Wheat Response to Time of Phosphorus Application

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Arkansas research shows that wheat can respond to topdressed applications of phosphorus (P), particularly on soils with poor internal drainage. This information broadens the window for P application for wheat growers under some conditions and demonstrates that surface P applications can be positionally available.

PHOSPHORUS is the second most limiting plant nutrient for winter wheat production on many soils. In Arkansas, P can limit wheat yields on silt loam soils where rice is in the crop rotation. Extended periods of flooding for rice production shift soil P to forms that are less available to upland crops. Wheat growth during the colder part of the year also limits P availability by limiting both P diffusion in the soil and release of P from organic forms. Due to the low solubility of P compounds in soil, P mobility is very low. Most research suggests that only incorporated P applications at or before seeding are effective.

Arkansas silt loam soils used for rice production have very poor internal drainage. That fact combined with excessive winter rainfall results in a saturated soil profile for much of the period between wheat seeding in late November and reproductive growth in mid-to-late March. Under those conditions, the wheat plant develops a lateral root system near the soil surface where a limited amount of oxygen is available for root respiration. Thus, topdressed P applications may be positionally available for uptake by the wheat plants.

Wheat production on these soils usually occurs in a system where either rice or soybeans is the preceding crop. When rice is the preceding crop, seedbed preparation and surface drainage are major problems. When soybeans are the preceding crop, the date of seeding can be a problem. In both cases, rainfall immediately after seeding can result in poor stands.

Growers may wish to delay inputs until an adequate stand is assured. If both nitrogen (N) and P could be topdressed after stand establishment, there might be a greater assurance of a return on the fertilizer investment. Research has shown that most or all of the N should be applied in late February. If more flexibility can be established for time of P application it would allow growers more options in managing wheat for optimum profitability.

Time and Method of P Application

We studied time and method of P application for wheat on two soils, a Crowley silt loam at the Rice Research and Extension Center (RREC) at Stuttgart, AR, and a Calhoun silt loam at the Pine Tree Experiment Station (PTS) at Colt, AR. Soil test P levels (Mehlich III) were 5 and 27 lb/A, respectively, for the two locations. The Crowley soil had been in a rice rotation for many years, but the Calhoun soil had never been cropped to rice.

Fall N application treatments were 0 and 30 lb N/A as urea applied after wheat emergence. The P treatments were: 1) no P applied, 2) broadcast preplant P incorpo-

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This study was funded in part by the Arkansas Fertilizer Tonnage Fee.

rated, 3) P banded with the seed, 4) P topdressed immediately after seeding, 5) P topdressed in early December, 6) P topdressed in early February, 7) P topdressed in early March, and 8) P topdressed in early April, all as triple superphosphate (0-46-0) at a rate of 60 lb P_2O_5/A. Nitrogen was topdressed at 110 lb N/A as urea in late February.

Study and Results

Phosphorus application had a significant effect on wheat plant growth, P concentration, P uptake and grain yield on the Crowley silt loam (low soil test P), but not on the Calhoun soil (low to medium soil test P). Only the results for the Crowley soil (RREC) will be discussed further.

Phosphorus application significantly increased plant growth at all three sampling dates on the Crowley silt loam (**Table 1**). Plant growth was increased two to threefold by P applied preplant, banded with the seed or topdressed. By March 1, topdressed P applied in early December resulted in plant growth equal to the earlier applications. When the P topdressing was delayed until February 1, plant growth had increased significantly by March 1, but had not reached the levels of growth obtained from P applied at planting or on December 1.

Table 1. Phosphorus applications increased wheat plant growth at all sampling dates on a low P, Crowley soil.

