PHOSPHORUS SOURCE EFFECTS ON DRYLAND WINTER WHEAT IN EASTERN WASHINGTON

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ABSTRACT

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 fertilizer P use efficiency in this area. Experiments conducted in 2004-2007 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 P_2O_5/acre) and one dry P (20 lb P_2O_5/acre) fertilizer rate. Sites were located in low rainfall (<12-inch), summer fallow and high rainfall (>18-inch), annual cropping areas. Dry matter yield was measured at anthesis and grain yield at maturity. Quadratic responses to fluid P were observed in three of the four site-years in the low rainfall region. 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. There was no response to either fluid or dry P in the high rainfall, annual cropped locations with a longer history of routine P fertilizer use. 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. Additional research is necessary to determine why wheat did not respond to P in higher rainfall areas.

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. In high (>18-inch annual) precipitation annual cropping environments, most growers use P fertilizer but at rates far below removal. For example, standard P application rates are 20 to 40 lb P_2O_5/acre whereas winter wheat yields may average 100 bu/acre or more. At standard removal rates of approximately 0.5 lb P_2O_5/bushel, more P is being removed than is added in most fertilizer programs. At the same time, 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. Reponses 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.

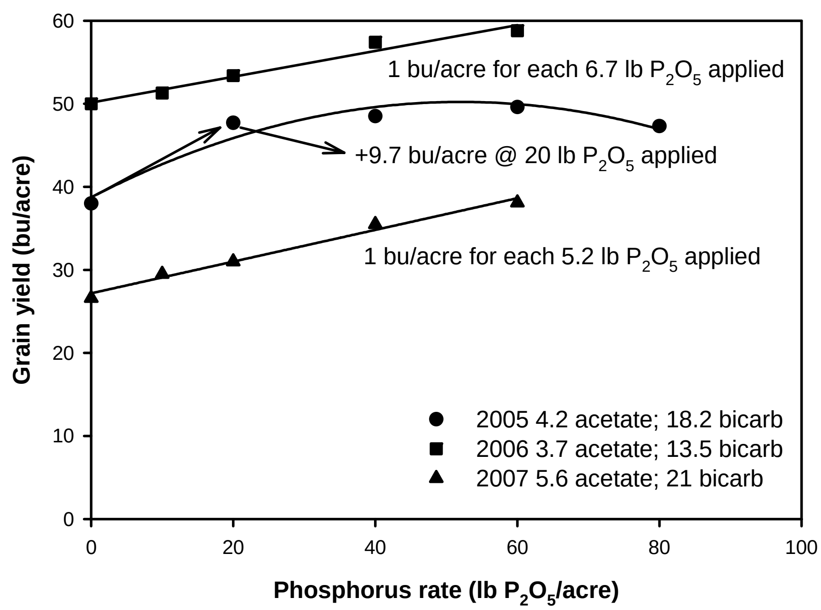


Figure 1. The effect of P rate on soft white winter wheat (cv. 'Eltan') yield in the low (<12-inch annual) rainfall zone of eastern Washington. The rotation is crop-chemical fallow. Responses are indicated by the trend lines. Initial soil test P (ppm; 0 to 1-ft depth) is indicated in the legend.

MATERIALS AND METHODS

Studies were conducted at two locations in the low rainfall zone of eastern Washington in 2005-06, and at the same two locations plus two additional locations in the high rainfall zone in 2006-07. Initial soil test P was measured at each site (Table 1). The Lind and Ralston locations involved winter wheat grown in a traditional, 2-year crop-tillage fallow rotation. The Johnson and Colfax sites are cropped annually in a 3-year rotation of winter wheat-spring wheat-spring legume. Each study included four rates of fluid ammonium polyphosphate P (0, 10, 20 and 40 lb P_2O_5/acre) placed in a deep band with nitrogen (32-0-0) and one rate of dry MAP (20 lb P_2O_5/acre). Phosphorus was placed 2 weeks before seeding at the crop-fallow sites and at seeding with a one-pass no-till drill at the annual cropping locations. Seeding rates were 40 lb/acre with 12-inch spacing in the crop-fallow zone and 100 lb/acre with 7.5-inch spacing in the annual cropping zone. 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. These data were not available at the time this report was prepared. 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.

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

		Soil test P by method (mg/kg soil)†	
Location	**Year**	**Acetate P**	**Bicarbonate P**
Lind	2005-06	7.3	12.1
	2006-07	3.9	11.0
Ralston	2005-06	5.8	17.8
	2006-07	5.5	22.5
Johnson	2006-07	7.0	24.5
Colfax	2006-07	4.0	21.8

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

RESULTS AND DISCUSSION

Responses to fluid P at summer fallow locations were obtained when soil test levels were near or above historical critical values (Figures 2 and 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 in these situations. Grain yield responses to dry P were lower than to fluid P at 3 of the 4 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 3 of the 4 site-years (Figures 2 and 3). At the highest rate of P, both anthesis whole-plant dry matter and final grain yields were reduced slightly over the intermediate 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).

