

PHOSPHORUS SOURCE EFFECTS ON DRYLAND WINTER WHEAT IN CROP-FALLOW ROTATIONS IN EASTERN WASHINGTON

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ABSTRACT

Wheat growers in eastern Washington are in a below-maintenance phosphorus (P) program where P removal exceeds P application. Subsurface banding and agricultural-induced soil pH decline may be responsible for the high fertilizer P use efficiency. Experiments conducted in 2004-2007 showed responses to P at rates higher than typically applied. The present 3-year study was initiated to compare dryland wheat responses to a range of fluid P (ammonium polyphosphate; 0, 10, 20 and 40 lb P₂O₅/acre) and one dry P (MAP; 20 lb P₂O₅/acre) fertilizer rate. Sites were located in low rainfall (<12-inch), summer fallow cropping areas. Dry matter yield and tissue P concentration were measured at anthesis and grain yield at maturity. Quadratic grain yield responses to fluid P were observed in four of the six site-years. High rates of fluid P reduced yield, possibly due to P stimulation of vegetative growth and subsequent depletion of stored soil moisture. Grain yields with dry P fertilizer were similar to or lower than with fluid P at three of six site-years. Tissue analysis at anthesis indicated P availability was lower with dry MAP than with fluid APP. Results indicate a good potential for dryland wheat to respond to fluid P in the low rainfall, crop-fallow and chemical fallow areas of eastern Washington. Intermediate rates of fluid P should be applied to optimize yields.

INTRODUCTION

Wheat growers in eastern Washington are in a below-maintenance P fertility program. In low (<12-inch annual) precipitation, winter wheat-fallow environments, few growers use P fertilizer due to low yield potential and need to minimize input costs. Yet, many growers report stable or increasing soil test P concentrations. The majority of growers in eastern Washington place P in a band beneath the surface with nitrogen, or directly with the seed. Clearly, this placement method is leading to high P use efficiency. However, the sustainability of this P management program is questionable. We are interested in explaining the apparent contradiction between below-maintenance P applications and the apparent increase in soil test P concentrations. One explanation may be related to changing soil pH. In alkaline soil, inorganic P is associated mainly with Ca-based minerals. In acidic soil, inorganic P is associated mainly with Fe/Al-based minerals. In the past 25 years soil pH has declined throughout eastern Washington and northern Idaho due to the use of ammonium-based fertilizers. It is likely that this recent pH decline has or will result in a shift in inorganic P forms from calcium to Fe/Al-based minerals. During the transition from neutral/alkaline to acidic soil pH, soluble and plant available forms of P may temporarily increase as calcium-based minerals dissolve and Fe/Al-based minerals form.

Beginning in fall 2004 we conducted a series of P fertility studies in a chemical fallow-winter wheat production system in the low rainfall zone of eastern Washington. Various rates of fluid P fertilizer were applied in a deep band directly beneath the seed row at planting. Responses to P were obtained in each of three years and with soil test P levels at or above critical values. These responses to P suggest more routine P use may be warranted in the low rainfall zones. Based on the results of this earlier research we conducted experiments to evaluate dryland winter

wheat responses to fluid and dry P fertilizer in low (<12-inch) rainfall zone of eastern Washington State. The intent was to compare wheat responses to dry and fluid P in more common crop-tillage fallow systems.

MATERIALS AND METHODS

Studies were conducted at two locations in the low rainfall zone of eastern Washington in 2005-06, 2006-07, and 2007-08. Initial soil test P was measured at each site (Table 1). The sites featured winter wheat grown in a traditional, 2-year crop-tillage fallow rotation. Each study included four rates of fluid ammonium polyphosphate P (0, 10, 20 and 40 lb P₂O₅/acre) placed in a deep band with nitrogen (32-0-0) and one rate of dry MAP (20 lb P₂O₅/acre). Phosphorus was placed 2 weeks before seeding. Seeding rates were 40 lb/acre with 12-inch spacing. Soft white or hard red winter wheat was sown as indicated in the figures. Each treatment was replicated four times in a randomized complete block experiment design. Individual plot dimensions were 7-8 feet wide by 50 feet long. Above-ground dry matter production was measured by harvesting six linear feet of plant row from each treatment at anthesis. Beginning in 2007, tissue was analyzed for total P. Grain yield was measured by harvesting an area five feet (4 rows) in width by approximately 40 feet in length from the center of each plot with a small plot combine.

