Phosphorus Nutrition in Idaho Potatoes

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Research in Idaho emphasizes the importance of phosphorus (P) placement and timing for maximum efficiency in potato production. Soil and petiole testing provides reliable guidelines for determining rates of P fertilization.

PHOSPHORUS is an essential nutrient required by all plants. Potato plant roots readily absorb P in the form of phosphate ions from the soil (water) solution. The absorbed P moves upward and downward in the plant. Phosphorus-deficient potato plants transfer P from older tissues to actively growing, younger tissues.

Symptoms of P deficiency include darker green, stunted, spindly leaves with younger leaflets that turn upward or curl. With prolonged deficiency, plants are small and have reduced leaf area.

Maximum potato yield occurs when sufficient P is available during early vegetative development and the entire period of tuber growth. Total plant P uptake increases rapidly during tuber initiation, levels off to a constant rate during tuber bulking and ceases with plant maturation. Tuber P uptake during maturation occurs primarily through the transfer of P reserves from the vine and roots.

Phosphorus Availability in Soil

The amount of P in the soil solution that is readily available for plant uptake is very small compared with the total amount of P in the soil. The calcium (Ca) in Idaho soils combines quickly with P fertilizer, causing reduced P availability to plants and very restricted P mobility in soil. Therefore, P fertilizer use efficiency is quite low compared with that of nitrogen (N) and potassium (K).

Preplant P Fertilizer

The accepted soil extraction method for measuring P availability in Idaho soils is sodium bicarbonate ($NaHCO_3$). Potatoes produced in soil containing little free lime . . . less than 5 percent calcium carbonate equivalent (CCE) . . . and soil test P less than 15 parts per million (ppm) respond to P fertilizer with improved yield and quality (**Table 1**).

Table 1. Recommended preplant P fertilizer application rates based on soil test P concentration and soil free lime content.

Soil test P, ppm (0 to 12 inch sample depth)	Free lime content		
	Less than 5%	10%	15% or more
	lb P_2O_5/A		
0	240	354	466
5	160	280	400
10	80	200	320
15	0	120	240
20	0	40	160
25	0	0	80
30	0	0	0

Potatoes growing in soil containing high amounts of free lime (15 percent or more) respond to P fertilizer application when soil test P is less than 30 ppm. In most soils, the P fertilizer application rates shown in **Table 1** should provide adequate P from early plant growth through maturation. About 15 lb P_2O_5/A will raise the soil test P level by 1 ppm.

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PHOSPHORUS is a key nutrient in potato production. This field is exhibiting a strong P response (left) that means higher yields and better quality.

Fertilizer Placement

Phosphorus availability is influenced by fertilizer placement and timing. Field research trials in southcentral Idaho compared banding and broadcasting preplant P fertilizer. Greatest petiole P concentrations occurred when P fertilizer was broadcast and tilled into the seedbed (**Figure 1**).

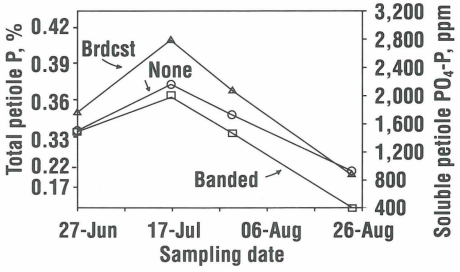

Figure 1. Potato petiole P concentration as influenced by placement.

Likewise, broadcasting P then incorporating it into the soil resulted in greater yields (**Table 2**). This is probably because broadcasting provides a greater opportunity for roots to come in contact with P fertilizer and to absorb it. Do not place P fertilizer below the active root zone of potatoes.

Place starter fertilizer materials above the seed piece at planting (directly in front of the hilling disks). Rates should not exceed 100 lb/A of fertilizer material.

Table 2. Influence of P fertilizer placement on total yield of potatoes.

