PROJECT TITLE: Fertilization of Late-Seeded Winter Wheat in Chemical Fallow

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INTERIM REPORT: Second Year

PROJECT OBJECTIVES: The general objective of this research is to develop phosphorus and sulfur fertilizer recommendations for the chemical fallow-winter wheat cropping system. Specific objectives are to:

(1) Characterize site conditions.
(2) Determine if P and/or S should be applied with N. Evaluate effects of P and S application on yield, test weight, and grain protein content of winter wheat.
(3) Evaluate early-season soil nutrient bioavailability and effects of seed zone water content and temperature.
(4) Determine early-season tissue nutrient concentrations and plant uptake.
(5) Quantify yield components and straw production.

KEY WORDS: Chemical fallow, fertilization, phosphorus, sulfur

STATEMENT OF PROBLEM: Winter wheat production on the Columbia Plateau occurs mostly on deep soils and in areas where average, annual precipitation ranges from 8 to 12 inches. Wheat is normally grown after a year of tillage fallow. An alternative to tillage fallow is chemical fallow. A renewed interest in chemical fallow can be attributed to: (1) limited success with annual cropping and (2) the recent availability of sulfentrazone (Spartan®)—a soil active herbicide that may improve control of Russian thistle (*Salsola iberica*). Optimism about chemical fallow is tempered by an understanding that yield reductions are a consequence of delayed seeding. Delayed seeding in chemical fallow is necessary because seed-zone moisture during optimum planting dates is frequently less than that required for uniform germination and emergence. The effect of later seeding dates on stand establishment and grain yield may be offset by improved fertilizer management.

ZONE OF INTEREST: Low precipitation (8 to 12 inches) zone.

ABSTRACT OF RESEARCH FINDINGS: Application of P fertilizer (30 lb P_2O_5/ac) improved grain yield at two of three experimental sites in 2004-2005. Yield responses appear to be the result of an increase in the number of heads per unit area (HPU). The accuracy of P fertilizer recommendations may be improved if soil test levels are evaluated in conjunction with the $CaCO_3$ concentration of soil. Assessment of seed-zone P concentrations may be warranted.

RESULTS AND INTERPRETATION: Planting details and fertilizer treatments can be found in Tables 1 and 2, respectively. Site characterization data (Tables 3, 4, and 5) will be used to identify an appropriate recommendation domain. Additional results and interpretations are reported for grain yield, test weight, grain protein content, nutrient bioavailability and uptake, yield components, and straw production.

Table 1. Planting details for: *"Fertilization of Late-Seeded Winter Wheat in Chemical Fallow."*

Location	Variety	Seeding Date	Seeding Rate	Seeding Depth
			(lb/ac)	(inches)
Adams County	Eltan	10/15/2004	50	1
Morrow County	Tubbs	10/14/2004	75	1
Umatilla County	Stephens	10/14/2004	75	1

Table 2. Experimental treatments and corresponding application rates for nitrogen, phosphorus and sulfur.

Treatment	Application Rate (lb/ac)		
	Nitrogen*	Phosphorus**	Sulfur
N Only	15	0	0
N + P (10)	15	10	0
N + S (10)	15	0	10
N + P (10) + S (10)	15	10	10
N + P (30)	15	30	0
N + P (30) + S (10)	15	30	10

**Nitrogen application rate based on yield potential of 40 bu/ac. Rates at each site adjusted for available soil nitrogen and estimates of mineralizable nitrogen. Actual application rates: Adams County = 20 lb N/ac; Morrow County = 15 lb N/ac; Umatilla County = 15 lb N/ac.*

***Phosphorus rate is lb P_2O_5/ac.*

Table 3. Depth and texture (surface foot) of soil at experimental sites in east-central Washington and north-central Oregon.

Location	Soil Type	Soil Depth	Sand	Silt	Clay
		(feet)	(%)	(%)	(%)
Adams County	Shano silt loam	6	29.5	62.1	8.4
Morrow County	Ritzville very fine sandy loam	4	63.2	28.4	8.4
Umatilla County	Ritzville very fine sandy loam	6	59.5	30.8	9.7

Table 4. Chemical characteristics of soil at experimental sites in east-central Washington and north-central Oregon.

