

# Interpretation of the phosphorus soil test for Alaska agricultural soils

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## Introduction

Phosphorus (P) along with nitrogen (N) and potassium (K) comprise the three macronutrients most frequently added as fertilizer for growing plants. In Alaska soils, P is often the second most limiting nutrient after N. A proper supply of plant-available P is important for root development and plant growth. To supply P to growing crops, the soil not only must contain enough P, but it must be in a form which is available for utilization by the plant.

The status of P in the soil has an important influence on fertilization practices. Agricultural soils of Alaska vary considerably, not only in their total content of P and its distribution (form it occurs in), but also in their characteristics for sorption or fixation of P (Ping and Michaelson, 1986). Forms of P in the soil will affect its availability. The P-sorption character of soils will affect P fertilizer reactions in the soil and thus influence the amount of P fertilizer necessary and carry-over effects of applied P. It is essential that P soil tests and their interpretation be tailored for soils with similar P reactions. A useful P soil test must be based on both correlation of test values to plant growth and to field calibration of soil test values with yield.

There are many P-extracting solutions in use today for soil testing. The two extractants most commonly used for Alaska soils have been the Bray 1 extractant (Bray and Kurtz, 1945) and Morgan's solution (Morgan, 1954). Recently agriculture has expanded in Alaska into areas with different soil types. Because of this expansion and continued advancements in the field of soil testing, a comprehensive study of soil P was initiated in 1983.

Representative agricultural soils of Alaska were used in this study. The objectives of the study were:

- 1) to characterize the P-reaction/sorption of representative soils (Ping and Michaelson, 1986),
  - 2) to identify a suitable P extractant for the range of soils and establish a correlation to plant growth (Michaelson and Ping, 1986),
  - 3) to assure suitability of the extractant for use in the lab (Michaelson et al., 1987), and
  - 4) to field-calibrate the P soil test under representative soil environments (Ping and Michaelson, 1988).
- Our studies determined that the Mehlich 3-P soil test is the most preferred of methods studied for Alaska's agricultural soils. In the tables that follow, data from the field calibration trials and laboratory studies have been summarized for practical interpretation of the Mehlich 3-P soil test.

## Interpretation of Soil Test Phosphorus

The following tables were developed for interpretation of the Mehlich 3-P soil test in five general areas of the state: Tables 1 and 6 for the Kenai Peninsula; Tables 2 and 7 for Pt. MacKenzie, Susitna Valley and Anchorage; Tables 3 and 8 for the Matanuska Valley; Tables 4 and 9 for the Copper River Basin; and Tables 5 and 10 for the Tanana Valley. Field trials for calibration of the P soil test were performed with the cooperation of farmers from each area. These trials were conducted from 1984 through 1987. Ten representative soils from the five areas were first studied in the laboratory. The data from laboratory studies were used to determine P fertilizer application rates necessary to establish plots with a range of P fertility at each field location. Oats and/or barley were grown as forage test crops in each area. The field trials provided the data to identify deficient (low) and sufficient or high P soil test values for each soil. A range was identified for each soil type. This is the range where crop response to additions of P fertilizer can be expected. The forage/grain tables presented here were developed using the current rates recommended for maximum yield by the

Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. Full recommended P rates are reduced for each location and individual soil according to the estimated contribution of soil P as indicated by the Mehlich 3 soil test. These tables are based on results of field trials on representative soils located in each area.

Tables 6–10 provide recommendations for vegetable crops in each area. These tables were developed using lab tests of soils from the field trial plots in each area. The ranges for recommended P rates in the tables are based on the relationship between known soil solution P concentrations required for vegetable crops (Nishimoto et al., 1977; VanderZaag et al., 1979) and the corresponding Mehlich 3 extractable P for each soil. Rates of P addition for each vegetable crop are rates currently recommended by the Agricultural and Forestry Experiment Station and the Cooperative Extension Service, University of Alaska Fairbanks.

Table 11 was developed for P fertilization of soils used in the greenhouse. This table was developed using both laboratory P-sorption and field trial data. All tables are intended only for general recommendations and should not exclude the consideration of other factors which may effect P fertilizer requirements at a specific location.

