

PHOSPHORUS SOURCE AND RATE EFFECTS ON DRYLAND WINTER WHEAT IN EASTERN WASHINGTON

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ABSTRACT

Many dryland wheat growers in eastern Washington State are in a below-maintenance phosphorus (P) fertility program where P removal exceeds P application. Subsurface banding and agricultural-induced soil pH decline may be responsible for the high efficiency of P fertilizer in this area. Experiments conducted in 2005-2007 showed responses to P at rates higher than typically applied. The present study was initiated to compare dryland wheat responses to a range of fluid P (0, 10, 20 and 40 lb P₂O₅/acre) and one dry P (20 lb P₂O₅/acre) fertilizer rate. Sites were located in low rainfall (<12-inch), summer fallow cropping areas. Dry matter yield was measured at anthesis and grain yield at maturity. Quadratic responses to fluid P were observed in four of six site-years. High rates of fluid P reduced dry matter and grain 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. 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 yield reductions.

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 use P fertilizer due to low yield potential and need to minimize input costs. Growers that do use P place it in a band beneath the surface with nitrogen, or directly with the seed at rates below crop removal. Band 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 reported by many growers. 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 (Figure 1). These responses to P suggest more routine P use may be warranted in the low rainfall zones. High rates of fertilizer P appeared to reduce yield compared to intermediate rates in one year (Figure 1). Residual effects of P applications were not measured but are expected.

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 and high rainfall zones of eastern Washington State. The intent was to compare wheat responses to dry and fluid P in more common crop-tillage fallow and annual cropping systems.

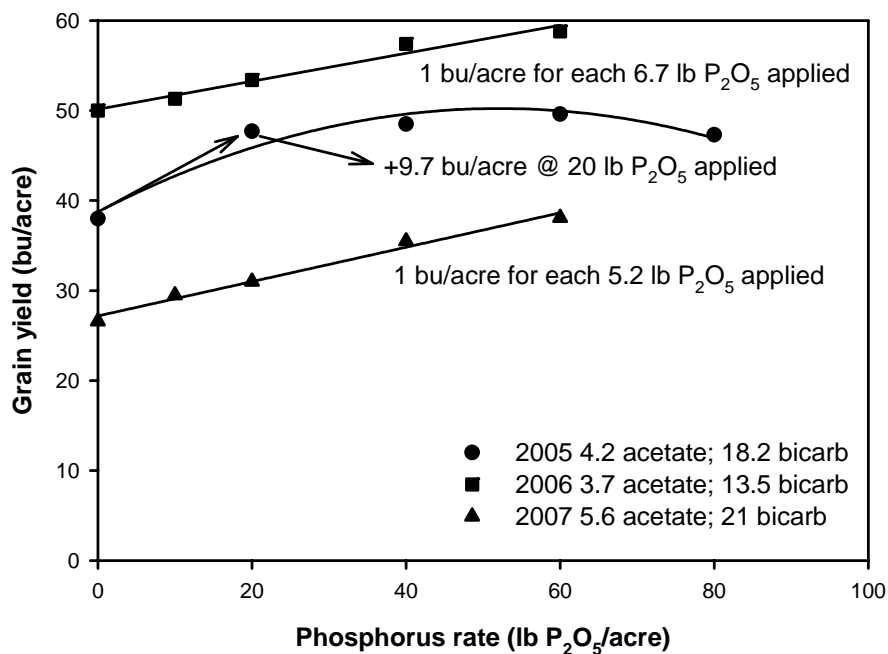


Figure 1. The effect of P rate on soft white winter wheat (cv. ‘Eltan’) yield in the low (<12-inch annual) rainfall zone of eastern Washington. The rotation is crop-chemical fallow. Responses are indicated by the trend lines. Initial soil test P (ppm; 0 to 1-ft depth) is indicated in the legend.

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. Soft white winter wheat seeding rates were 40 lb/acre with 12-inch spacing. 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. Grain yield was measured by harvesting an area five feet (4 or 8 rows) in width by approximately 40 feet in length from the center of each plot with a small plot combine.

