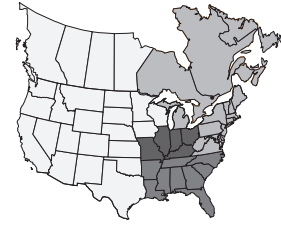


# NEWS & VIEWS

A regional newsletter published by the  
Potash & Phosphate Institute (PPI) and the  
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Multi-Region  
Fall 2003

## Phosphorus Nutrition of Wheat—Optimize Production

**SPRING AND WINTER WHEAT** represent a dominant crop in rotation across large areas of North America. Improvements in plant genetics, pest management, fertilizer management, and agronomic practices have all contributed to progressively increasing wheat yields. Since 1960, average wheat yield has increased by 0.38 bu/A/year in the U.S. and 0.31 bu/A/year in Canada. Since about 1980, yields of winter wheat have increased by about 0.68 bu/A in the Southeast states and by about 0.77 bu/A in the Midwest states. In 2003, wheat yields in the southern Midwest were especially high, with some fields topping 100 bu/A. It may be time for revising P application plans.

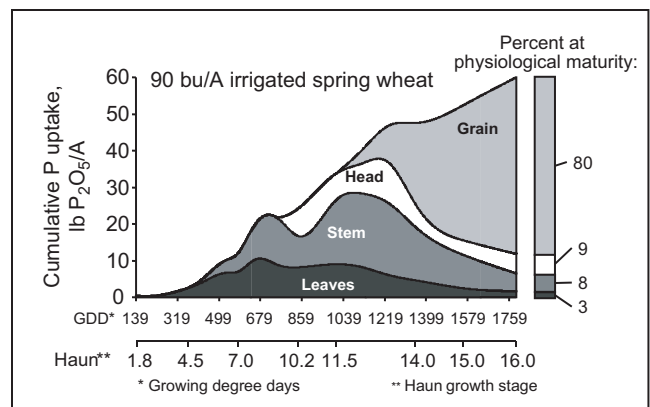

Phosphorus (P) fertilization is a major input in crop production in many areas, because some soils lack sufficient P to optimize crop yields and quality. Effective nutrient management requires that nutrients be available in adequate amounts when needed by the plant. Ensuring that P is plant available early in the growing season is of particular importance. Phosphorus is critical in the metabolism of plants, playing a role in cellular energy transfer, respiration, and photosynthesis.

Wheat takes up P throughout the growing season (**Figure 1**). Total P uptake by wheat is about 0.68 lb  $P_2O_5$ /bu. Harvesting grain removes P at a rate of about 0.50 to 0.55 lb  $P_2O_5$ /bu. Maintaining adequate P supplies throughout the soil ensures P is sufficient to meet plant needs during the entire season. Banding  $P_2O_5$  near the seed at planting provides ready access to P supplies during early season growth, and is practiced in the hard wheat production regions. Broadcast applications prior to planting are more typical in the Southeast, and may or may not be soil incorporated.

**Attention Crop Advisers:**

Are you looking for a current resource on P management for wheat? If so, we encourage you to review and download a free PowerPoint presentation and notes. Titled "Phosphorus Nutrition of Wheat", it is available on the PPI website. This comprehensive presentation reviews the role of P in building wheat yields, P uptake, soil testing, and fertilizer management approaches. Notes and references included with each slide will help you build knowledge for working with clients. Add regional and local information to personalize your presentations. Go to:

>[www.ppi-ppic.org/pwheat](http://www.ppi-ppic.org/pwheat)<



**Figure 1. Wheat takes up P throughout the growing season. Grain removes about 0.50 lb/bu harvested.**



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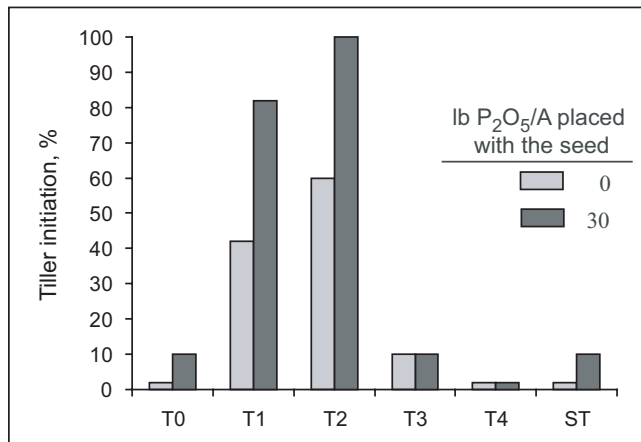
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Wheat produces two kinds of stems—the main stem and a variable number of tillers. Early in its life cycle, wheat “decides” which tillers to develop. Factors such as P or N deficiency, hard soil, or planting too deep can create stresses that reduce the initiation of tillers. Early season limitations in P availability can result in restrictions in crop growth from which the plant will not recover, even if P supply is later increased to adequate levels.

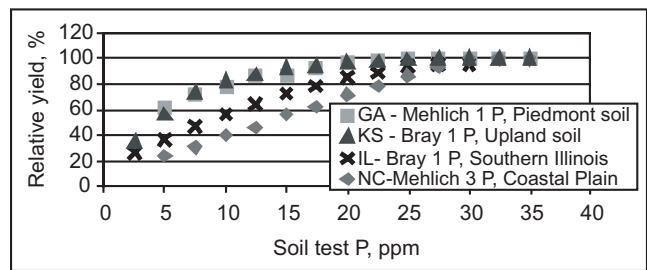
Of all the tillers formed, grain from the T1 and T2 tillers (originating from the bases of the first and second leaves, respectively) accounts for about half of the final yield. The other half comes from grain from the main stem. Tillers originating from the base of the third and fourth leaves (T3 and T4) generally have little to no impact on final grain yield. Early in the season, when wheat is “deciding” how many tillers to initiate, P from fertilizer may account for more than 50% of the total P in the plant. If P supplies in the plant become deficient, the initiation of T1 and T2 tillers can be significantly inhibited, cutting into sources of approximately half of the final yield (Figure 2).



**Figure 2. Improved initiation of tillers from 30 lb P<sub>2</sub>O<sub>5</sub>/A placed with the seed on a soil testing 10 parts per million (ppm) Olsen P (North Dakota). T=tillers; ST=sub-tillers.**

Soil testing calibration research has been conducted throughout North America to establish the general relationship between relative yield (percent of yield attainable when P is sufficient) and soil test levels. There is close similarity between relative yield and P for both spring and winter wheat. These response data come from studies examining broadcast applications of P for wheat (Figure 3). Wheat yields are maximized at soil test P levels above about 25 ppm, regardless of the soil test method used, but response may vary according to soil texture and clay mineralogy. If P fertility is built to these levels, continued applications of P will be necessary to maintain soil levels. As a first approximation, apply a rate equal to crop removal, then check periodically to see if soil tests are staying in the desired range.

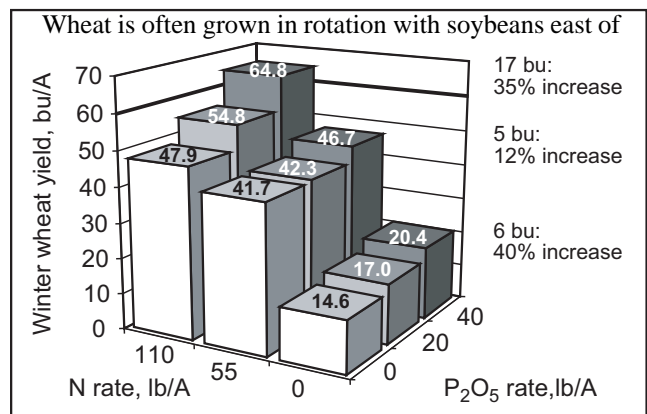
Although higher soil fertility levels are important for season-long P nutrition, early season P supplies must be accessible to the limited root system of the young wheat



**Figure 3. Winter wheat yield response to soil test P.**

plant. For this reason, P placed near the seed at planting (starter P) has proven effective, especially in cold soils in the hard wheat production regions. The response of wheat to low rates of starter P is often referred to as the “pop-up effect”, and is marked by improved leaf and root growth, tiller formation, and yield.

