Phosphorus fertilization of late-planted winter wheat in no-till fallow

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Introduction

Wheat growers interested in experimenting with or transitioning to no-till fallow are concerned about reduced yields caused by late planting. Late planting is necessary in no-till fallow because seed-zone moisture during optimum planting dates (late August to mid-September) is almost always inadequate for germination and emergence.

Growers who practice no-till fallow begin planting in October. This is often a “dusting-in” operation. Seed is placed in dry soil about three-quarters of an inch below the surface. Stand establishment is initiated later, after the onset of fall rains. Seedlings grow slowly and reach the three- or four-leaf stage before cooler winter temperatures force plants into dormancy. These plants are much smaller and have fewer tillers than wheat planted earlier in the fall.

Figure 1. Winter wheat production in the low-precipitation zone of Oregon and Washington occurs on plateaus and uplands bisected by ravines, canyons or drainages. Soils are mostly deep silt loams or very fine sandy loams formed in windblown loess.

Credit: Larry Lutcher, © Oregon State University

The yield penalty associated with late planting, or delayed growth and development, typically ranges from 7 to 20 bu/a in the low-precipitation zone (less than 12 inches of precipitation per year), but growers have minimized, and in some years eliminated, this problem by using modern grain drills to apply nitrogen (N) and sometimes sulfur (S) close to the seed while planting.

Enhancing the supply of phosphorus (P) in the soil could further improve the grain yield of late-planted winter wheat in no-till fallow. Research conducted in tilled fallow suggests that response to applied P occurs more often when winter wheat is planted in late fall, and similar results have been reported for annually cropped wheat in areas with higher rainfall. This publication describes results of field research conducted to determine if P fertilization improves the grain yield of late-planted winter wheat in no-till fallow. Results and conclusions are applicable to the low-precipitation zone of Oregon and Washington (Figure 1).

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Field research

This research was conducted over three years in Adams County, Washington, and Morrow and Umatilla counties, Oregon. There were nine research sites (three years and three locations) and 12 plots at each site (three P rates replicated four times).

Soils at these locations are mapped as Ritzville or Shano silt loams. These closely related soils are representative of 3.85 million dryland acres on the Columbia Plateau. Average annual precipitation ranges from 9.4 inches in Adams County to 11.4 inches in Umatilla County. There are fewer growing degree days in Adams County, where fall and winter temperatures are lower. Air temperatures in Umatilla County usually exceed those in Adams and Morrow counties.

Soft white winter wheat was planted during the third week of October after 15 months of no-till fallow. Wheat was planted with a customized Fabro plot drill equipped with narrow, hoe-type openers on 12-inch row spacing or with a Cross-Slot drill equipped with notched, coulter disc openers on 7-inch row spacing. The Cross-Slot drill was used in Adams County in 2003–2004 and 2004–2005. The Fabro drill was used at all other sites.

Figure 2. Weed control applications in commercial-sized fields are often made with large, self-propelled sprayers capable of treating 800 acres or more in a single day.

Credit: Bill Jepsen, Morrow County, Oregon. Reproduced by permission.

Note: At the time this research was conducted, sulfentrazone was registered for use under these conditions. Sulfentrazone is no longer labeled for use in no-till fallow. Always follow label directions.

Phosphorus fertilizer, banded 2 inches below and 1 inch beside the seed, was applied through the Fabro drill as triple super phosphate (0-45-0). Urea (46-0-0) was applied simultaneously with P at a uniform rate across treatments. Ammonium polyphosphate (10-34-0) was used with the Cross-Slot drill. Urea-ammonium nitrate (solution 32) was applied with 10-34-0 to achieve desired N rates. Nitrogen rates varied from 15 to 40 lb/a and were based on recommendations in the Oregon State University Extension fertilizer guide for winter wheat in summer-fallow systems (see “For more information” section below).

Effective weed control during the fallow cycle was achieved with a late-fall tank-mix application of glyphosate (16 oz/a of 3 lb ae/gal) plus a water-dispersible, granular formulation of sulfentrazone (Figure 2). Sulfentrazone, a soil-residual herbicide, was used to control Russian thistle (*Salsola iberica* Sennen & Pau) — one of the most troublesome weed species in fallow-based systems.

