PHOSPHORUS FERTILIZATION OF POTATOES - A REVIEW

by
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The objective of a plant nutrient fertilization program is to provide sufficient available nutrients at the right time, in the right place, and in the right amount for maximum economical plant yields. This requires using a good preplant soil testing and fertilization program, as well as monitoring nutrient concentrations in plant tissues during crop growth. Sufficient soil P must be available preplant for early vegetative potato plant growth and for continued P uptake during tuber growth if tuber yields are to be maximized. Phosphorus uptake increases rapidly during tuber initiation and then parallels tuber growth until the start of plant maturation. Phosphorus can then be lost from the vegetative parts of the plants to the tubers without any yield reduction during plant maturation (senescence).

Preplant P Fertilization

Experimental data show that preplant soil test P concentrations (STPC) should be 15 ppm or above for maximum potato tuber yields (Fig. 1). This STPC will provide sufficient available P for early plant growth and for much, if not all, of tuber growth. Recommendations for preplant P fertilization rates can be found in the University of Idaho CIS 261, Idaho Fertilizer Guide: Potatoes. Growers are also encouraged to take the necessary soil samples to identify and correct soil variability problems in their potato fields. Eroded or scraped field areas (white, high lime soil conditions) present special P availability problems for potatoes and their STPC's should be maintained between 20 to 30 ppm P. In many fields this problem may be corrected by fertilizing the problem areas at twice the recommended P fertilization rate.

Preplant fertilizer materials should be plowed down or disked into the seedbed 4 to 6 inches for maximum benefits. Banding or sidedressing of preplant P materials at planting or at hilling were not as effective as plowdown or disking under southern Idaho growing conditions in terms of tuber yields or P uptake fromthe P fertilizer materials (Table 1). Starter fertilizer materials, containing P, should be placed above the seed piece at planting for maximum benefits.

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Figure 1. The relationship between relative potato tuber yields and preplant soil test P concentration (STPC).

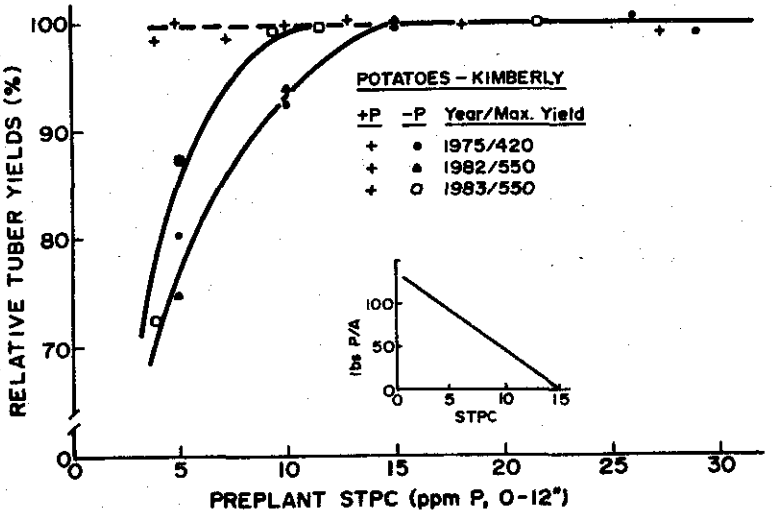


Table 1. Effect of P fertilizer placement on total potato tuber yields.

Method of Placement	P Rate, lbs P/A			
	0 P	30 P	120 P	300 P
	cwt/A			
None	364	---	---	---
Banded	---	389	441	---
Plowed	---	464	473	489
Disked	---	415	490	---

(ARS-USDA, 76, 77, and 84)

Plant P Concentrations

The P concentration in the petiole during tuber growth is a good indicator of the P status of the potato plant. The soluble P concentration in the petiole should be greater than 1000 ppm until the start of normal plant maturation or 20 days before vine kill. Both the P and dry matter balance of the potato plant are satisfactory for continued growth above this concentration of soluble P (Table 2).

Table 2. The relationship between P concentrations in the fourth petiole and the P-uptake (P) or dry weight (D.M.) balance in the plant expressed as (Total plant: Tuber). A ratio less than one indicate the plant's top and roots are losing P or dry matter to the tubers.