Location	P	SO_4-S	pH	CEC	OM	$CaCO_3$
	(ppm)	(ppm)		(meq/100 g)	(%)	(%)
Adams County	13	5.9	6.4	10.6	0.6	1.4
Morrow County	8	6.8	6.9	12.7	1.0	1.6
Umatilla County	16	6.2	6.2	13.5	1.1	1.4

Table 5. Comparison of soil water storage and crop year precipitation among sites.

Location	Total Soil Water Content* [November]	Total Soil Water Content* [April]	Crop Year Precipitation
	(inches)	(inches)	(inches)
Adams County	9.6	9.3	7.0
Morrow County	7.3	5.2	7.4
Umatilla County	11.2	8.5	7.2

* *Plant available water is less than total water by about 50%.*

Grain Test Weight, Protein, and Yield. Test weight and grain protein content were not affected by fertilizer treatment. Test weights within and among sites ranged from 59 to 60 or 61 lb/bu. Grain protein concentrations were lower (11-12%) in Morrow and Umatilla County and higher (≅ 13%) in Adams County. Differences in grain protein content appear to be correlated with the timing of spring rainfall and the position of available N in the soil profile.

Grain yield in Adams County was significantly less than yields in Morrow and Umatilla County. Lower yields in Adams County may be a consequence of soil compaction and/or variety selection. The Adams county site has been direct seeded for nine years, and compaction is evident in the surface foot. The winter wheat variety 'Eltan,' which was grown in Adams County, is much more winter-hardy than varieties grown at the other two sites. The genetic background that "gives" Eltan its winter hardiness also prevents it from growing during a mild winter or getting an "early start" in the spring. Varieties grown farther south (Morrow and Umatilla County) have less cold tolerance and more of an opportunistic growth habit. These same varieties are less likely to survive cold temperatures often experienced in Adams County.

Sulfur application failed to produce a significant yield response at any of the three experimental locations. Application of 30 lb P_2O_5/ac had a relatively small, but statistically significant, effect on grain yield in Adams County and Morrow County (Table 6). Yield response to application of 10 lb P_2O_5/ac was most pronounced at the Adams County site—a site with a relatively high soil test P level. A much smaller response to application of 10 lb P_2O_5/ac was observed at Morrow County and Umatilla County sites (Figure 1). Response to the lower P rate was similar at both of these sites, and this is intriguing because soil test P levels were low-to-moderate in Morrow County and relatively high in Umatilla County. Yield response to application of 30 lb P_2O_5/ac was more closely related to soil test P levels.

Table 6. Treatment effects on grain yield of late-seeded winter wheat in chemical fallow.

Treatment	**Yield (bu/ac)** Adams County	Morrow County	Umatilla County
N Only	23.7	43.2	50.3
N + P (10)	25.6	43.7	51.1
N + S (10)	24.4	41.5	48.4
N + P (10) + S (10)	25.0	44.1	52.6
N + P (30)	27.1	47.3	52.4
N + P (30) + S (10)	26.8	46.3	51.8
$LSD_{(0.05)}$	*2.8*	*1.6*	*NS**
CV (%)	*7.3*	*2.4*	*3.5*

