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WINTER WHEAT RESPONSE TO HIGH RATES OF PHOSPHORUS[1]

A. D. Halvorson, Soil Scientist
USDA-ARS, Akron, Colorado

J. L. Havlin, Assistant Professor
Kansas State University, Manhattan, KS

ABSTRACT

Winter wheat responses to high rates of P fertilizer application were studied on a calcareous loam soil with a medium $NaHCO_3$ soil test P level, 10.2 ppm, during the 1986 and 1987 crop years. With the application of 50 lb N/acre, winter wheat grain yields increased with increasing rates of P up to 207 lb P_2O_5/acre when broadcast incorporated or banded below the seed. A rate of 276 lb P_2O_5/acre was needed to maximize grain yields when the P was broadcast without incorporation. Grain yields were significantly lower when the P fertilizer was placed directly with the seed at 25% of the rates used with other P placement methods. A significant response to N fertilization was obtained. The results indicate that higher rates of fertilizer P than those normally recommended may be needed to minimize P deficiency as a yield limiting factor in the Central Great Plains. However, to be cost effective, the P fertilizer may need to be amortized over several years.

OBJECTIVE

Limited information is available in the Central Great Plains on P fertilizer placement and rate effects on winter wheat yields in reduced and no-till dryland farming systems. Banding low rates of P fertilizer near the seed on soils testing low in P is generally more effective than broadcasting the same rate of P during the first year of application (Leikam et al., 1983; Westfall et al., 1987). As soil test P levels increase from low to high, the yield difference between banded and broadcast P applications is expected to decrease (Peterson et al., 1981).

On a long-term basis, a broadcast application of P fertilizer may be equally as effective as a band application at equal rates for wheat production (Sleight et al., 1984). Several long-term P studies conducted in the northern Great Plains indicate that benefits from a single P fertilizer application may last as long as 16 years, depending on initial rate of P application and cropping history (Alessi and Power, 1980; Halvorson and Black, 1985; Read et al., 1977). Halvorson (1987) reported irrigated winter wheat, grown annually, responded positively to residual broadcast P fertilizer under no-till conditions in Colorado.

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Halvorson and Black (1985) suggested that a one time, high rate application of P fertilizer may be one way to satisfy the P needs of crops grown with reduced and no-till systems for several years. This study was designed to evaluate their suggestion in addition to comparing the effects of placement method on the long-term effectiveness of residual P fertilizer within a reduced tillage system. Study objectives are to (1) evaluate the efficiency of P placement methods for winter wheat production in reduced tillage systems, (2) determine the level of P fertilizer needed for optimum winter wheat yields with and without N fertilization, (3) determine the residual P fertilizer effects on winter wheat yields, and (4) determine the effects of N and P fertilization on water-use efficiency by dryland winter wheat. This paper reports results obtained during the first year of P fertilizer application from two adjacent identical sets of plots.

MATERIALS AND METHODS

The research site was located about 10 miles west of Peetz, Colorado on a Rosebud-Escabosa loam soil, with a pH of 7.8 and organic matter level of 2.4%. The initial sodium bicarbonate-extractable soil P level (0 - 6" depth) was 10.2 ppm, a medium soil test level. A split-split plot, randomized block design was used with P placement method as main plots, P fertilizer rate as subplots, and N fertilizer rate as sub-subplots, with four replications. Specific treatments were as follows: 1) P placement methods (a) broadcast prior to planting with no incorporation, (b) broadcast prior to planting with shallow incorporation with a disk (3" deep), (c) deep banded at planting with drill at about a 4" soil depth (3" below seed), and (d) banded directly with seed at 25% of P rates of other methods for each of 4 crop years; 2) fertilizer P_2O_5 (0-45-0) rates for broadcast and deep banded treatments of 0, 69, 138, 207, and 276 lb P_2O_5/acre (applied only one time); and 3) fertilizer N (34-0-0) rates of 0 and 50 lb N/acre. Duplicate sets of treatments were established on adjacent plot areas to allow the harvest of a winter wheat crop each year. One set was established in September 1985, from which a crop was harvested in 1986, and the other in September 1986, from which a crop was harvested in 1987. A no-till crop-fallow rotation was followed. Tam 105 winter wheat was grown in 1986 and Tam 107 in 1987. Wheat was planted about mid-September and harvested in mid-July each year. A no-till drill with dual seed row openers (two rows 3" apart) on each shank with 12" shank spacing was used. A plot combine was used to harvest the plots. Herbicides were used to control weeds. Soil samples were collected for soil NO_3-N and water (0-4,) and P (0-6") analyses.