### **Use of the Tables**

There are two tables for each of the five general geographical areas. These tables, one for forage/grain crops and one for vegetable crops, should be used to interpret a Mehlich 3–P soil test (Mehlich, 1984) as currently performed by the University of Alaska Fairbanks Soil and Plant Tissue Testing Laboratory at Palmer, Alaska. These tables are to be used to find the recommended amount of  $P_2O_5$  fertilizer to be added to a given soil with a given soil-test P level for the specified crop. These recommended rates are for fertilizer which is incorporated 4–6 inches evenly into the surface. The recommendations are in accordance with those currently used by the University of Alaska Cooperative Extension Service. These tables are only appropriate for the Mehlich 3–P soil test and for the specified soil series or closely related soils of the area.

To use the tables, find the one appropriate for your area and crop type, then identify your soil type or series from the USDA-Soil Conservation Service soil survey report. A complete listing of the soil survey reports containing soils maps for each area can be found in the appendix of this circular. Soil surveys in the Fairbanks North Star Borough and Matanuska–Susitna Valley are being either remapped or recorrelated. Some of the soil series in the published soil survey reports may be changed or correlated to other series. There are other areas within the state lacking soil–test calibration data. For soils in the southwest and southeast Alaska, and Kodiak Island, follow the recommendation rate tables for the Kenai Peninsula. In interior Alaska, follow recommendation rate tables for the Tanana Valley. If you have doubts, check with your local Soil Conservation Service district office for up–to–date field sheets. Compare your P soil test value (Mehlich 3) to the value found in the appropriate soil test column for your soil on the left side of the table. Then go to the recommended  $P_2O_5$  column for your crop on the right side of the table corresponding to the soil test value on the left hand side. If your test value is between two table values then interpolate between the values using the corresponding  $P_2O_5$  values to calculate the appropriate recommended  $P_2O_5$  rate. The equations under each table can be used as a more convenient way of calculating your exact recommended  $P_2O_5$  rate. Except for small rounding differences, the equations will give the same recommendation as the table. Find the equation for your soil and crop: Then enter your soil test value in the equation (ppm P soil test) and solve for the lbs  $P_2O_5$ /acre recommended.

Table 1: KENAI PENINSULA

Category	Cereals		
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for:	
	ppm soil	Forage	Grain
Very Low	4	90	60
Low	8	69	45
Medium	13	43	30
High	17	23	15
Very High	21	0**	0**

Equations:  
 Forage: lbs P<sub>2</sub>O<sub>5</sub>/acre\*\* = 111 - 5.3 (ppm P soil test)  
 Grain: lbs P<sub>2</sub>O<sub>5</sub>/acre\*\* = 74 - 3.5 (ppm P soil test)

\* Applicable to the following soil series (from SCS soil survey reports): Beluga, Cohoe, Island, Kachemak, Kenai, Mutnala, Naptowne, Soldotna, Tustumena series, and soils from southeastern and southwestern Alaska.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for conditions, such as cool soil temperatures and sampling variation.

Table 2: Pt. MacKENZIE - SUSITNA VALLEY - ANCHORAGE

Category	Cereals		
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for:	
	ppm soil	Forage	Grain
Very Low	4	90	60
Low	7	68	45
Medium	10	45	30
High	13	23	15
Very High	16	0**	0**

Equations:  
 Forage: lbs P<sub>2</sub>O<sub>5</sub>/acre\*\* = 120 - 7.5 (ppm P soil test)  
 Grain: lbs P<sub>2</sub>O<sub>5</sub>/acre\*\* = 80 - 5 (ppm P soil test)

\* Applicable to the following soil series (from SCS soil survey reports): Chulitna, Flathorn, Homestead, Kashwitna, Nancy, Rabideaux, Schrock, Talkeetna, and Whitsol series.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for conditions, such as cool soil temperatures and sampling variation.

Table 3: MATANUSKA VALLEY

Category	Cereals	
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for Forage and Grain
	ppm soil	lbs P <sub>2</sub> O <sub>5</sub> /acre
Very Low	43	80
Low	46	60
Medium	49	40
High	52	20
Very High	55	0**
Equation: Forage/Grain: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 367 - 6.7 (ppm P soil test)		

\* Applicable to the following soil series (from SCS soil survey reports): Bodenburg, Doone, Knik, Matanuska, Niklason, Susima series, and the Homestead series mapped along the Matanuska River and foothills of Lazy Mountain.

Note: Soils applicable to the Susitna Valley recommendation tables but mapped in the Matanuska Valley include the Homestead, Kenai, Naptowne, Schrock and Talkeetna series mapped west of Wasilla

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for conditions, such as cool soil temperatures and sampling variation.

