Phosphorus On Barley

Relation of Placement On Growth and Nutrition

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Phosphorus fertilizers commonly are banded with the seed of small grain in the Great Plains. When P fertilizer is broadcast, the application rate is usually doubled. This difference in rate is probably the result of differences in P availability with position. Eck, et al. (3) in their study of P placement for sorghums showed that P uptake increased with depth of fertilizer placement when moisture was available. Olson and Dreier (7) in Nebraska found that P placement with the seed of small grains is desirable in the drier regions as long as the N added with the seed does not exceed 15 lb/acre. In other studies, variable results were obtained with fertilizer placement, depending upon source of P, rate, time of application, crop and level of soil P (5, 8, 10).

Effective use of P fertilizer banded at various depths appears to depend upon soil moisture supply. Workers in Montana found wheat yield responses on low- and medium-P soils were directly proportional to the total available water supply and varied as a result of intermittent soil moisture stress (2, 9).

The purpose of this study was to determine how fertilizer P placement and soil moisture in the fertilizer zone would affect P availability, barley growth and grain yield, and uptake of P under semiarid conditions.

METHODS

Field experiments were conducted at Mandan, North Dakota in 1962 through 1965 on Eakin silt loam. Each year the experiment was transferred to an adjacent site that was cropped to spring wheat the previous year. Soil characteristics for Eakin silt loam are shown in Table 1. $NaHCO_3$-soluble soil P was determined by the method of Olsen et al. (6), pH on saturated soil pastes, total soil N by Kjeldahl analysis, and organic carbon by a modification of Walkley's potassium dichromate method. Soluble P (0- to 6-inch soil depth) ranged from 13 to 21 lb/acre, a value indicating low to meduim P availability (1). Plot size was 8 x 20 feet. Each year 40 lbs N/acre as ammonium nitrate was broadcast on all plots and plowed under.

Contribution from the Northern Plains Branch, Soil and Water Conservation Research Division, Agricultural Research Service, **USDA.**

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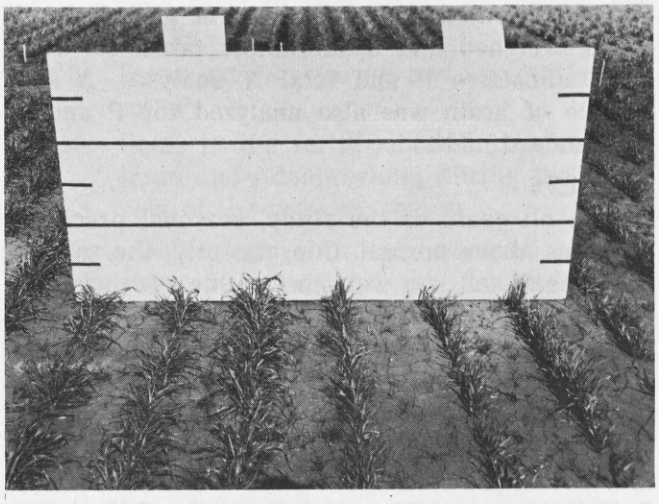

Figure 1. Barley growth in April, 1962 at Mandan, N. Dak. Plants (left) from P - with seed and plants (right) from check, no P.

In all years P was banded: (a) slightly below surface; (b) 2 inches deep; (c) 4 inches deep; or (d) with seed (drill). A check plot without P was included. Fertilizer was placed 6 inches from the row for all placements except P with the seed. Concentrated super-phosphate was used at 17 lbs P/acre (0-45-0 at 38 lbs/acre). All treatments were replicated three times. Traill barley (**Hordeum vulgare** L.) was seeded in 12-inch rows at the 2-inch depth. The experiment was conducted under both natural moisture supply and with supplemental irrigation whenever the 0- to 6-inch depth of soil began to dry out (Figure 1).

In 1965, radioactive concentrated superphosphate was used to determine the effect of placement upon soil and fertilizer P uptake. At various

Table 1. Soil characteristics of Eakin silt loam on experimental sites.

Treatment Year	N Total	P*	Paste pH	Organic C
	%	lb/A		%
	0-6 inches			
1962	.204	17	6.6	2.2
1964	.200	13	6.4	2.3
1965	.199	21	6.6	2.1
	6-12 inches			
1962	.158	5	6.6	1.61
1964	.143	4	6.5	1.50
1965	.199	16	6.6	1.76

*extracted with 0.5M $NaHCO_3$ solution.

stages of growth, tops were cut at ground level, dried, weighed and a subsample taken for total and radioactive P and total N analyses. A subsample of grain was also analyzed for P and N by standard methods.