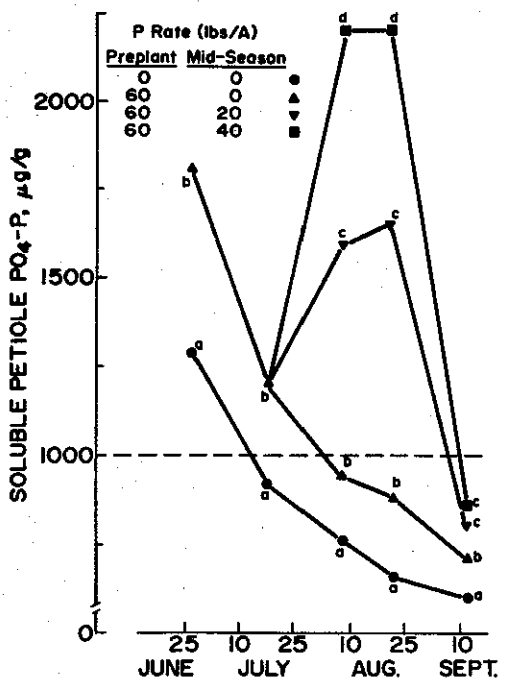
Petiole P Concentration		Balance Ratio	
Total %	Soluble ppm	P	D.M.
<0.17	< 700	<1.0	<1.0
>0.22	>1000	>1.0	>1.0

Petiole concentrations may drop below 1000 ppm during tuber growth even when the STPC is adequate because of increasing severity of root diseases, different plant and tuber growth rates, and other environmental constraints. Growers are encouraged to monitor the P concentrations and other nutrients in their potato fields to ensure an adequate plant nutrient concentration for maximum tuber production. The total P concentration (%) is related to the soluble P concentration (ppm) in the petiole by the following equation:

$$\text{Soluble P} = 5600\ (\text{Total P})^2 + 3620\ (\text{Total P}) - 10$$

Future petiole P concentrations during the growing season may be estimated by plotting the P concentration (ppm) on a logarithmic scale (y-axis) against time (t) on a linear scale (x-axis). The predicted time-interval from the first petiole sampling until the soluble P concentration reaches 1000 ppm is estimated by drawing a straight line between the first and second petiole samplings down to 1000 ppm (Fig. 2). Both samples must be after the petiole P concentration has peaked and between 10 to 20 days apart. As a general rule, the first petiole sample should be taken when the tubers are 1-inch diameter or greater to use this technique. Additional petiole samples can be used to adjust the slope of the extrapolated line and will increase the accuracy of the prediction. Estimating future petiole P concentrations will (1) allow the grower to determine if the plant's P nutrition will be adequate for the remainder of the growing season and (2) allow the scheduling of additional P fertilizer materials if and when needed.

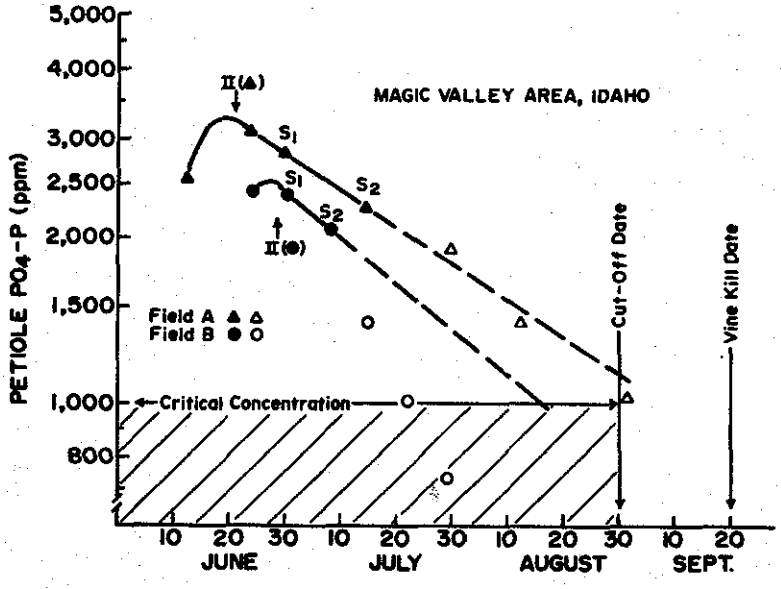
Figure 2. The effect of a preplant and mid-season P fertilizer application on petiole PO_4-P concentrations. Initial STPC was 12 ppm before the preplant P fertilizer application. Tuber yields are shown in Table 3 (Kimberly).