Responses to P were not obtained at annual cropping sites (Figure 4) even though yields were high and soil test P levels (Table 1) were as low as in the summer fallow locations. We are unable to explain why there was no response to P at the annual cropped sites. It is possible the response to P was related to or required moisture stress conditions. There is also a longer history of fertilizer P use at these annual cropped locations.

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. While responses to applied P were not obtained in the high rainfall zone, given the high yields in these areas regular P applications are still necessary.

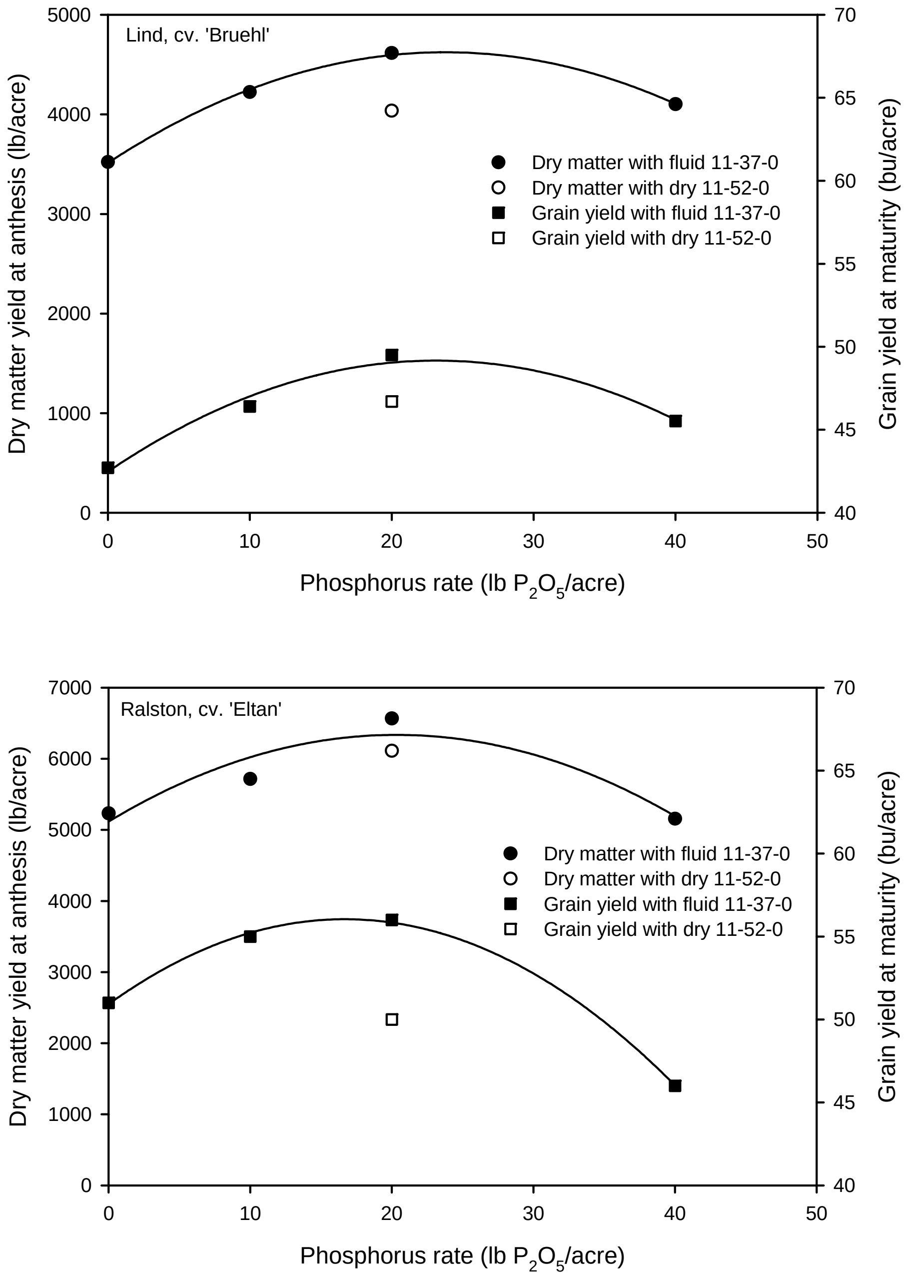
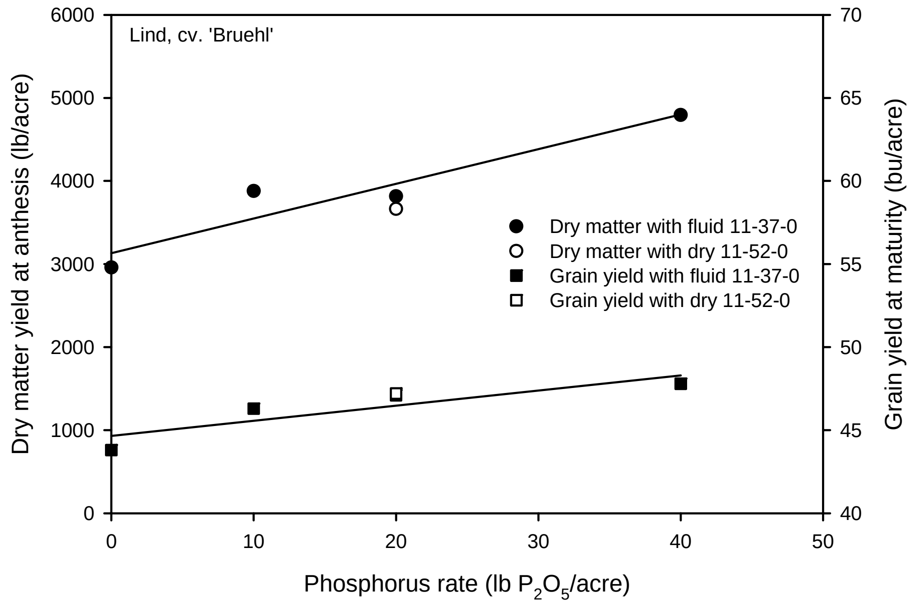


