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Fertilizing Spring Wheat with Phosphorus

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Central and north-central Montana spring wheat producers have applied phosphorus (P) with the seed while planting for many years without the benefit of localized information relating yield response (increase in yield due to P fertilization) to P soil analysis.

Experiments were initiated during the mid-1980s and were intensified during the 1990s to relate spring wheat response to P fertilizer applications and the Olsen (sodium bicarbonate extractable) P soil test. Small field plots were located throughout the spring wheat growing areas of central and north-central Montana, from Highwood to Straw, Straw to Loring, Loring to Cut Bank, and Cut Bank to Choteau. Eventually, 19 experiments were planted no-till on spring wheat or barley stubble, five were established on chemical fallow, two on pre-plant tilled spring wheat or barley stubble, and 44 on conventional fallow.

Treatments ranging from 0 to 60 lbs P_2O_5/a were applied on soils with P soil levels varying from 4 to 37 ppm. Phosphorus application was usually with the seed, however, some P treatments in 1993 were broadcast prior to seeding. Optimal levels of nitrogen (N) and potassium (K) were applied broadcast while planting or before planting. The P source was mono-ammonium phosphate (11-52-0) or treble super phosphate (0-45-0). Data were analyzed by ANOVA, Cate-Nelson plot, and multiple regression. The Cate-Nelson procedure was utilized to determine the P soil analysis critical level or the soil analysis level above which spring wheat response to P fertilization is less likely to occur.

Results from 70 locations were selected for the Cate-Nelson analysis, which plots relative yield (or percent yield) of each location versus the respective P soil level. Percent yield for each location is calculated by dividing the check plot yield (0 P treatment) by the highest yielding P treatment and multiplying by 100. Therefore, the number can exceed 100% if P fertilization reduces yield. Figure 1 shows this relationship. According to this method, the critical level for spring wheat is 16 ppm.

Considering these data and assuming P application with the seed, interpretation guidelines are:

Olsen P Soil Test	**P_2O_5 Recommendation**
---*ppm*---	-----*lbs/a*-----
> 16	10 to removal rate
16 - 12	20 - 30
12 - 8	30 - 40
8 - 4	40 - 50
< 4	50

The removal rate can be estimated by multiplying grain yield (in lbs/a) of the previous crop by 0.01 (1%). For example, a 50 bu/a crop would remove 30 lbs P_2O_5/a (50 bu/a × 60 lbs/bu × 0.01 = 30). The fertilization philosophy of removal rate replacement of P looks into future years and may not dramatically influence the spring wheat crop in the year of application. These response data represent dryland grain yields ranging from 15 to 90 bu/a. As indicated in Figure 1, some locations responded to P regardless of soil analysis level.

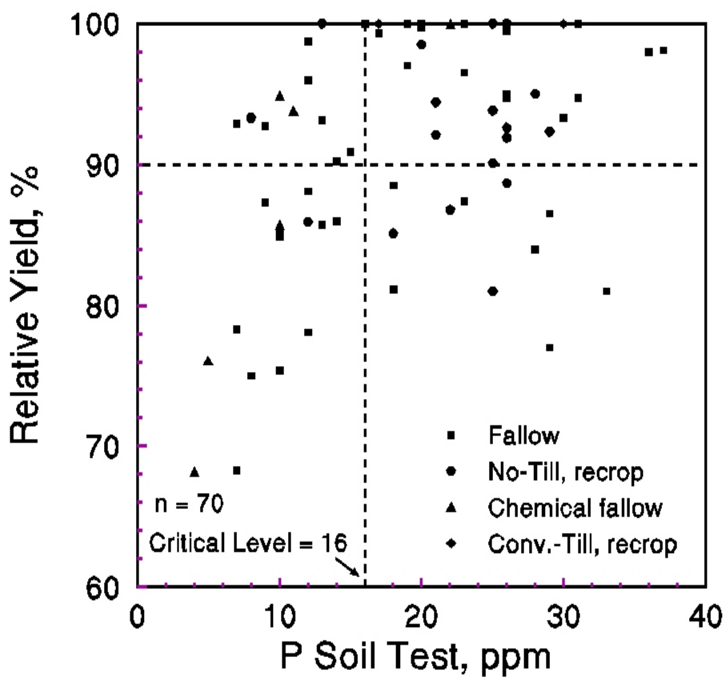

Figure 1. Relationship of relative spring wheat yield and P soil analysis level.