Table 1. Study location and average initial soil test P (0 to 1-foot depth).

Location	Year	Soil test P by method (mg/kg soil)†	
		Acetate P	Bicarbonate P
Lind	2005-06	7.3	12.1
	2006-07	3.9	11.0
	2007-08	3.3	14.3
Ralston	2005-06	5.8	17.8
	2006-07	5.5	22.5
	2007-08	5.4	27.0

†Adequate soil test values = 8 mg/kg for acetate and 16 mg/kg for bicarbonate (Koenig, 2005).

RESULTS AND DISCUSSION

Responses to fluid P were obtained when soil test levels were near or above historical critical values (Figures 1-3; Table 1). This suggests current soil test-based fertilizer recommendations may be outdated and critical levels do not accurately predict a response to P. Grain yield responses to dry P were lower than to fluid P at 3 of the 6 site-years. This is similar to results from Australia showing better responses to fluid P than to dry P (Holloway et al., 2004). Tissue P concentration was statistically higher for fluid P than for dry P at 2 of 4 site-years for which tissue P was measured. This suggests that dry P was less available than fluid P and supports tissue and grain yield responses to P source (Figures 2-3).

Interestingly, grain responses to fluid P rate were quadratic in 4 of the 6 site-years (Figures 1 and 2). At the highest rate of P, anthesis whole-plant dry matter (3 site-years) and final grain yields (4 site-years) were reduced slightly over the intermediate P rate. Moisture is a main limiting factor in the summer fallow cropping systems at these locations. Higher rates of P apparently stimulated excessive vegetative growth that depleted stored soil moisture and reduced late-season vegetative and grain yields. This is similar to the “haying off” response observed in wheat grown in low moisture, crop-fallow rotations in Australia (Van Herwaarden et al., 1998).