RESULTS

In all years of the study, seasonal precipitation was above normal. Consequently, the surface 6 inches of soil was wet most of the season. Additional moisture increased grain yields in only one of three years and did not affect the response to P. Therefore, data for the two moisture levels were combined and only the means are reported.

The effect of P placement on yield of dry matter and grain for three years is shown in Table 2. Hail destroyed the crop in 1963. In 1965 erratic stands resulted from the 4-inch depth of placement so yields are not shown for this treatment. Each year P with seed increased dry weights at tillering and heading. This treatment hastened emergence of heads by 1 to 2 days.

P fertilization consistently increased dry weights of whole plant and grain, except for surface placement in 1964. Increased grain yields ranged from 4 to 8 bushels for various years. Phosphate placement was as effective at the 2-inch depth as placement of P with seed. Phosphate response from surface placement was less effective than placement of P at greater depths.

Table 2. Oven-dry weights of barley at three stages of growth and grain yield as influenced by placement of fertilizer phosphorus.

Placement of fertilizer P	Yield 1962	Yield 1964	Yield 1965	Average Yield (1962,1964)	Average Yield (1962,1964,1965)
depth					
	Tillering (lb/A)				
No-P	146	336	492	241	325
Surface	159	372	505	266	345
2 inches	152	418	482	285	351
4 inches	164	437	—	301	—
With seed	279	670	594	475	515
	Heading (lb/A)				
No-P	3002	2124	3962	2563	3029
Surface	3700	1990	4066	2845	3252
2 inches	3538	2388	3946	2963	3291
4 inches	3746	2083	—	2914	—
With seed	4302	2924	4376	3613	3867
	Whole Plant (lb/A)				
No-P	7204	4276	6098	5739	5859
Surface	7952	4186	6414	6068	6183
2 inches	7764	5082	6416	6422	6420
4 inches	7846	4436	—	6141	—
With seed	7956	5082	6648	6519	6562
	Grain (bu/A)				
No-P	62.4	39.6	49.7	51.0	50.6
Surface	65.1	38.5	53.2	51.8	52.3
2 inches	66.2	46.6	57.8	56.4	56.9
4 inches	66.2	40.4	—	53.3	—
With seed	65.7	47.6	53.2	56.6	55.5

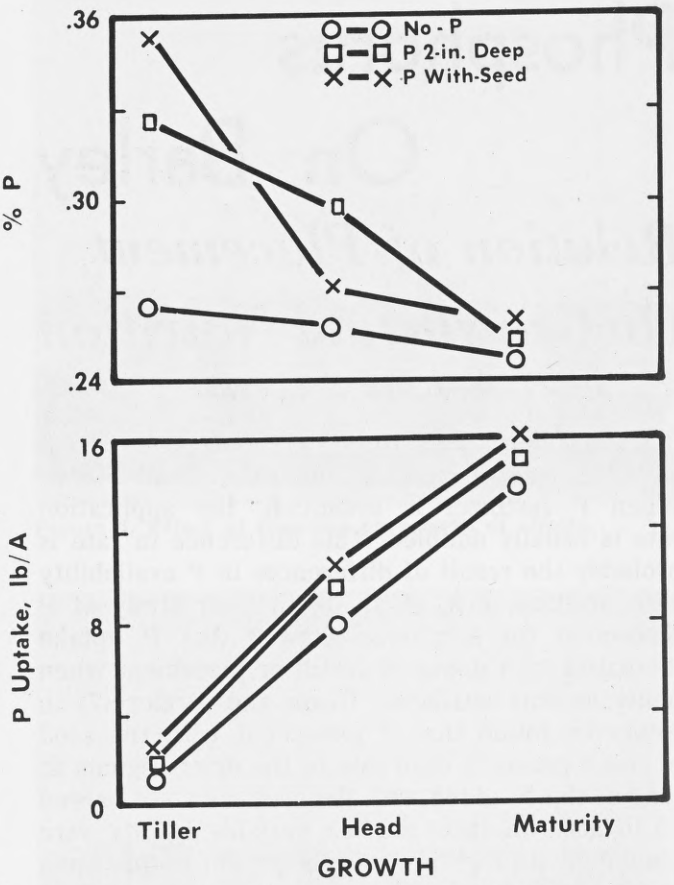

Figure 2. P uptake and per cent P of barley at three harvests as affected by placement as affected by fertilizer phosphorus (3-year average).

