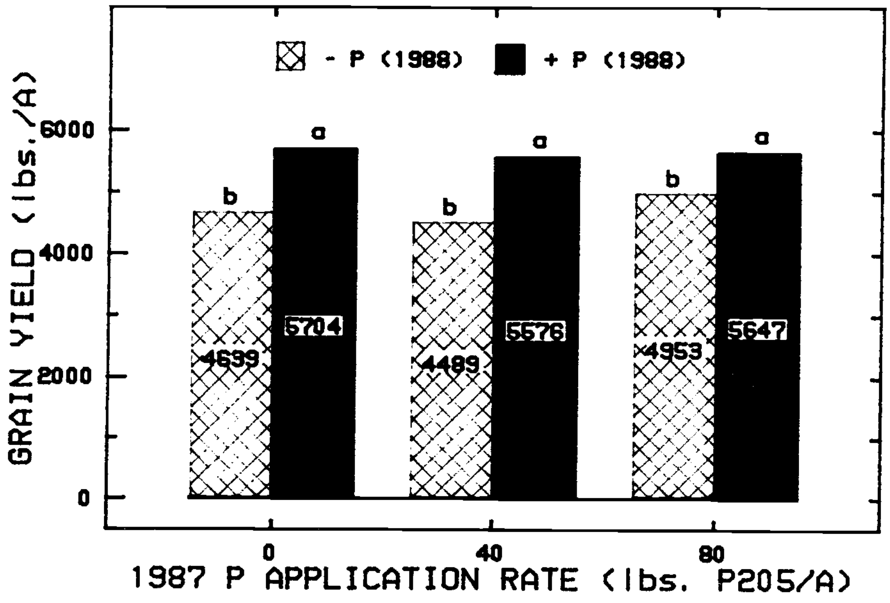

Figure 1. The effect of residual soil P from three 1987 fertilizer P rates and the application of 50 lbs. P_2O_5/A in 1988-89 on 'Aldura' durum wheat yields. Bars labeled with the same lower case letter are not statistically different at the 5% level of probability.

Table 1. Three year field history of fertilizer rates, resulting soil test levels and grain yield response to P applications on a Pima cl.

Crop Year	Preplant Soil NO_3-N	N Application Rate	Preplant Soil Test P Level(s)	P Application Rate(s)	Yield Increase With P
	ppm	lbs. N/A	ppm	lbs. P_2O_5/A	lbs./A
1986-87	1.3	150	8.0	40	0
1987-88	8.7	200	9.5	0, 40, 80	546
1988-89	14.5	175	6.3, 9.3, 11.5	0, 50	1065

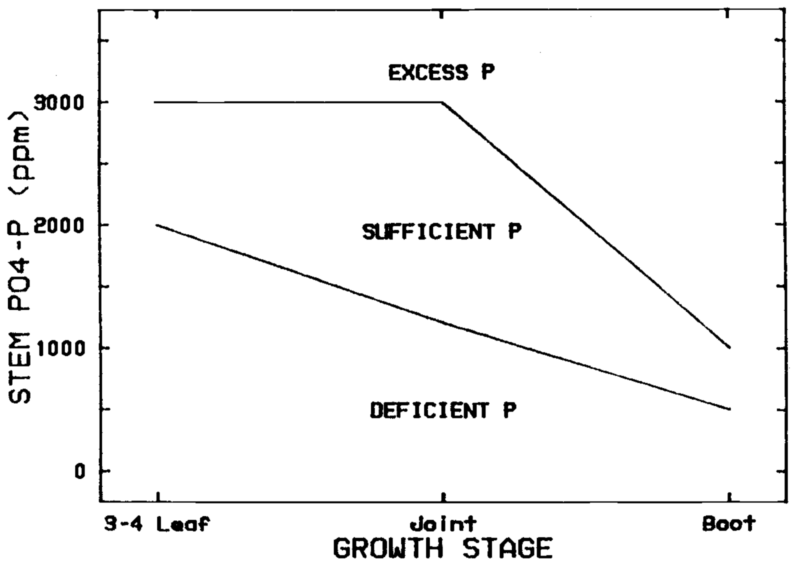

Figure 2. Seasonal stem tissue PO_4-P levels measured in 'Aldura' durum wheat receiving 0 and 50 lbs. P_2O_5/A.

