Great Plains

Phosphorus: Impact on Small Grain Plant Development

By Carl Fanning and Jay Goos

Phosphorus (P) has dramatic impact on small grain plant component development, including tillers, roots, heads and, in some varieties, leaves. Yield loss with stressed plants occurs when components are sacrificed or simply fail to develop. Today's management requires early season damage assessment. Critical plant components are easy to count and evaluate.

PHOSPHORUS fertilization of small grains in low rainfall areas has been a key to profitable management for several decades. In the Great Plains and Prairies, years of dedicated research have provided a well calibrated soil testing program which most growers understand and use regularly. However, few growers recognize or understand how P changes small grain growth to increase yield. Nitrogen (N) is also needed. The lush green, rapid rate of growth provided by N dominates grower impressions of what's essential for a high-yielding crop.

Rainfall limits yields and increases production risk across this region. Production research has alternately examined factors to increase yields or control costs. Recent work focused on banding P with N as a technique to reduce cost. This is achieved partially through more efficient P use, but more specifically through combined operations that reduce trips through a field. It's been an effective program. The proliferation of new grain drill and fertilizer equipment designs for band placement reflects the program's success. However, in addition to reduced costs, band placement has

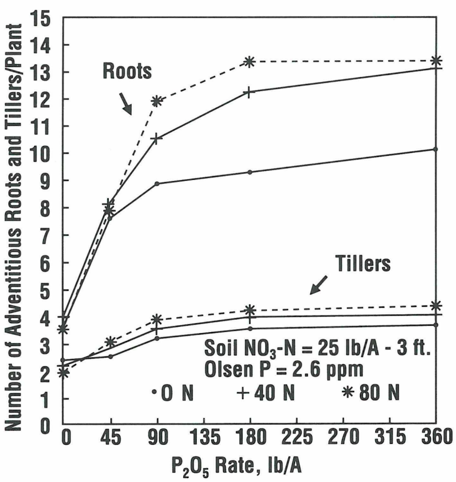

Figure 1. Spring wheat adventitious roots and tillers as influenced by phosphorus and nitrogen fertilization. (USDA-ARS, Montana)

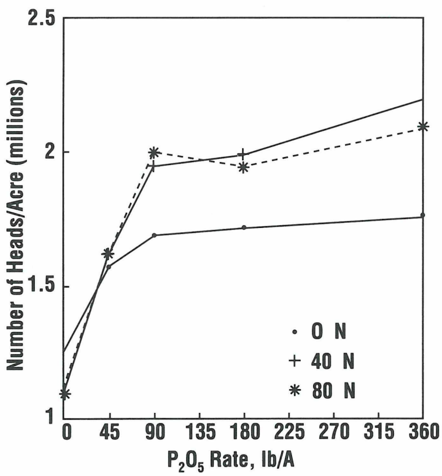

Figure 2. Spring wheat heads per acre as influenced by phosphorus and nitrogen fertilization. (USDA-ARS, Montana)

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has also provided growers a yield increase. The yield increase is technically and economically interesting . . . good reason to re-examine how P effects small grain development and yield.

Risk Control

Risk levels in low-rainfall-area small grain production are such that any easily identified plant growth factor becomes a valuable management tool.

It's significant that early research identified increased water use efficiency with P fertilization. Some envisioned P fertilization as a tool to moderate drought risk. However, identification of crop response mechanisms attributable to P languished and was overshadowed by recognition that both yields and water use efficiency maximized with combined N-P applications. Without plausible, easily described mechanisms, growers have not been interested in P fertilization to control low-rainfall-year risk.

Research Contributions

Spring wheat research at Sidney, Montana, provided key data. A number of plant measurements were made, including a count of adventitious roots (**Figure 1**). Adventitious roots in a small grain crop are those that grow from the crown as a complement of new roots for each new tiller added. Researchers observed that four adventitious roots were normally required to mature each head and that root counts were a more reliable early season indicator of potential head numbers than tiller counts.

Adventitious roots dominate the root mass of a mature wheat plant. Rationally, a large adventitious root system can provide a plant more extensive soil mass exploration and increase potential for efficient use of water or nutrients the soil contains.

Spring wheat yield in the Montana study peaked with the 40 lb/A N application rate. Simple comparison of root numbers (**Figure 1**) with 0 and 40 lb N/A rate show P is responsible for about 75 percent of adventitious root development. Clearly, the role of P in root development overshadows N. Similarly, head count numbers attributable to P are quite high and dominate plant response (**Figure 2**).