Figure 2. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2005-06.



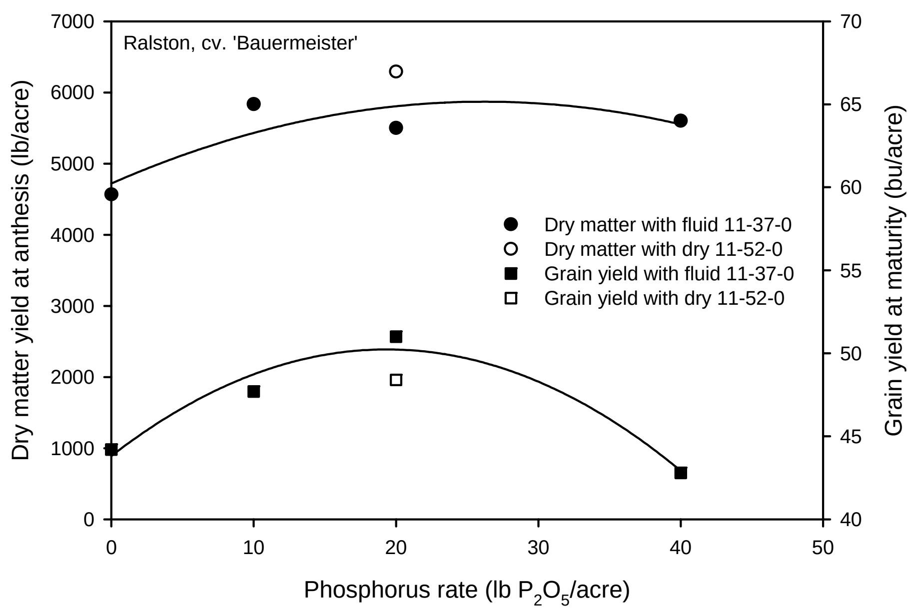


Figure 3. The effect of phosphorus rate and form on dry matter and grain yields of winter wheat at Lind (top) and Ralston (bottom) in 2006-07.

References

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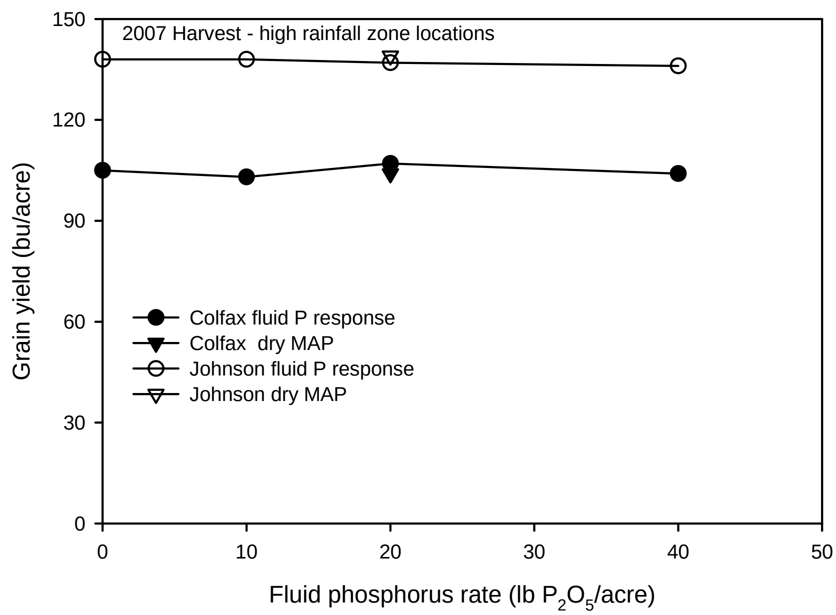

Figure 4. Winter wheat grain yield response to P rate at two locations in the high rainfall zone of eastern Washington. There was no significant grain yield response to either source of P.