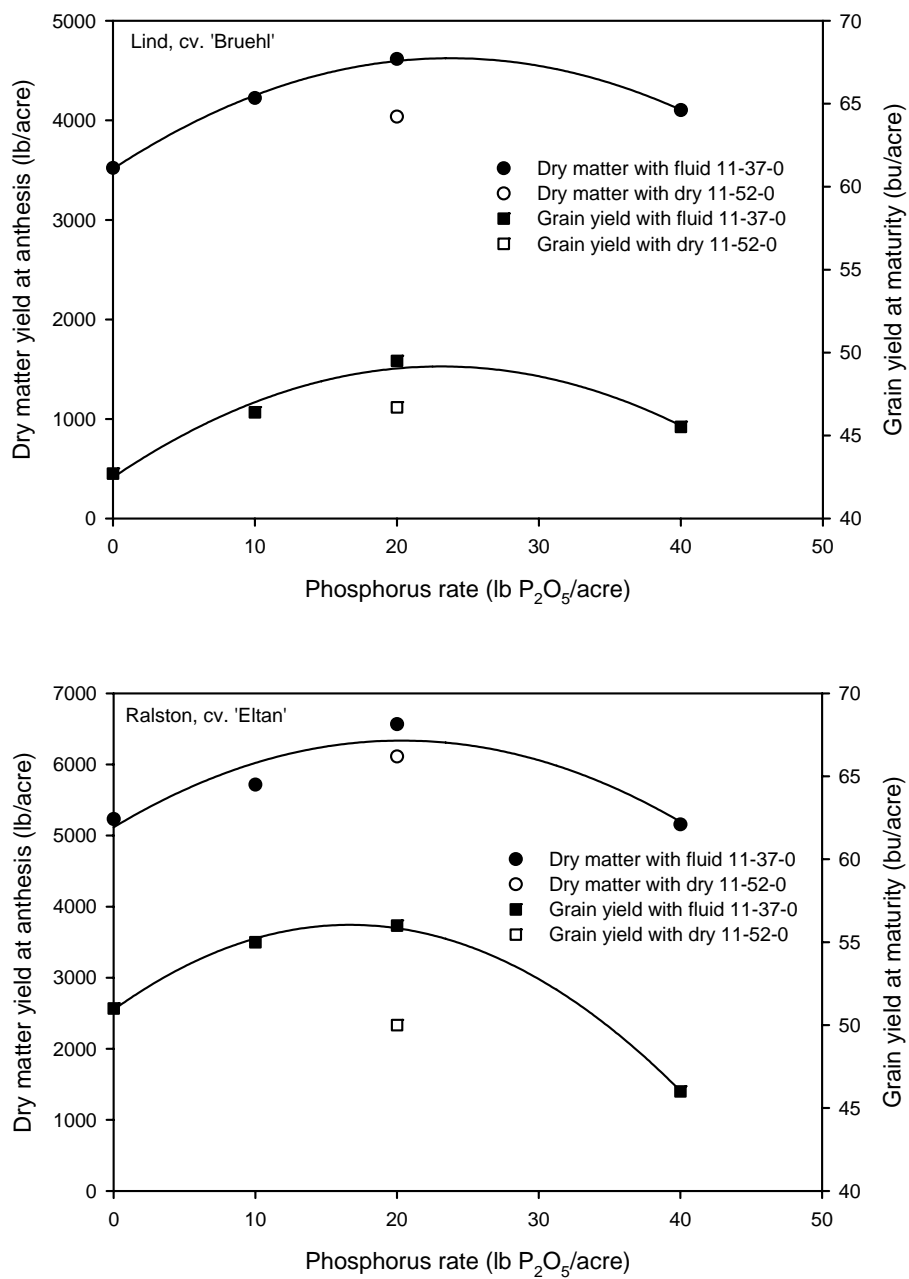


Figure 1. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2005-06. Trends indicated by lines are significant at $p < 0.05$.