RESULTS AND DISCUSSION

Responses to fluid P at summer fallow locations were obtained when soil test levels were near or above historical critical values based on a bicarbonate extract (Figs 2 - 4; Table 1). This suggests current soil test-based fertilizer recommendations may be outdated and critical levels do not

accurately predict a response to P in these situations. Alternatively, the bicarbonate extract may not be accurately estimating plant available P in these recently acidified soils. Acetate-extractable P was below critical levels for 5 of 6 site-years.

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	14.0
Ralston	2005-06	5.8	17.8
	2006-07	5.5	22.5
	2007-08	5.4	27.0

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

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 Australian research, showing better responses to fluid P than to dry P (Holloway et al., 2004). Interestingly, responses to fluid P rate were quadratic in 4 of the 6 site-years (Figures 2 and 3). At the highest rate of P, both anthesis whole-plant dry matter (3 site-years) and final grain yields (4 site-years) were reduced slightly at 40 lb P₂O₅ compared to the low or intermediate rate. Moisture is the 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 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).

Early results of this study 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.

References

Holloway, R.E., B.M. Frischke and D.M. Brace. 2004. Residual effects of MAP and APP on calcareous soils. Pp 119-124 in L. Murphy (ed) Proceedings of the Fluid Fertilizer Forum, Scottsdale, Arizona, February 22-24.

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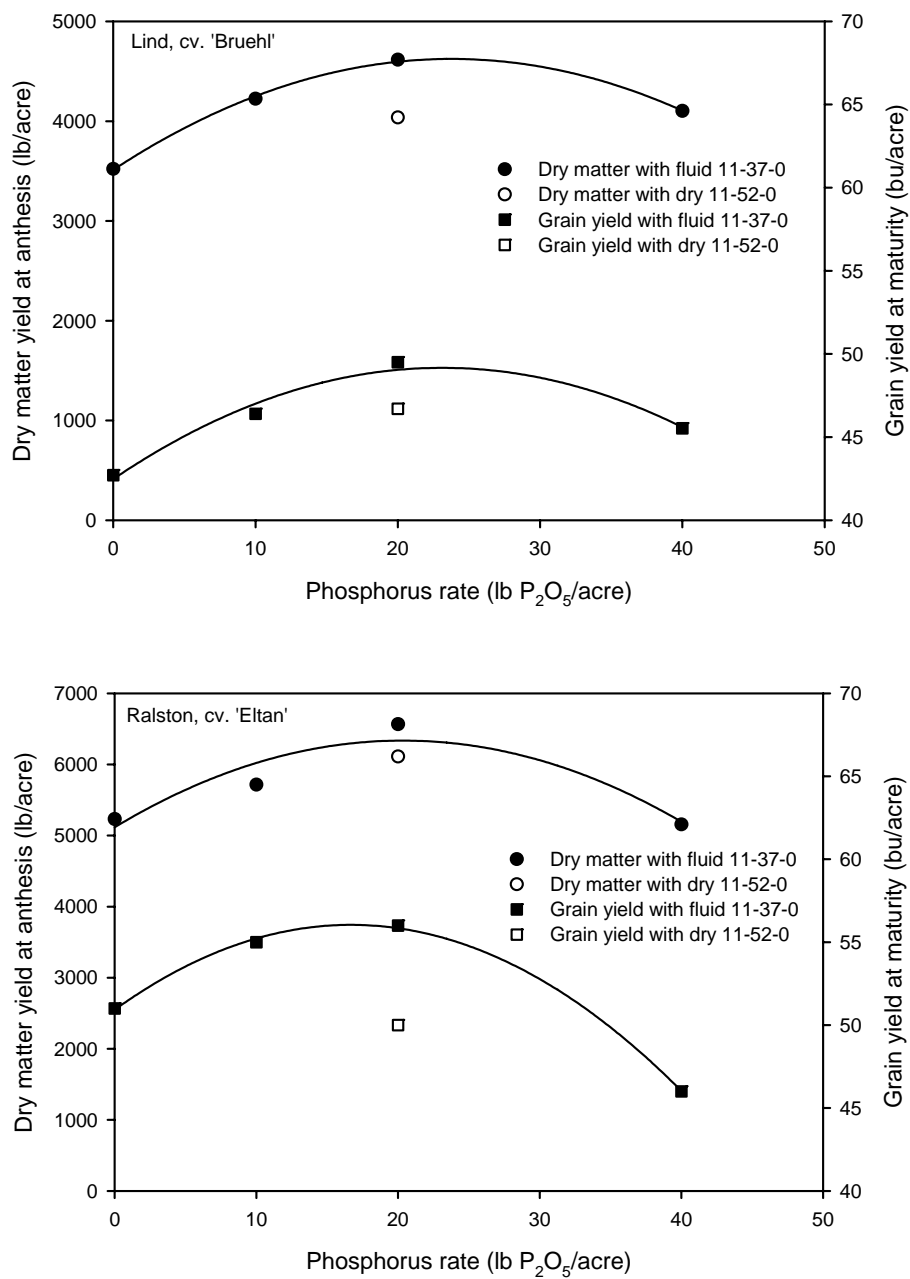