The effects of fertilizer placement on total P uptake and P content of the whole plant are shown in Figure 2. Only data for three treatments are shown. For surface banding and 4-inch placement (not shown) P uptake and P content were intermediate between 2-inch and no-P treatments. P uptake increased as the barley grew and matured. In all years P uptake at early stages of growth was significantly greater for with-seed placement than for other placements. However, at maturity, placement affected P uptake in 1964 only.

Placement of phosphorus with the seed increased per cent P in the plant at early growth stages (Figure 2). Differences in plant P content were great at tillering, but narrowed as the plants matured. The total P of plants grown on check plots was low (below .15 per cent) at all times.

Placement of fertilizer P had no effect on the P content of barley grain. Total P content in grain ranged from .39 to .41 per cent for the various treatments. Total P was not related to plant weights or grain yields. However, at tillering and heading, treatments that stimulated plant growth reduced the protein content of plants.

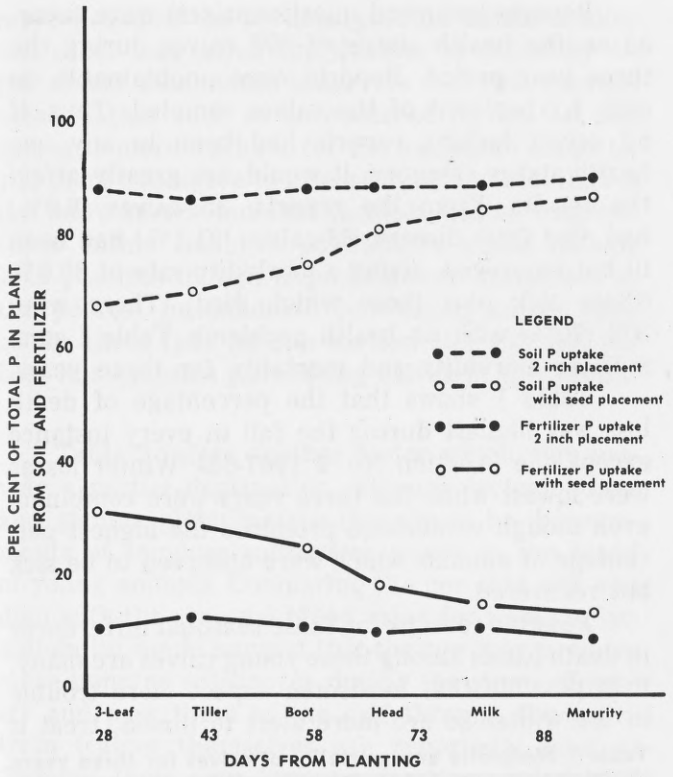

Figure 3. Per cent of total P absorbed by barley from fertilizer and soil at six growth stages in 1965.

Data on per cent of total P absorbed by plants that came from soil and P^{32} tagged fertilizer in 1965 are shown in Figure 3. The data shown for the 2-inch placement in Figure 3 are typical of all other placements except P with seed. For the various P placements, barley plants absorbed most of their P from the soil.

Per cent of total P absorbed from fertilizer was in the range of 10 to 14 per cent at all dates for all placements except P with seed. For both surface placement (data not shown) and the 2-inch placement, P uptake from soil and from fertilizer at all dates remained relatively constant. However, P uptake from soil and fertilizer changed greatly during the season when fertilizer P was placed with the seed. Fertilizer P uptake for this treatment was greatest during the early stages of growth. With time, the per cent plant P derived from fertilizer decreased and the per cent from soil increased. These results for P uptake from the seed placement agree with earlier work in North Dakota (4).

Increased uptake of soil P relative to that of fertilizer P as the season progressed for P with seed placement can be attributed to several causes:

1. Increased chemical immobilization of fertilizer phosphorus with time.
2. Decreased solubility of fertilizer P with time due to dehydration of the fertilizer zone through root action or normal soil drying.
3. Increased root growth and exploration for soil P.
4. Roots in the fertilizer band became cutinized and nonabsorbing during the latter part of the growing season.

In a field study with oats, Sherrell and coworkers (10) found that best yields resulted when P was banded with or below the seed. Other coworkers obtained best results from fertilizer placement with the seed of small grains or equal results from placement to side-and-below seed (1, 7). Results from the present trials are in agreement with other studies, except that P placed 2 inches deep and to the side of the seed was as favorable as placement of P directly with the seed.

From our study, fertilizer P placement beside the seed of small grain appears to be as good as banding with seed if (1) adequate surface water is present most of the growing season, and (2) soil P availability is in the medium to moderately low range. It appears that depth of P placement becomes less critical as soil P solubility increases, provided water is reasonably adequate.

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