Reduced tillering is often listed as a characteristic of P-deficient small grains. Failure to develop tillers 1 and 2 as shown in **Figure 3** can be especially damaging in spring grain. These tillers mature with the mainstem head and have higher yield potential than later tillers. It's common to find this problem across eroded landscapes and in fields subjected to severe

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Table 1. Spring wheat main stem leaf number as influenced by phosphorus fertilization.

	P, mg/pot	
Variety	0	50
	% of plants with 8 main stem leaves[1]	
Amidon	100	100
Butte 86	28	96
Grandin	0	92
Len	87	100
Marshall	100	100
Stoa	71	100

[1]Other plants had 7 main stem leaves.
North Dakota research: Goos, Johnson, Feuchtenbeiner

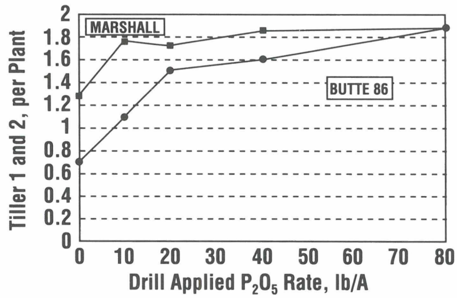

Figure 3. Reduced tillering is a characteristic of phosphorus-deficient small grains.

Phosphorus application produced an average of 2.8 bu/A more grain for wheat grown on fallow, and 2.0 bu/A more grain for wheat grown on stubble (**Figure 2**). These increases were consistent over the 24-year period and occurred as frequently in the latter half of the study as the first half. Thus, the gradual build-up in available soil P due to fertilization did not appear to dampen the response to P fertilizer. This shows that, although frequent use of fertilizers will increase available P levels in prairie soils, farmers may still experience significant yield response to small applications of P fertilizer placed with the seed.

The variability in yield response was closely related to the influence of spring weather conditions. For example, for wheat grown on fallow, yield reponse to P was directly related to temperature between emergence and 3-leaf stage but was depressed when soils were very wet at seeding. The positive relationship between yield and temperature may be because bare fallow soils are often moist and therefore cool in early spring. Because they have been fallowed, they are likely to have sufficient available P but, at low temperature, plant root growth will be slowed, as will available P uptake and translocation within the plant.

The literature suggests that fertilizer P placed close to the seed will be extremely important because early spring is the period when wheat makes maximum use of fertilizer P. In contrast, the importance of soil P increases rapidly from about four weeks after emergence. The negative relationship between yield response to P and precipitation at seeding may be the result of excessive water due to the combination of high levels of stored water plus high early May precipitation. For wheat grown on stubble, response to P was greater when soil temperatures were low at about 3- to 4-leaf stage. This type of response is similar to that obtained in growth chamber studies by other scientists.

Summary

Although prairie soils may have higher levels of soil available P resulting from decades of P fertilizer use, seed-placed P can still offset some yield variability related to climatic conditions and can result in moderate to substantial yield increases. Under excellent growing conditions, seed-placed P can aid plants in reaching higher yield capabilities leading to higher profit potentials. ■

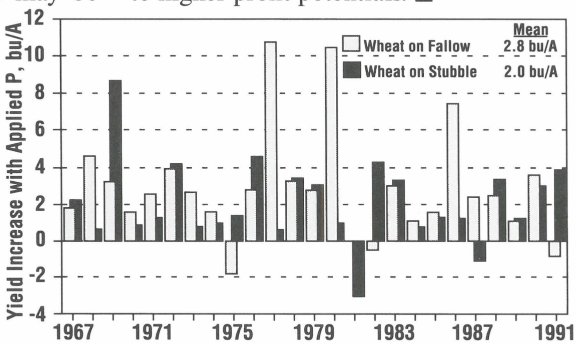

Figure 2. Phosphorus application produced an average of 2.8 bu/A more grain for wheat grown on fallow and 2.0 bu/A more grain for wheat grown on stubble.

Plant Development . . . from page 27

early season drought. Leaf development failure may also serve as a P deficiency symptom, based on results from a greenhouse study evaluating several hard red spring wheat varieties (**Table 1**).

Summary

Most spring wheat varieties will develop eight leaves on the plant main stem. Data indicate that varieties differ in P response for both tiller and leaf development. The significance of this lies with the fact that leaf development loss hasn't been recognized as a small grain production management concern. Like tiller and head count numbers, small grain adventitious roots and mainstem leaves are easy to count and evaluate and are related to crop yield potential.■