Figure 2. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2005-06.

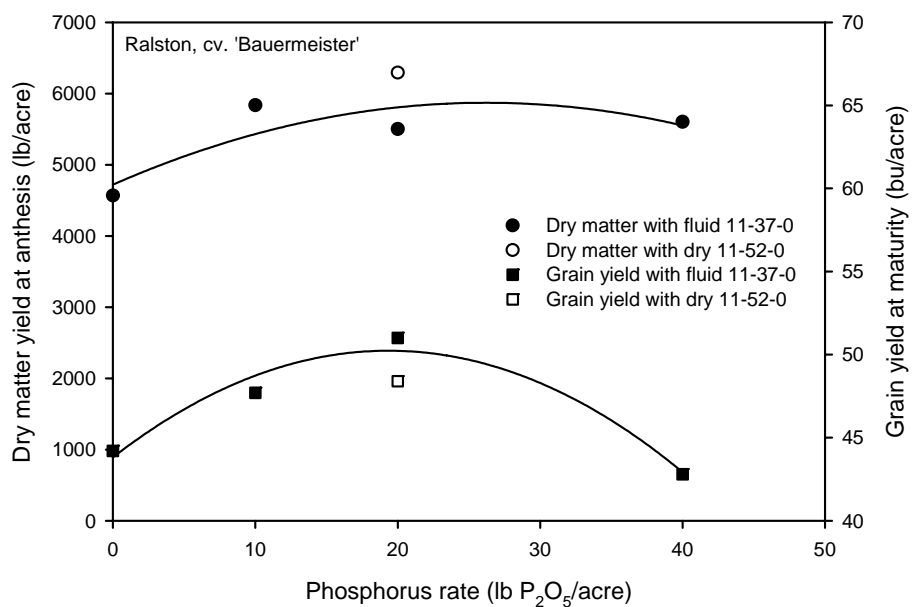
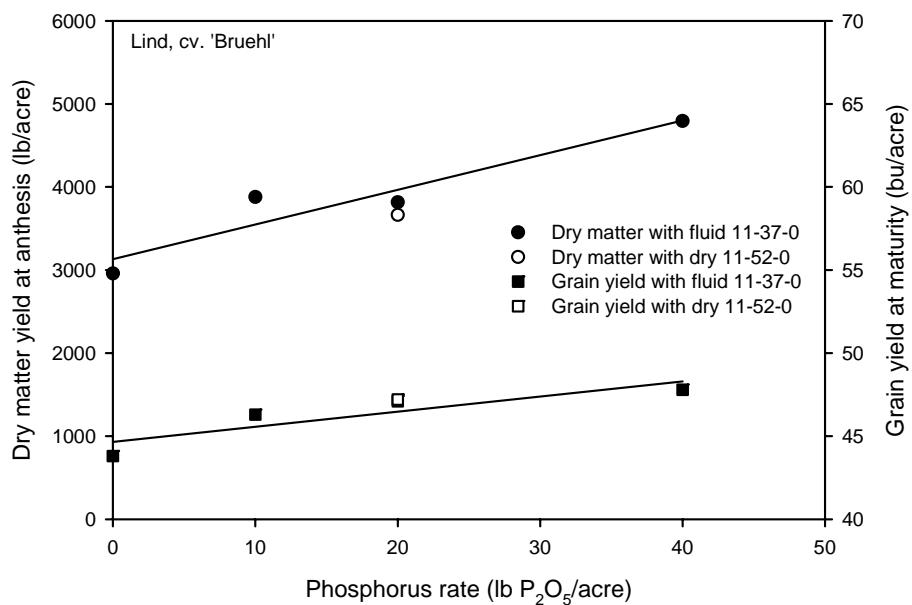


Figure 3. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2006-07.