A second glyphosate application (24 oz/a of 3 lb ae/gal) in March or April was used to control broadleaf weeds as well as downy brome (*Bromus tectorum* L.) and volunteer wheat that emerged after the initial (late-fall) application. At some sites, late-season glyphosate applications were used to control localized populations of Russian thistle, prickly lettuce (*Lactuca serriola* L.), horseweed (*Conyza canadensis* (L.) Cronquist), downy brome and ripgut brome (*Bromus diandrus* Roth). In-crop weed control was accomplished by applying labeled rates of bromoxynil + MCPA when wheat was tillering and weed species were small and actively growing.

Initial soil test P levels (Table 1) were determined from samples collected in September of the crop year. Wheat was harvested from the center of plots with a research combine (Figure 3) equipped with a 5-foot cutting platform. Grain yield was calculated from the weight of harvested grain after adjustment to 10% moisture.

Table 1. Initial soil test phosphorus (P) levels, by year, at field research sites in Adams County, Washington, and Morrow and Umatilla counties, Oregon

Site	Initial soil test P level (ppm)[1]		
	2003–2004	2004–2005	2005–2006
Adams County	14.3	12.5	11.1
Morrow County	9.4	8.7	11.7
Umatilla County	6.8	16.1	13.5

[1] Sodium bicarbonate ($NaHCO_3$) extractable P values for samples (0- to 12-inch depth) collected in the fall prior to seeding.

Figure 3. Harvesting soft white winter wheat from research plots in Morrow County, Oregon. Plots at all sites were 8 or 10 feet wide and 180 feet long.

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Growing conditions

Quantity and timing of precipitation (Table 2) and accumulation of growing degree days varied during the 3 years this research was conducted, but year-to-year trends were consistent among sites. Weeds were effectively controlled in all plots, and there were no symptoms of damage from insects or foliar pathogens.

In Adams County in 2004–2005, a chocolate-brown discoloration of stems just above the crowns of plants was evidence of a minor crown rot infection caused by *Fusarium pseudograminearum* and *Fusarium culmorum*. Nonlethal crop injury from sulfentrazone, expressed as leaf banding and a reduction in early season plant growth, was evident in Adams and Umatilla counties in 2005–2006.

Table 2. Monthly precipitation, by year, at field research sites in Adams County, Washington, and Morrow and Umatilla counties, Oregon

Site and month	Precipitation (inches)		
	2003–2004	2004–2005	2005–2006
Adams County			
Sept.	0.28	0.61	0.32
Oct.	0.26	0.62	1.07
Nov.	0.66	0.65	1.13
Dec.	2.05	1.06	1.68
Jan.	1.03	0.68	3.33
Feb.	1.31	0.05	0.74
Mar.	0.31	0.85	0.48
Apr.	0.58	0.37	0.78
May	0.61	0.95	1.40
June	0.29	0.41	0.97
July	0.00	0.37	0.00
Aug.	0.70	0.23	0.00
Total	**8.08**	**6.85**	**11.90**
Morrow County			
Sept.	0.44	0.38	0.14
Oct.	0.73	0.37	0.79
Nov.	0.90	0.33	1.20
Dec.	1.54	1.04	3.03
Jan.	1.18	0.62	2.14
Feb.	1.83	0.27	0.69
Mar.	0.47	0.82	1.35
Apr.	1.57	1.04	1.06
May	1.16	1.66	1.99
June	0.55	0.55	1.65

Site and month	Precipitation (inches)		
July	0.02	0.25	0.23
Aug.	0.65	0.93	0.01
Total	**11.04**	**8.26**	**14.28**
Umatilla County			
Sept.	0.69	0.32	0.17
Oct.	0.27	0.51	0.97
Nov.	0.83	0.82	0.94
Dec.	1.87	0.79	2.80
Jan.	2.63	0.48	1.96
Feb.	1.65	0.19	0.47
Mar.	0.56	0.65	1.34
Apr.	1.47	0.89	1.30
May	1.04	1.82	1.49
June	1.81	0.65	2.01
July	0.09	0.24	0.17
Aug.	0.72	0.02	0.09
Total	**13.63**	**7.38**	**13.71**