* *NS = not significantly different.*

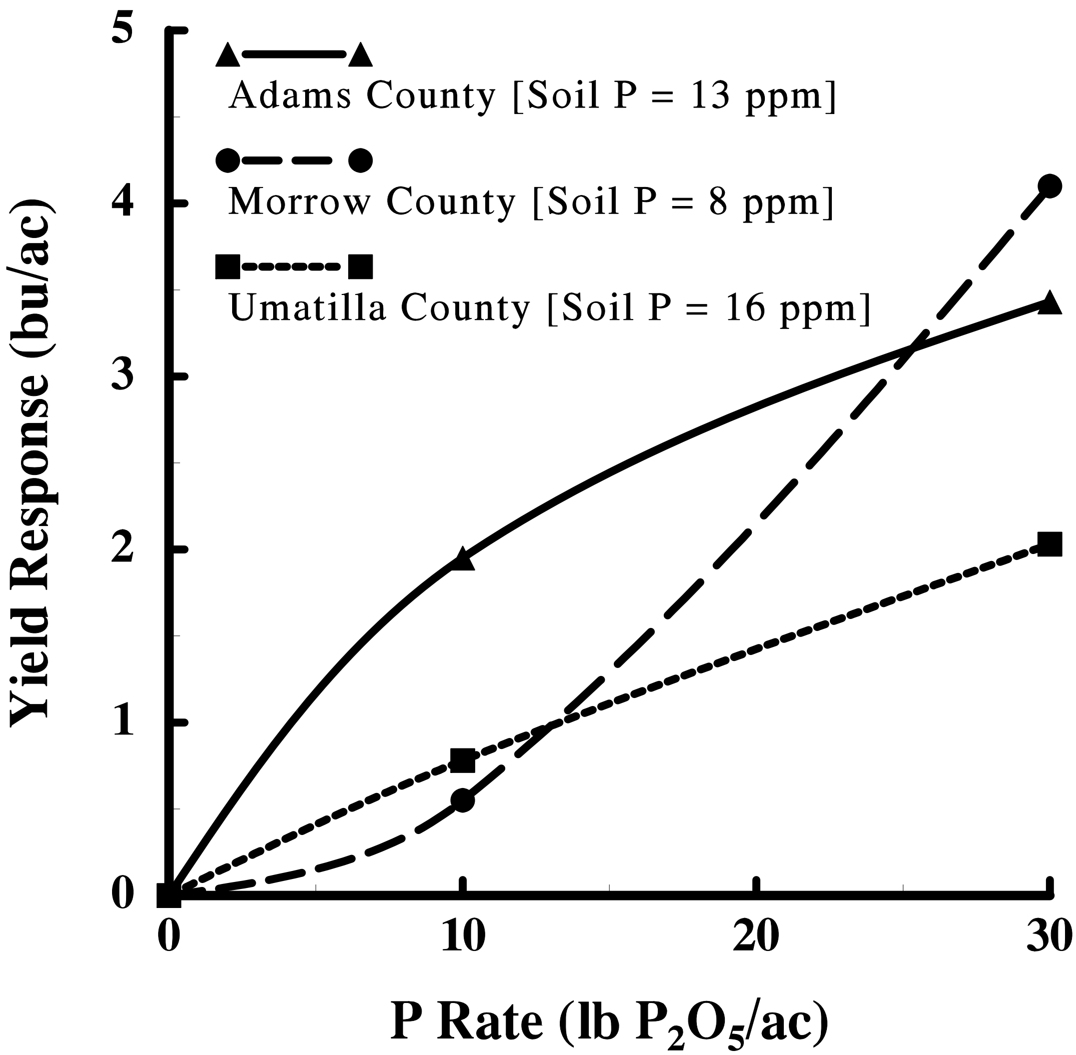

Figure 1. Yield response to P application for late-seeded winter wheat in chemical fallow. *Note:* There was no 20 lb P_2O_5/ac treatment.

Bioavailability of Phosphorus in the Seed-Zone. Seed-zone bioavailability of PO_4-P (Table 7) was measured after emergence in the fall and during the spring when plants were in the mid-tillering stage of growth. Small (1" x 3") sheets of $NaHCO_3$ charged resin were placed in contact with a layer of soil at the 1-to-4-inch depth. Sheets were removed from the seed-zone 48 hours after installation. Bioavailability was determined using ICP analysis of desorbed anions in a weak HCl extractant.

Resin sheets were placed in control plots only (plots that did not receive an application of either P or S). Collected data are being used to improve our understanding of field conditions associated with observed responses to fertilization.

Table 7. Seed-zone bioavailability of PO_4-P. Traditional soil test results and potential bioavailability numbers are included for comparison.