A well-managed fertility program must consider the complete nutritional needs of wheat. As an example, consider how wheat responds to both nitrogen (N) and P, shown in Figure 4. Applied alone to this winter wheat crop in Manitoba, Canada, fertilizer P resulted in a minor increase in yield. With 55 lb N/A, increasing P rate had a modest impact on grain yield. However, with 110 lb N/A applied, large yield increases were obtained with increasing rates of P fertilizer. This response to P illustrates the interaction between N and P; fully attainable yield response to N is achieved only when accompanied by sufficient P.



**Figure 4. Interaction of N and P results in higher wheat yields.**

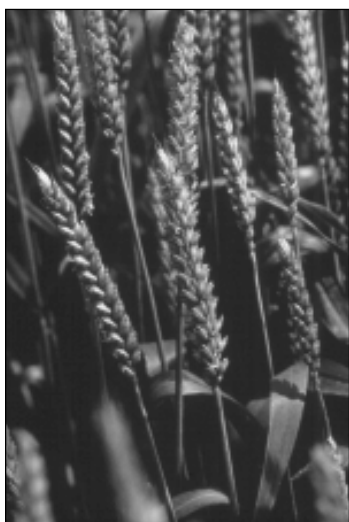
the Mississippi River, usually in a rotation of corn-soybeans-wheat–doublecrop soybeans or corn-wheat-soybeans. In the southern Midwest and Southeastern states, double-cropping soybeans after wheat is a common practice. These rotations take a heavy toll on soil P reserves.

Table 1 shows how the combined uptake and removal rates for wheat and soybeans increase as yields of these crops increase. If fertilizer is applied only before corn in the rotation, soil nutrients can be severely depleted by the time the next application is made. Farmers and crop advisers should replace P<sub>2</sub>O<sub>5</sub> removed by the harvested crops, and strive to apply P<sub>2</sub>O<sub>5</sub> rates to maintain soil test P in the high range. This may require supplemental applications at other

points in the rotation. Otherwise, yield potential and profits will suffer.

**Table 1. Combined uptake and removal of P<sub>2</sub>O<sub>5</sub> by soybeans and wheat at different yield levels, based on southern Midwest data.**

Wheat yield, bu/A	Uptake, lb P <sub>2</sub> O <sub>5</sub> /A			Removal, lb P <sub>2</sub> O <sub>5</sub> /A		
	----- Soybean yield, bu/A -----			0	40	60
	0	40	60	0	40	60
40	27	79	105	20	52	68
60	41	93	119	30	62	78
80	54	106	132	40	72	88
100	68	120	146	50	82	98



## Summary

**Management of P plays a significant role in optimizing wheat production.** Key points are:

- P nutrition is critical to reaching the attainable yield potential of wheat.
- Early in the growing season, the wheat plant is dependent on sufficient P to establish tillers to build high yield.
- While wheat accumulates P through the entire growing season, early season P deficiencies can be more detrimental than those occurring later.
- Doublecropping of soybeans after wheat or the corn-soybean-wheat and corn-soybean-wheat-doublecrop soybean (4 crops in 3 years) rotations remove large amounts of P from the soil. Growers should be sure wheat P needs are met by including supplemental applications of P in the rotation, especially if wheat or soybean yields actually obtained are higher than expected. Applications before the corn in both rotations, and before the wheat in the 4-crop rotation, are usually sufficient to make needed adjustments.
- Phosphorus nutrition should be part of a management strategy that considers the importance of nutrient balance and high yield goals.
- When wheat is included in the rotation, the soil test build-up goal should be higher than for a corn-soybean rotation, due to the additional P requirement for wheat. ■

### New Software Tool to Track Nutrients

To track nutrient removal in comparison to nutrient applications, and to customize this information to your own field, try out the “PKalc” software. This simple-to-use Excel spreadsheet was developed by the PPI staff under a Foundation for Agronomic Research project with partial funding from the USDA-CSREES/IFAFS program.

It is available free and may be downloaded from the PPI website at: [www.ppi-ppic.org/toolbox](http://www.ppi-ppic.org/toolbox), and then opening “PKalc” within that site. It helps determine whether nutrient applications over several years have been sufficient to match crop removal.

For more about Phosphorus Nutrition of Wheat, a PowerPoint slide presentation is available free at <http://www.ppi-ppic.org/pwheat>

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