RESULTS AND DISCUSSION

Winter wheat yields averaged over the 1986 and 1987 growing seasons are shown in Figure 1. Grain yields increased with increasing rates of P fertilization for all placement methods. Grain yields were near or at maximum with the application of 207 lb P_2O_5/acre plus N for

the broadcast and band-below-seed placement methods. When the fertilizer P was broadcast prior to planting, but not incorporated, yields were maximum at the 276 lb P_2O_5/acre rate. The grain yields of the seed-placed P treatments (P rates 25% of other placements) increased with increasing P rate but were considerably lower than those obtained with the other P placement methods with and without N. The leveling off of grain yields at 69 lb P_2O_5/acre may have been the result of some stand loss with this seed-placed P rate. Although no stand counts were taken, visual observation, particularly in 1986, indicated that wheat stands were much poorer for this P rate and placement method. Winter wheat grain yields were increased significantly by the application of 50 lb N/acre (Table 1). The P x N interaction was not significant at the 95% level.

Table 1. Average winter wheat grain and straw yields, grain test weight, and 1986 grain protein and P content as affected by P placement method. P fertilizer rate, and N fertilizer rate of N.

Treatment	Grain Yield	Straw Yield	Heads per Acre	Grain Test Weight	1986 Grain Protein	1986 Grain P Content
	bu/A	lb/A	million	lb/bu	%	%
P Placement*						
BC Incorp	59.4	4131	2.53	59.2	12.6	0.400
BC no Incorp	56.7	3908	2.42	58.8	12.5	0.409
Deep Band	58.7	4019	2.54	59.7	12.3	0.442
Seed Placed	51.9	3693	2.27	58.3	12.4	0.422
LSD(.05)	4.2	N.S.	0.16	N.S.	N.S.	0.031
P205 rate, lb/acre						
0	50.4	3505	2.07	58.5	12.5	0.408
69	55.1	3726	2.28	59.0	12.5	0.404
138	58.1	4063	2.55	59.3	12.6	0.418
207	59.5	4161	2.65	59.1	12.4	0.424
276	60.2	4234	2.65	59.2	12.4	0.427
LSD(.05)	2.2	234	0.11	0.5	N.S.	0.015
N rate, lb N/acre						
0	53.8	3744	2.34	59.2	I2.0	0.422
50	59.6	4131	2.54	58.9	12.9	0.415
LSD(.05)	1.2	162	0.07	0.3	0.2	N.S.

*BC Incorp=broadcast incorporated; BC no Incorp=broadcast without incorporation; Seed Placed P at 25% of the given P_2O_5 rate.