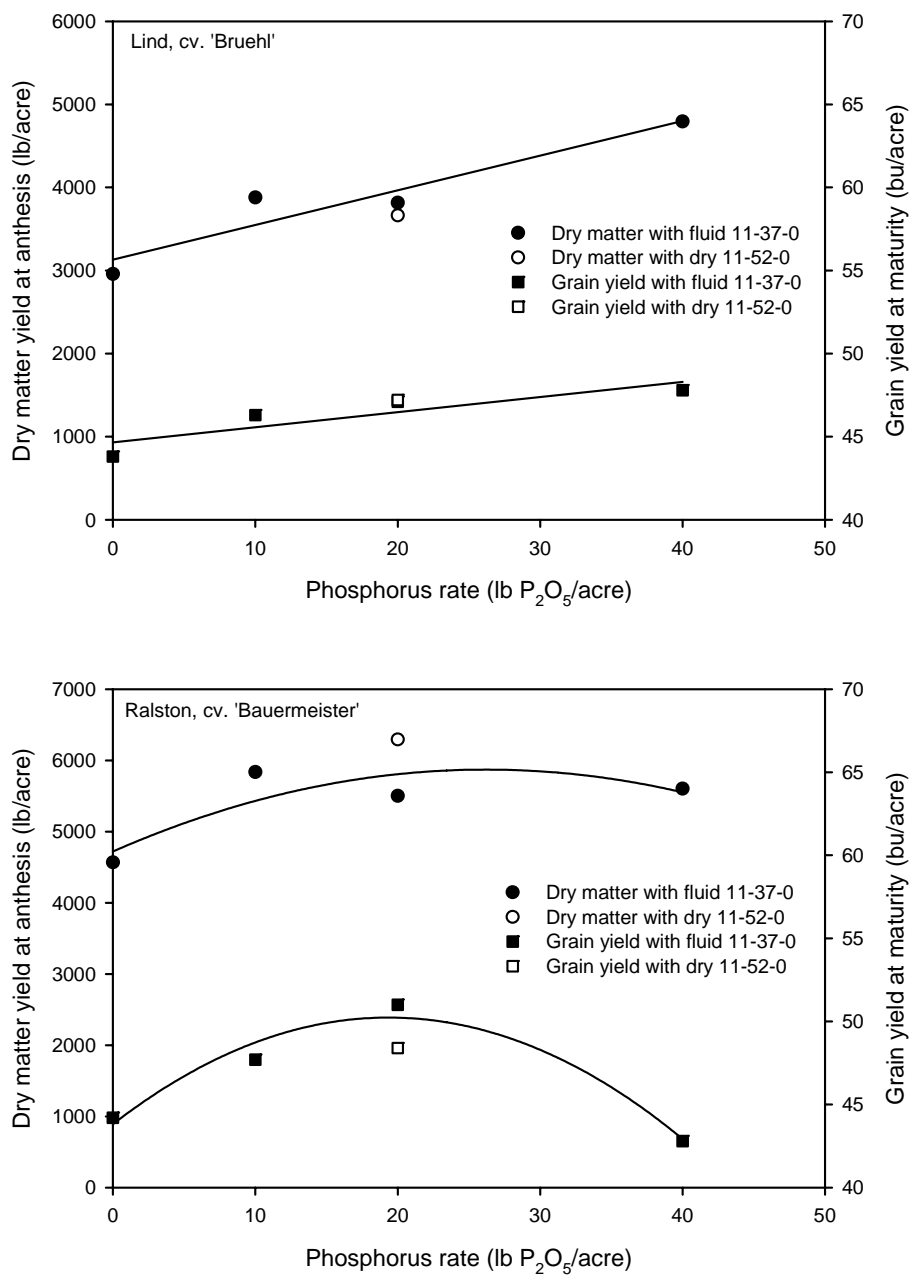


Figure 2. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2006-07. Trends indicated by lines are significant at $p < 0.05$.

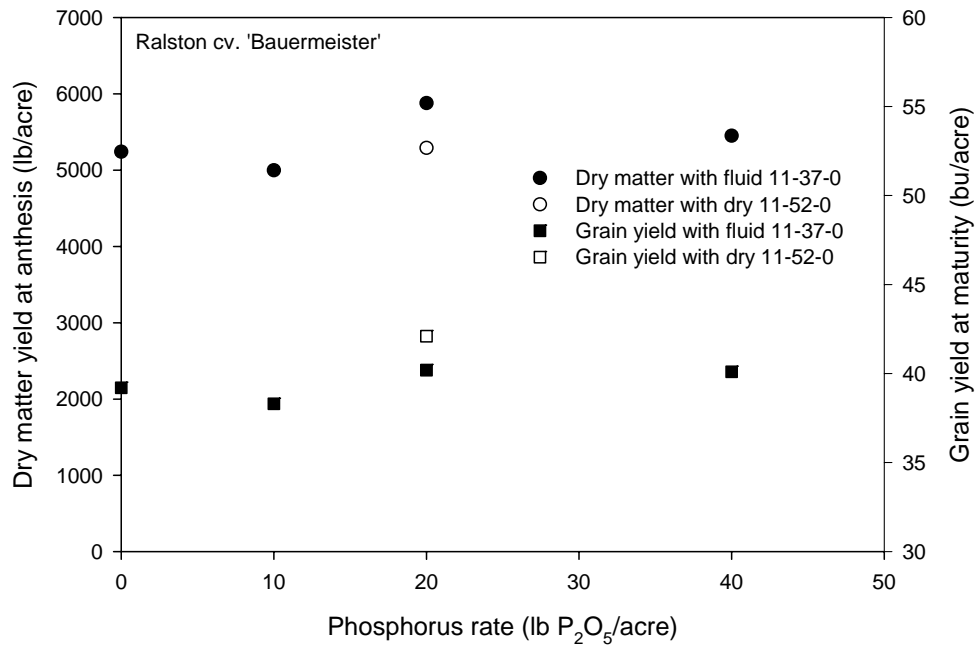
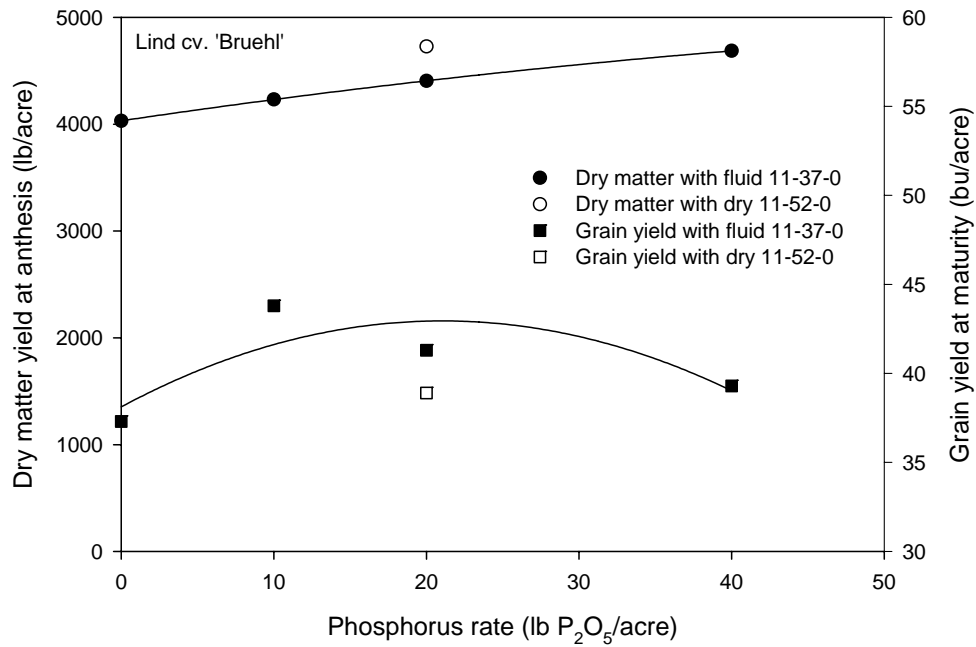