Seasonal P Fertilization

Management practices that might be used to raise low plant P concentrations are (1) the application of foliar sprays directly to the plants and (2) applying P fertilizer solutions with an irrigation or as a dry material followed by an irrigation. Research data indicate that a mid-season application of a high water soluble P fertilizer material can help maintain an adequate plant P status until normal plant maturation. A single application of 20 to 40 lbs P/A on 25 July increased total plant P uptake 4 to 5 lbs P/A and maintained an adequate petiole P concentration during all of tuber growth (Fig. 3).

Figure 3. Two examples of estimating future petiole PO_4-P concentrations from two petiole samples on semi-logarithmic graph paper. S_1 and S_2 are the first and second samples. The dashed line was extrapolated to 1000 ppm by drawing a straight line through S_1 and S_2. Additional P fertilizer would need to be applied to field B but not field A. An additional petiole sample from field B could have improved the accuracy its' prediction. Open symbols are petiole samples taken after making the estimate.



Final tuber yields, total USDA #1, and the (#1 + #2)> 10 oz were also increased (Table 3). An average tuber growth rate of 7 cwt/acre-day requires a P uptake rate of 0.3 lbs P/acre-day to satisfy the tuber's P needs for growth. An additional 3 lbs P/A taken up by the plant and used for tuber growth could increase final tuber yields 70 cwt/A if P was limiting during late seasonal tuber growth.

Both 10-34-0 and 12-62-0 were equally effective at the rates used in our studies. An optimum single mid-season application rate was about 40 lbs P/A. Sprinkler applications have generally proven to be more effective than an application of dry materials. Growers need to be cautioned that a sprinkler application of some P fertilizer solutions is not recommended under certain water quality conditions because a precipitate forms and clogs sprinkler nozzles upon injection of the material. The possibility of this problem occurring can be identified by the formation of a white precipitate when 1/2 teaspoon of the intended fertilizer solution is added to 1-gallon of fresh irrigation water (equivalent to 40 lbs P/A in 1.3-inch water per acre).

If a precipitate forms, growers should use the same test to check other P-solutions (e.g., urea-phosphoric acid, phosphoric acid, or 10-34-0) or consider other application methods. None of the P-solutions should be applied directly to plants in their concentrated forms, however, an aerial application of 1 to 2 gallons of 10-34-0 has been included in blight sprays but will have to be repeated to be as effective as a sprinkler application. Foliar nutrient sprays containing P may be effective if correctly applied and if the amount of P needed for the plants to reach maturity or vine kill is small.

The mid-season P fertilizer application is most effective when applied to a healthy growing crop. Applications should be scheduled as soon as possible after determining that the plants will be low in P before natural maturation or vine kill. This will allow a longer time interval for the plants to obtain the applied P before plant diseases become a significant problem.

Table 3. Effect of P fertilization on potato tuber yields and size distribution, Kimberly, Exp. 228-83. (Petiole soluble P concentration shown in Fig. 2)

P Rate, lbs P/A		Tuber Yields				
Preplant P	Mid-Season* P	Total	#1 Total	#1 >10oz	#2 Total	#1+#2 >10oz
lbs P/A				cwt/A		
0	0	467	298	92	130	150
60	0	460	383	130	30	143
60	20	485	405	142	47	165
60	40	520	434	195	45	217
60	80	494	406	185	53	208

* Applied as 10-34-0 or 12-62-0 on 25 July

Summary

Growers are encouraged to use a good preplant soil testing and fertilization program and then monitor the nutritional status of their potato fields during the growing season. These techniques will identify seasonal and environmental effects and allow the grower to make the necessary corrections to maintain maximum plant and tuber growth rates until normal plant maturation or scheduled vine kill. This practice should help maximize tuber yields and quality if there are no other production constraints.