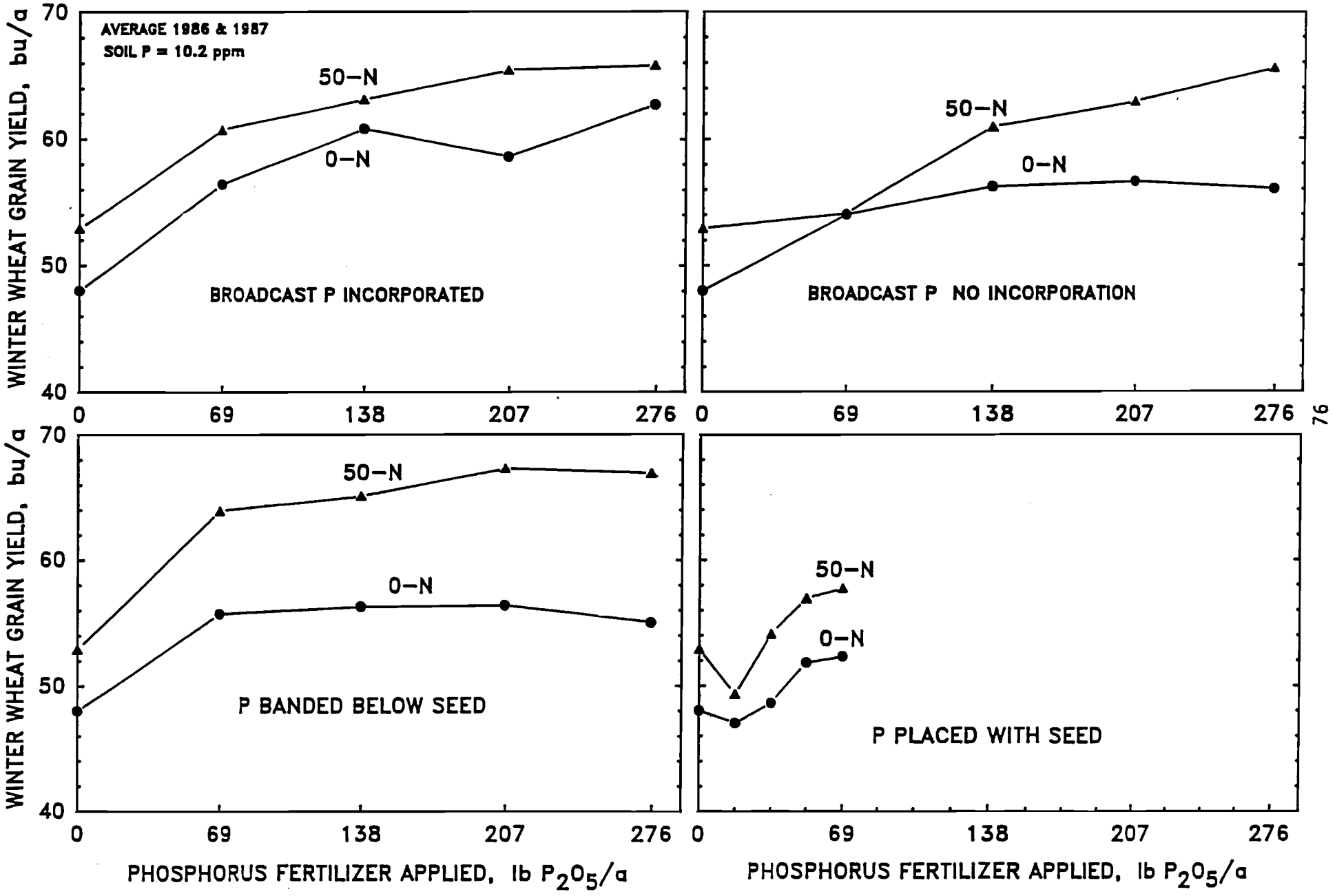

Figure 1. Winter wheat grain yield as a function of phosphorus fertilizer application rate and placement method.

Water supplies during both growing seasons were adequate, with 9.6 and 11.7 inches of precipitation from April until harvest for 1986 and 1987, respectively. Soil water measurements indicated very little soil water-use in 1986, with only 0.6 inch depleted from the 0 to 4 ft soil depth at harvest and 2.2 inches in 1987. This resulted in an average estimated total water use by the wheat crops in 1986 and 1987 of about 12.1 inches. Since soil water-use was not affected by fertility level, the water-use efficiency by winter wheat increased significantly as fertility level increased. Estimated water-use efficiency was 3.97 bu/inch for the check (zero N and P) treatment and 5.29 bu/inch for the 276 lb P_2O_5/acre plus 50 lb N/acre treatment. Phosphorus and N fertilization resulted in a significant increase in straw yield and number of heads/unit area at harvest (Table 1). Phosphorus placement significantly affected number of heads/acre, with seed-placed P treatments having the lowest number of heads/acre. Grain test weight was increased by P fertilization and decreased by N fertilization.

Nitrogen fertilization significantly increased grain protein from 12.0% without N to 12.9% with 50 lb N/acre in 1986 (1987 data not available). The effect of P placement on grain protein and P concentration was not significant. Grain protein decreased slightly as the rate of P application increased.

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USDA-ARS SOIL FERTILITY RESEARCH AT AKRON, COLORADO

The purpose here is to briefly outline the soil fertility research projects being conducted by USDA-ARS and cooperators at the Central Great Plains Research Station at Akron, Colorado.

PROJECT TITLE: Effect of N fertilization on water-use efficiency by winter wheat, barley, and corn in the Central Great Plains.
Objective: Determine the effects of N fertilization on crop yields, quality, and water-use efficiency with reduced tillage and annual cropping under dryland conditions.
Personnel: Ardell D. Halvorson and C. A. Reule

PROJECT TITLE: Effect of N source, placement, and rate on dryland winter wheat yields in a no-till system.
Objective: Determine the effectiveness of several N sources for use in no-till production systems and the best method of managing these N sources to obtain optimum economic returns.
Personnel: Ardell Halvorson, USDA-ARS, and Hunter Follett, CSU

PROJECT TITLE: Management of P fertilizer for dryland winter wheat in reduced tillage systems.
Objective: Determine most efficient method of P placement for optimum economic yields and the value of residual fertilizer P for future wheat production.
Personnel: Ardell Halvorson, USDA-ARS, Akron, CO and John Havlin, Kansas State University, Manhattan.

PROJECT TITLE: Crop rotation and N fertilization for efficient water use.
Objective: Determine the potential of producing economical dryland corn or sorghum yields following winter wheat in a wheat-corn-fallow rotation using reduced tillage systems. The N fertilizer requirements for optimum crop production and efficient water use are being evaluated.
Personnel: Ardell Halvorson, USDA-ARS.