Time of application, 60 lb P_2O_5/A	Sampling date		
	Dec. 1	Feb. 1	Mar. 1
	Above-ground plant material, g/m²		
Control	18	65	180
Preplant incorporated	31	147	289
Banded with seed	45	171	370
Topdressed after seeding	33	174	359
Topdressed Dec. 1	—	83	378
Topdressed Feb. 1	—	—	267
LSD (0.05)	7	30	66

Variety: Cardinal

Phosphorus application increased plant P concentrations at the initial sampling in December (**Table 2**). By the March 1 sampling date, only plots where P was applied in December or February still showed elevated P concentrations. Initially, the P banded with the seed produced the highest plant P concentrations, but by March 1 this difference had disappeared. Higher plant P concentrations from the banded P were positively influenced by the application of fall N at both the December 1 and February 1 sampling dates. By March 1 the interaction with fall N was no longer evident (data not shown). The effects of time of P application on plant P concentrations raise serious questions as to the validity of tissue testing for P during the spring growing season.

Phosphorus uptake followed similar patterns to plant growth (**Table 3**). Phosphorus uptake by March 1, however, was strongly influenced by both plant growth and P concentration for the December and February topdress treatments. Phosphorus uptake was increased two to threefold by P applications, regardless of time of application.

Fall N application had no effect on grain yield with or without added P. Both sites had been summer fallowed in 1991 and nitrate N levels in the surface soils were approximately 100 lb/A.

Table 2. Time and method of P application affect wheat plant P concentrations.

Time of application, 60 lb P_2O_5/A	Sampling date		
	Dec. 1	Feb. 1	Mar. 1
	P concentration in plant tissue, %		
Control	0.15	0.21	0.23
Preplant incorporated	0.27	0.20	0.20
Banded with seed	0.40	0.24	0.23
Topdressed after seeding	0.20	0.19	0.22
Topdressed Dec. 1	—	0.35	0.31
Topdressed Feb. 1	—	—	0.36
LSD (0.05)	.08	0.03	0.03

Variety: Cardinal

Application of P preplant incorporated, banded with the seed, or topdressed anytime between seeding and early March increased grain yields by approximately 20 bu/A on the P-deficient Crowley silt loam soil (**Table 4**). Even early April P application significantly increased grain yield compared to the controls. However, there was a trend for less

TOPDRESSED P has been effective for wheat following rice in Arkansas studies. Delaying P application and topdressing with N can allow determination of stand adequacy before expenditures for fertilizer input. Better growth in some plots shown here is due to P application.

Table 3. Wheat plant P uptake was strongly influenced by plant growth, plant P concentrations and time of P application.

Time of application, 60 lb P_2O_5/A	Sampling date		
	Dec. 1	Feb. 1	Mar. 1
	Plant P uptake, g/m²		
Control	3	13	40
Preplant incorporated	8	29	57
Banded with seed	17	40	84
Topdressed after seeding	10	33	79
Topdressed Dec. 1	—	29	116
Topdressed Feb. 1	—	—	97
LSD (0.05)	2	9	19

Variety: Cardinal

response from P applied after February.

Visual growth responses to P applications were noted two to four weeks after each P application at Stuttgart RREC. Neither visual growth responses nor increased grain yields occurred at the Pine Tree site despite a soil test P value below the critical level. Phosphorus availability was apparently not limiting at this location. Since the Pine Tree site had never been cropped to rice, soil P had not been subjected to conversion of the less soluble ferric and occluded forms that are only sparingly available to upland crops.

Table 4. Phosphorus application method and application date influence wheat yields.

Time of P application, 60 lb P_2O_5/A	Wheat yield, bu/A	
	Rice Research and Extension Center	Pine Tree Station
Control	75	87
Preplant incorporated	92	86
Banded with seed	94	84
Topdressed after seeding	93	86
Topdressed early Dec.	94	87
Topdressed early Feb.	94	84
Topdressed early March	90	86
Topdressed early April	85	88
LSD (0.05)	8	NS
Soil test P (lb/A)	5	27

Summary

Topdress applications of P are positionally available for uptake by wheat on P-deficient Crowley soils with poor internal drainage. Growers may be able to wait until after the determination of adequate stands before applying needed P. Data indicate that the value of using only P tissue concentration as the criteria for need for P fertilization may be questionable due to the interactive effects of P application time and subsequent plant growth. ■