Table 4: COPPER RIVER BASIN

Category	Cereals	
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for Forage and Grain
	ppm soil	lbs P <sub>2</sub> O <sub>5</sub> /acre
Very Low	29	80
Low	38	60
Medium	48	40
High	57	20
Very High	66	0**
Equation: Forage/Grain: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 142 - 2.1 (ppm P soil test)		

\*Applicable to all cleared soils with a silt loam topsoil.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.

Table 5: TANANA VALLEY

Category	Cereals		
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for:	
		Forage	Grain
	ppm soil	lbs P <sub>2</sub> O <sub>5</sub> /acre	
Very Low	6	45	60
Low	8	35	47
Medium	11	20	28
High	13	10	15
Very High	15	0**	0**
Equations:			
Forage: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 74 - 4.9 (ppm P soil test)			
Grain: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 99 - 6.5 (ppm P soil test)			

\* Applicable to the following soil series (from SCS soil survey reports): Beales, Chena, Fairbanks, Gilmore, Goldstream, Jarvis, Nenana, Richardson, Salchaket, Steese, Tanana, Volkmar series, and other soils of interior Alaska

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.

Table 6: KENAI PENINSULA

Category	Vegetables/Potatoes		Recommended P <sub>2</sub> O <sub>5</sub> for all soils	
	Mehlich 3-P Soil tests		Vegetables	Potatoes
	Group 1 soils*	Group 2 soils*		
	ppm		lbs P <sub>2</sub> O <sub>5</sub> /acre	
Very Low	4	4	200	320
Low	35	55	150	240
Medium	66	107	100	160
High	97	158	50	80
Very High	128	209	0**	0**
(lbs /acre x 0.0023 = lbs/100 sq ft)				
Equations:				
<u>Group 1 soils*</u>				
Vegetables: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 206 - 1.6 (ppm P soil test)				
Potatoes: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 330 - 2.6 (ppm P soil test)				
<u>Group 2 soils*</u>				
Vegetables: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 204 - 0.97 (ppm P soil test)				
Potatoes: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 326 - 1.6 (ppm P soil test)				

\* Applicable to the following soil series (from SCS soil survey reports):  
 Group 1 soils: Cohoe, Island, Kenai, Naptowne, Soldoura, and Tustumena series.  
 Group 2 soils: Beluga, Kachemak, Mutnala series, and soils from southeastern and southwestern Alaska.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions. such as cool soil temperatures and sampling variation.

Table 7: Pt. MacKENZIE - SUSITNA VALLEY - ANCHORAGE

Category	Vegetables	
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> for vegetables
	ppm soil	lbs P <sub>2</sub> O <sub>5</sub> /acre
Very Low	4	200
Low	58	150
Medium	111	100
High	165	50
Very High	219	0**
(lbs/acre x 0.0023 = lbs/100 sq ft)		
Equation:		
Vegetables: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 204 - 0.93 (ppm P soil test)		

\* Applicable to the following soil series (from SCS soil survey reports): Chulitna, Flathorn, Homestead, Kashwitna, Nancy, Rabideaux, Schrock, Talkeetna, and Whitsol series.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.

Table 8: MATANUSKA VALLEY

Category	Vegetables			
	Mehlich 3-P soil test*		Recommended P <sub>2</sub> O <sub>5</sub> for:	
	Potatoes	Garden/ Vegetables/ Lettuce	Lettuce	Potatoes
	ppm soil		lbs P <sub>2</sub> O <sub>5</sub> /acre	
Very Low	43	43	200	320
Low	70	74	150	240
Medium	96	105	100	160
High	123	136	50	80
Very High	150	167	0**	0**
(lbs/acre x 0.0023 = lbs/100 sq ft)				
Equations:				
Vegetables/Garden: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 281 - 1.9 (ppm P soil test)				
Potatoes: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 449 - 3 (ppm P soil test)				
Lettuce: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 269 - 1.6 (ppm P soil test)				

\* Applicable to the following soil series (From SCS soil survey reports): Bodenbug, Doone, Knik, Matanuska, Niklason, Susitna, and Homestead series, mapped along the Matanuska River and foothills of Lazy Mountain.

Note: Soils applicable to the Susitna Valley recommendation tables but mapped in the Matanuska Valley include the Homestead, Kenai, Naptowne, Schrock and Talkeetna series mapped west of Wasilla.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.