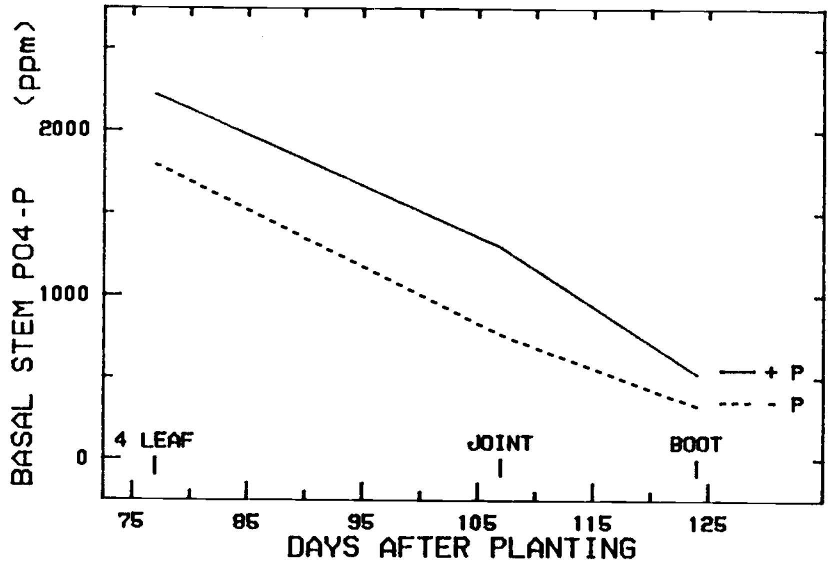

Figure 3. Interpretation of durum wheat basal stem tissue PO_4-P concentrations throughout the vegetative growth period.

Table 2. Growth characteristics of 'Aldura' durum wheat receiving different P fertilizer treatments (1988-89).

P Rate	Grain Yield*	Bushel Weight	1000 Seed Weight	Grain Protein
lbs. P_2O_5/A	lbs./A	lbs./bu.	gm	%
0	4639b#	62.1b	38.1b	15.8a
50	5704a	64.1a	40.2a	14.8b
LSD 0.05	381	0.6	1.7	0.2

*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.

Growth characteristics of 'Aldura' durum wheat receiving an application of P fertilizer in 1988-89 (on residual plots not receiving P in 1987) are shown in Table 2. The application of 50 lbs. P_2O_5/A significantly increased wheat grain yield, bushel weight and kernel weight; however, the application decreased grain protein concentrations. No yellowberry or lodging was observed in any of the plots.

Figure 2 shows the pattern of PO_4-P concentrations in wheat stems throughout the 1988-89 growing season. Basal stem PO_4-P levels were significantly increased at the 3-4 leaf and joint growth stages by the banding of P at planting. Greatest concentrations of stem P occurred prior to jointing. Therefore, basal wheat stem P levels are most indicative of differences in P nutritional status prior to jointing.

Based on PO_4-P levels observed in 1986-89, critical levels of 2000, 1200 and 500 ppm PO_4-P are proposed for basal stem tissue sampled at the 3-4 leaf, joint and boot growth stages, respectively. Grain yield reductions occurred when stem PO_4-P concentrations remained below these critical levels. Durum wheat may have shown some luxury consumption of P when stem PO_4-P levels exceeded 3000 ppm prior to jointing and 1000 ppm at the boot growth stage.

Figure 3 shows our interpretation of basal stem PO_4-P concentrations as an indicator of P fertility status in durum wheat. The narrow range between deficient and excess P at each growth stage requires accurate laboratory analysis. Corrective measures for P deficiencies should be carried out fairly early in the season, or, at the expense of the current wheat crop, P fertilizer rates could be increased the next season.

REFERENCES

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