Location	Soil Test P*	Bioavailable PO_4-P [Fall]	Bioavailable PO_4-P [Spring]	Potential Bioavailability PO_4-P**
	(ppm)	(ug/10 cm^2)	(ug/10 cm^2)	(ug/10 cm^2)
Adams County	13	0.82	1.24	30.2
Morrow County	8	0.96	1.78	14.9
Umatilla County	16	0.82	2.06	16.2

* *Soil test P determined for samples collected from the 0-12" depth.*
** *Potential bioavailability determined from resins placed in a saturated paste (70 °F) of soil from each location.*

Soil test P and bioavailable PO_4-P comparisons should be interpreted with caution. Soil test P was determined for samples collected from the surface foot. Bioavailable PO_4-P results apply to the seed-zone only. There is no clear relationship or correlation between soil test P and bioavailability. Expectations for a good correlation are not realistic since measurements of soil test P and bioavailable PO_4-P are "made" on samples collected from different depths of the soil profile.

Should our sampling protocol for P testing be modified to include soil from the surface foot and the seed-zone layer? Would this improve our ability to predict responses to fertilization? Oregon fertilizer guides, *for the low precipitation zone*, currently recommend an application of 20 to 25 lb P_2O_5/ac if soil test levels are less than or equal to 5 ppm. Application of P is not recommended if soil test values are greater than 15 ppm. Response to P is highly variable when soil test values are between 6 and 15 ppm. Our ability to predict a response in fields with intermediate soil test levels may improve if seed-zone P concentrations are also evaluated. This may be a particularly important strategy for chemical fallow fields—fields that are prone to nutrient stratification. Assessment of **early-season** P availability might be improved by making use of resin sheet methodology. A traditional P soil test, *on samples collected from the 0-to-4-inch depth*, may be a more practical alternative.

Seed-zone bioavailability of PO_4-P was low during the 2004-2005 crop year. Seed-zone water contents (at the time resins were in the field) ranged from 8 to 12% on a weight-by-weight basis. These low water content values are fairly common in the low precipitation zone and may be responsible for limited rates of P diffusion. The practical implication of limited diffusion is significant. An economic yield response to P fertilization may only occur in years when seed-zone moisture is greater than some yet-to-be-determined level.

The **potential** bioavailability of PO_4-P in Adams County was nearly double that in Umatilla County. This information is important because soil test P levels at these locations are similar.

The enhanced potential for bioavailability of PO_4-P in Adams County may be attributed to a reduced concentration of calcium carbonate ($CaCO_3$) in soil. This hypothesis is supported by results from the analysis of resin sheets for the bioavailability of calcium (Ca). Bioavailable Ca in the seed-zone is only half of that measured in soils at the Umatilla County site (Table 8). This is especially noteworthy because the average $CaCO_3$ concentration in surface foot soil samples was equal to 1.4% at both locations. Calcium combines with P to form insoluble compounds that cannot be taken up by plants. Phosphorus fertilizer recommendations may be improved if P soil test levels are evaluated in conjunction with $CaCO_3$ concentrations.

Table 8. Comparison of Ca bioavailability and potentially-bioavailable PO_4-P in the chemical fallow seed zone. Surface foot $CaCO_3$ concentrations are included for comparison.

Location	Potential Bioavailability [PO_4-P]	Bioavailable Calcium [Ca]	Surface Foot $CaCO_3$ Concentration
	(ug/10 cm^2)	(ug/10 cm^2)	(%)
Adams County	30.2	1124	1.4
Morrow County	14.9	2223	1.6
Umatilla County	16.2	2546	1.4

<u>Tissue Nutrient Concentrations and Plant Uptake</u>. Detailed information about tissue nutrient concentrations and plant uptake will be provided in the final report. Preliminary results show that yield increases from P fertilization are correlated with enhanced P uptake. Maximum grain yield was measured in plots where plant uptake of P was equal to about 30 lb/ac. Treatments had no effect on S uptake.

<u>Yield Components and Straw Production</u>. Treatments had no effect on 1000 kernel weight (KW) or kernels per head (KPH). There was a trend of increased straw production (whole sample weight minus grain weight) from fertilization with P. Heads per unit area (HPU) increased in plots where P was applied at 10 or 30 lbs P_2O_5/ac (Table 10).