Table 3. Phosphorus (P) rate effects on spike (head) production, 1,000-kernel weight, kernels per spike and grain yield

P rate (lb/a)	Spikes (no./sq. yard)	1,000-kernel weight (g)	Kernels/spike (no.)	Grain yield (bu/a)
0	223 a	37.5 a	31.2 a	42.8 a
5	252 b	37.6 a	30.8 a	44.7 b
15	269 c	37.8 a	29.7 a	46.1 c

Note. Data are averages from all nine sites. Within columns, values followed by a different letter are significantly different at $p \leq 0.05$.

Figure 4. Improved grain yield from phosphorus fertilization was due to spike (head) production and enhanced early season growth and development.

Credit: Larry Lutcher, © Oregon State University

Overall effects of phosphorus fertilization

Overall, the 5 and 15 lb/a P rates increased the number of spikes (heads) per unit area by 13.1% and 20.6%, respectively (Table 3). A positive response in number of spikes was evident at six of the nine sites; this response was a consequence of enhanced early season growth and development (Figure 4).

Phosphorus fertilizer recommendations are often expressed as the amount of phosphate (P_2O_5) to apply. To convert P rates to rates of P2O5, multiply by P rates 2.2. The 5 and 15 lb/a P rates discussed in this publication are equivalent to 11 and 33 lb/a of P_2O_5, respectively.

Phosphorus fertilization had no effect on 1,000-kernel weight or kernels per spike, although there was an overall tendency for reduced kernels per spike at the maximum P rate. Compared with the control, the 5 and 15 lb/a P rates increased overall grain yield by 4.4% (1.9 bu/a) and 7.7% (3.3 bu/a), respectively (Table 3).

Results from individual sites

Phosphorus fertilization improved grain yield at the six sites where there was also an increase in spike production. The initial soil test P level at four of those sites was less than 12 ppm. Responses to the 5 lb/a P rate ranged from 1.3% (0.5 bu/a) to 6.1% (2.1 bu/a). Responses to the 15 lb/a P rate ranged from 9.5% (4.1 bu/a) to 14% (4.7 bu/a). The 14% response occurred in Adams County during 2005–2006, when above-normal rainfall in April, May and June improved yield potential.

There was no grain yield response to P fertilization in Morrow County during 2005–2006 even though initial soil test P values indicated a response was probable. Analysis of postharvest soil samples from this site revealed a moderately alkaline reaction (soil pH ranged from 7.6 to 8.3), calcium carbonate ($CaCO_3$) content that varied from 1.1% to 4.3%, and enhanced buffering capacity in 5 of the 12 plots. Phosphorus fertilizer may have been less available in these plots because of reactions with $CaCO_3$.

Grain yield response on soils with an initial soil test P level greater than 12 ppm was limited to sites where soilborne pathogens or carryover effects of sulfentrazone may have caused root injury. Compared with the control, application of 15 lb/a P increased grain yield by 14.5% (3.4 bu/a) in Adams County during 2004–2005. Fusarium crown rot is a frequent problem at this location and other dryland areas in the Pacific Northwest, and P fertilization may have alleviated root injury normally associated with this disease. Similarly, applied P may have lessened the deleterious effect of sulfentrazone on root growth in Umatilla County during 2005–2006, where grain yield increased by 10.2% (4.6 bu/a) and 13% (5.9 bu/a) for the 5 and 15 lb/a P rates, respectively.

Summary

This research showed a consistent grain yield response to P fertilization at sites where the initial soil test P level was less than 12 ppm. At sites where the initial soil test P level was greater than 12 ppm (and less than 15 ppm), grain yield response was limited to situations where plants had, or were suspected to have, root injury.

Maximum benefit was usually achieved with 15 lb/a P, but in some cases, responses to this rate were no different from those achieved with only 5 lb/a P. The significant overall effect of the 15 lb/a P rate on spikes per unit area and grain yield is evidence that applying more than 5 lb/a P is not unreasonable, particularly in years with greater-than-average yield potential.

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