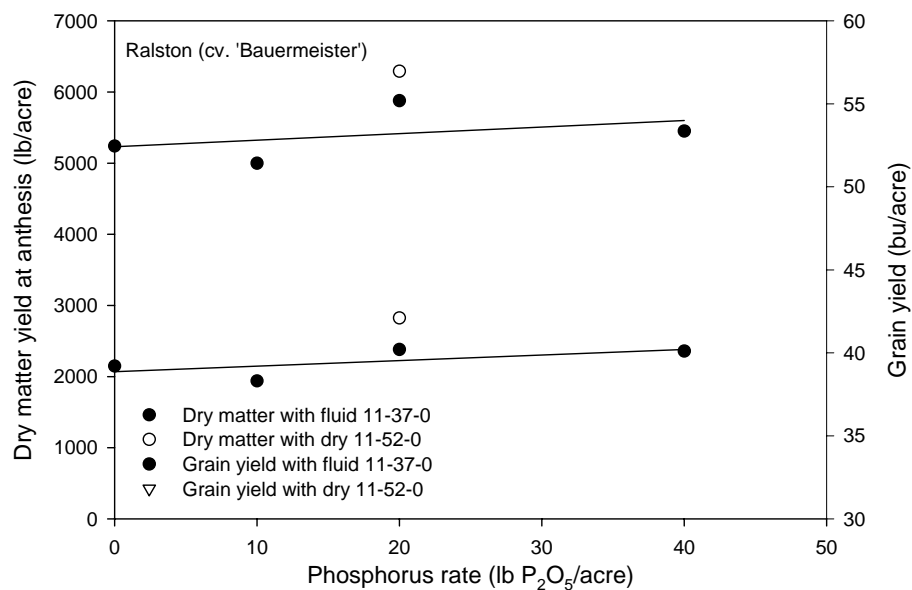
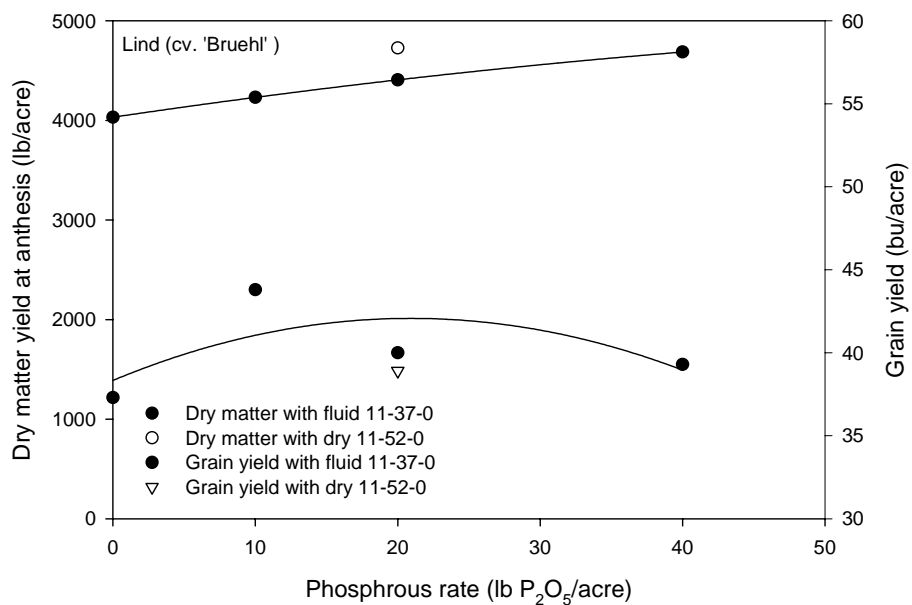


Figure 4. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2007-08.