Table 9. Treatment effects on yield components and the quantity of crop residue in Adams County, 2004-2005.

Treatment	KW*	KPH**	HPU***	Residue
				(lb/ac)
N Only	31.7	31.8	55.5	2793
N + P (10)	33.1	31.3	55.0	2713
N + S	32.0	29.5	57.5	2699
N + P (10) + S	33.3	31.3	56.5	2898
N + P (30)	32.4	28.6	54.0	2604
N + P (30) + S	33.0	29.5	64.3	3116
LSD (0.05)	*NS*[+]	*NS*[+]	*NS*[+]	*NS*[+]
CV (%)	*5.0*	*9.5*	*13.2*	*13.9*

[*] KW = 1000 kernel weight.
[**] KPH = kernels per head.
[***] HPU = heads per unit area (heads/meter-row).
[+] NS = not significantly different.

Table 10. Treatment effects on yield components and the quantity of crop residue in Morrow County, 2004-2005.

Treatment	KW*	KPH**	HPU***	Residue
				(lb/ac)
N Only	35.8	32.2	96.8	4929
N + P (10)	35.9	32.3	108.3	5312
N + S	35.2	35.0	99.0	5014
N + P (10) + S	35.4	34.3	97.0	4859
N + P (30)	36.2	32.2	114.3	5732
N + P (30) + S	36.7	33.3	106.0	5570
LSD (0.05)	*NS*[+]	*NS*[+]	***11.7***	*NS*[+]
CV (%)	*3.0*	*5.3*	*7.5*	*11.2*

[*] KW = 1000 kernel weight.
[**] KPH = kernels per head.
[***] HPU = heads per unit area (heads/meter-row).
[+] NS = not significantly different.

Table 11. Treatment effects on yield components and the quantity of crop residue in Umatilla County, 2004-2005.

Treatment	KW*	KPH**	HPU***	Residue
				(lb/ac)
N Only	40.1	26.4	126.3	6298
N + P (10)	40.5	25.2	139.8	6481
N + S	40.5	27.2	117.5	5620
N + P (10) + S	40.8	28.1	131.8	6610
N + P (30)	41.1	25.6	138.3	6522
N + P (30) + S	40.9	26.2	135.8	6598
LSD $_{(0.05)}$	*NS+*	*NS+*	*NS+*	*NS+*
CV (%)	*4.3*	*10.4*	*7.5*	*12.1*

**KW = 1000 kernel weight.*
***KPH = kernels per head.*
****HPU = heads per unit area (heads/meter-row).*
+ NS = not significantly different.

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITY:
The PI is cooperating with Stewart Wuest, Bill Schillinger, Don Wysocki, Mary Corp, and Dan Ball on chemical fallow and/or reduced tillage systems research.

PUBLICATIONS:
Lutcher, L.K., S.B. Wuest, W.F. Schillinger, D.J. Wysocki, and N.W. Christensen. 2005. Fertilization of late-seeded winter wheat in chemical fallow. *In:* STEEP 2004 Annual Report. Pp.79-86.

PRESENTATIONS:
Lutcher, L.K., 2005. "Nutrient recommendations for the low precipitation zone." Mid Columbia Regional Fertility Workshop. Wasco, OR. February 2005.

Lutcher, L.K. 2005. "Fertilization of winter wheat in summer fallow systems." Columbia Basin Cereal Seminar. Pendleton, OR. January 20.

Lutcher, L.K., S.B. Wuest, W.F. Schillinger, D.J. Wysocki, and N.W. Christensen. 2005. Poster Session: Fertilization of late-seeded winter wheat in chemical fallow. Northwest Direct Seed Cropping Systems Conference. Spokane, WA. January 13-14.

Lutcher, L.K., S.B. Wuest, W.F. Schillinger, D.J. Wysocki, and N.W. Christensen. 2004. Poster Session: Fertilization of late-seeded winter wheat in chemical fallow. Oregon Wheat Growers League Annual Conference. Tigard, OR. December 7-9.