Fifty-one locations were used to develop a P response equation by relating yield response (bu/a) to soil test (ST), P fertilizer rate that caused the response (P), P^2, and the interaction between P and ST. Again, yields ranged from 15 to 90 bu/a. The yield response equation follows:

$$Y = -0.206 + 0.469\,P - 0.0039\,P^2 - 0.0069\,P \times ST,\ R^2 = 0.58.$$

Where Y = Grain Yield Response, bu/a
P = P Fertilizer Rate, lbs P_2O_5 /a
ST = Olsen P, ppm

The effect of P rate and soil analysis on yield response is readily apparent when the equation is shown as a response surface (Figure 2 below). Figure 2 indicates how increasing P soil analysis values interact with P fertilizer and affect yield response. It shows that a producer can expect P fertilization response from all soil analysis levels, the magnitude of yield response will decline with high soil analysis levels, and no response when soil analysis levels and P rates are very high. This surface is like a "twisting roll" or cone shaped and explains why P soil analysis, by itself, was not included in the equation. The twisting roll response could not take place with an expected negative linear relationship with soil Plevel. By converting yield response and fertilizer rate to dollars, the equation can be used in spreadsheet programs to select P fertilizer rates based on expected returns (difference between yield response in dollars and fertilizer material and application cost) from P fertilization as affected by soil P level. Thus, field P fertilization decisions can be based on commodity and fertilizer prices as well as expected P response.

P (and K) soil analysis is an index of plant nutrient availability, however, other factors such as soil temperature and water affect nutrient availability. Soil P availability is depressed by cool and moist, cool and dry, or warm and dry spring weather. In addition, soil P levels and fertilizer response are highly variable on a field scale. Thus, some P fertilizer is always recommended.

Fertilizer Facts:

- P soil analysis is a useful tool for predicting spring wheat response to P fertilization.
- Spring wheat growers should use a minimum of 10 lbs P_2O_5/a with the seed as a starter fertilizer.
- Grain yields and protein levels may be reduced when fields with a very high P soil test are fertilized with a very high P rate.
- Grain test weights are not usually affected by P fertilization.

Edited by Jeff Jacobsen, Extension Soil Scientist

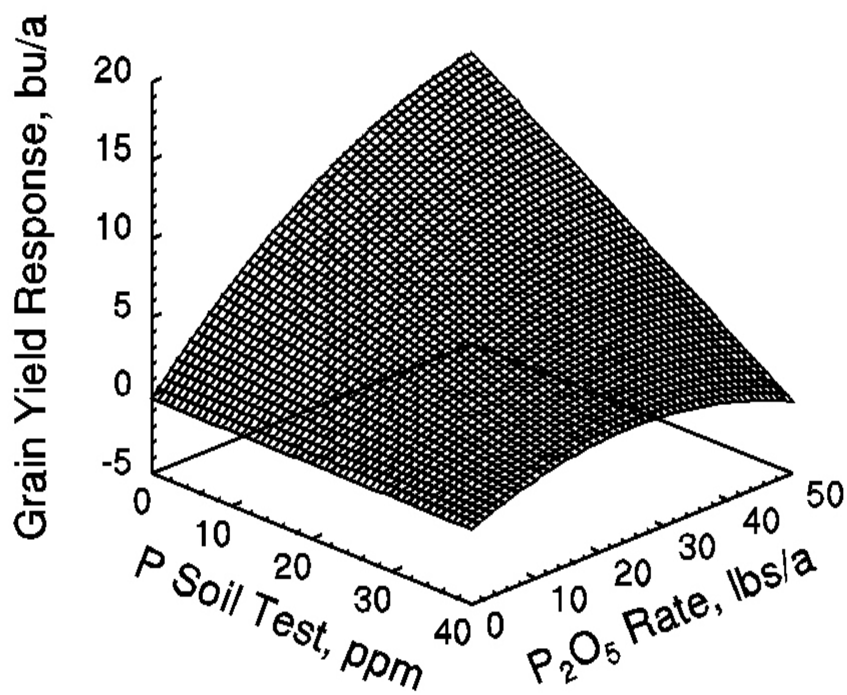

Figure 2. Effect of P soil analysis and fertilizer rate on spring wheat yield response.