Figure 3. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2007-08. Trends indicated by lines are significant at $p < 0.10$.

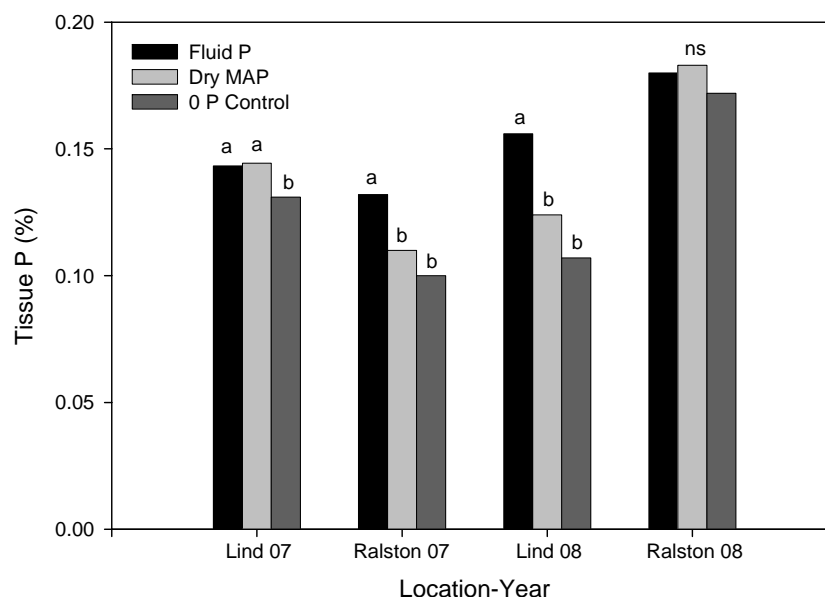


Figure 4. Effects of P rate and form on tissue P concentration at anthesis at Lind and Ralston locations in 2007 and 2008. Phosphorus rates were 20 lb P₂O₅/acre. Within a site-year, bars capped with the same letter are not significantly different ($\alpha = 0.05$); ns = no significant difference among treatments for a given site-year.

CONCLUSIONS

Results indicate a good potential for dryland wheat to respond to fluid P in the low rainfall, crop-fallow areas of eastern Washington. Intermediate rates of fluid P should be applied to optimize yields and prevent grain yield reductions in this moisture limited environment. Phosphorus availability from dry MAP is apparently not as great as from fluid APP in this environment.

REFERENCES

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