Placement method	Phosphorus fertilizer rate, lb P_2O_5/A			
	0	68	272	682
	Yield, cwt/A			
None	364	–	–	–
Banded	–	389	441	–
Plowed	–	464	473	489
Disked	–	415	490	–

Available soil P = low

Mid-Season P Application

Mid-season P fertilizer application to potentially P deficient, healthy potato crops can significantly improve potato yield and quality (**Table 3**). However, fertilizing potato crops infested with root pathogens will probably have little effect on yield and quality.

Petiole P concentration is a good indicator of plant P status. Maintain P concentration above 0.22 percent total P (1,000 ppm soluble P) in the fourth petiole from the growing tip from tuber bulking until the beginning of maturation or until 20 days before vine kill (**Figure 2**). Petiole P concentrations higher than 0.22 percent provide enough P for maximum vegetative and tuber growth.

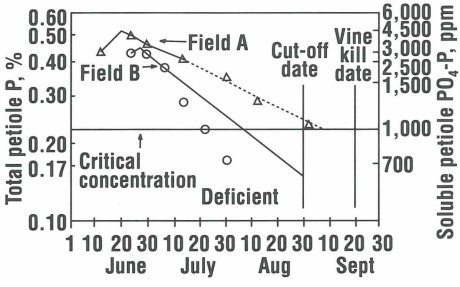

Figure 2. Evaluating mid-seasonal plant P adequacy from petiole P concentrations.

The need for a mid-season fertilizer application can be determined using a technique for predicting future P concentrations in petioles. Take petiole samples shortly after the petiole P concentration

Table 3. Influence of preplant and mid-season P fertilization on potato tuber yield and size distribution.

P_2O_5 rate, lb/A		Tuber yield, cwt/A				
Preplant	Mid-season[1]	Total	U.S. No. 1	>10 oz.	U.S. No. 2	U.S. No. 1 and 2 >10 oz.
0	0	467	298	92	130	150
136	0	460	383	130	30	143
136	45	485	405	142	47	165
136	91	520	434	195	45	217
136	182	494	406	185	53	208

[1]Applied as 10-34-0 or 12-62-0 on July 25; Available soil P = medium

PHOSPHORUS-DEFICIENT potato plants are stunted and are sometimes darker green than adjacent nondeficient plants. As severity of deficiency increases, leaves roll upward, exposing the gray-green lower leaf surface and giving the field a more "normal" green color.

has peaked and every 10 days afterward. As a general rule, collect the first petiole sample when the tubers are about 1 inch in diameter. Three or four sample dates will improve the accuracy of the prediction.

An example of predicting the need for additional P is presented in **Figure 2**. Early-season petiole samples for two fields are plotted on a semi-logarithmic basis. A line is drawn through the data points to the cut-off date (20 days before vine kill). If the line remains above this critical P concentration of 0.22 percent, then no additional P fertilizer will be needed during the growing season. In the example, Field A has sufficient P for the entire growing season. Field B does not and will require a mid-season P fertilizer application.

If additional P is needed, P fertilizer may be injected through the irrigation system. An injection rate of 40 lb/A P_2O_5 in early to mid-July will often satisfy mid-season petiole P deficiencies. Application should coincide with the presence of fine roots near the surface of the potato hills to ensure maximum P uptake. Be sure that the fertilizer and irrigation water are compatible to avoid plugging the nozzle with precipitates.

Summary

- Preplant P fertilizers should be broadcast and disked into the upper 4 to 6 inches of soil or plowed under. Banding or sidedressing preplant P fertilizer during marking, planting or hilling generally results in lower plant uptake and tuber yield. If P is adequate according to the soil test, placement probably has little effect.

- Starter fertilizer containing P should be placed above the seed piece.

- The availability of P in most solid granular and liquid P fertilizer materials is similar when the materials are applied at equivalent rates.

- Monitor petiole P concentrations at regular intervals throughout the early and mid-tuber bulking stages of potato development. Mid-season P fertilizer needs can be determined by plotting early season petiole P concentrations on semi-logarithmic graph paper and using the plot to predict late season P concentrations. ■