Table 9: COPPER RIVER BASIN

Category	Vegetables	
	Mehlich 3-P Soil test*	Recommended P <sub>2</sub> O <sub>5</sub> Vegetables
	ppm soil	lbs P <sub>2</sub> O <sub>5</sub> /acre
Very Low	29	200
Low	52	150
Medium	74	100
High	97	50
Very High	120	0**
(lbs/acre x 0.0023 = lbs/100 sq ft)		
Equation: Vegetables: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 264 - 2.2 (ppm P soil test)		

\* Applicable to all cleared soils with a silt loam topsoil.

\*\* No recommendation indicated at very high soil test levels; however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.

Table 10: TANANA VALLEY

Category	Vegetables		Recommended P <sub>2</sub> O <sub>5</sub> for all soils Vegetables/potatoes
	Mehlich 3-P Soil Tests		
	Group 1 soils*	Group 2 soils*	lbs P <sub>2</sub> O <sub>5</sub> /acre
	ppm P		
Very Low	6	6	200
Low	61	39	150
Medium	115	72	100
High	170	106	50
Very High	225	139	0**
(lbs/acre x 0.0023 = lbs/100 sq ft)			
Vegetable/Potato Equations: Group 1 soils*: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 205 - 0.9 (ppm P soil test) Group 2 soils*: lbs P <sub>2</sub> O <sub>5</sub> /acre** = 209 - 1.5 (ppm P soil test)			

\* Applicable to the following soil series (from SCS soil survey reports):

Group 1 soils: Beales, Chena, Fairbanks, Gilmore, Goldstream, Nenana, Steese, and other well-drained soils of interior Alaska.

Group 2 soils: Jarvis, Richardson, Salchaket, Tanana, Volkmar, and other moderately well- or somewhat poorly-drained soils of interior Alaska

\*\* No recommendation indicated at very high soil test levels: however, a small amount of fertilizer-P (25% of very low P category recommendation) may be advisable to compensate for certain conditions, such as cool soil temperatures and sampling variation.



Table 11. SOILS USED IN THE GREENHOUSE

Area Soils	Recommended rates for previously unfertilized soils* used in the greenhouse		General greenhouse: optimum Range for Mehlich 3-P soil test ppm P
	lbs/cu yd 0-45-0 (TSP)	lbs /100 sq ft 0-45-0 (TSP)	
Kenai Peninsula			
Group 1 soils**	9	17	175-190
Group 2 soils**	11	20	345-380
Pt. MacKenzie, Anchorage, Susitna Valley			
Pt. MacKenzie, Anchorage	13	24	290-320
Susitna Valley	15	28	275-295
Matanuska Valley	4	7.5	200-215
Copper River Basin	5.5	10	185-200
Tanana Valley			
Fairbanks Soil Series	1.5	3	330-365
Group 1 soils**	3	5.5	305-330
Group 2 soils**	3.5	6.5	180-200

\* Recommended rates assume 100% mineral soil in greenhouse. Reductions should be made according to proportions of soil used in greenhouse mixes.

\*\* Refer to footnotes under vegetable tables in the appropriate area to find pertinent soil series.

## REFERENCES

- Bray, R.H., and L.T. Kurtz. 1945. Determination of total, organic, and available forms of phosphorus in soils. *Soil Sci.* 59:3945.
- Mehlich, A. 1984. Mehlich No. 3 extractant: A modification of Mehlich No. 2 extractant. *Commun. Soil Sci. and Plant Anal.* 15:1409-1416.
- Michaelson, G.J., and C.L. Ping. 1986. Extraction of phosphorus from the major agricultural soils of Alaska. *Commun. Soil Sci. and Plant Anal.* 17:275-297.
- Michaelson, G.J., C.L. Ping, and G.A. Mitchell. 1987. Correlation of Mehlich 3, Bray 1, and ammonium acetate extractable P, K, Ca, and Mg for Alaska agricultural soils. *Commun. in Soil Sci. and Plant Anal.* 18:1003-1015.
- Morgan, C.F. 1954. Chemical soil diagnosis by the universal soil testing system. *Conn. Agric. Exp. Stn. Bull.* No. 450.
- Nishimoto, R.K., R.L. Fox, and P.E. Parvin. 1977. Response of vegetable crops to phosphorus concentrations in soil solution. *J. Amer. Soc. Hort. Sci.* 102(6):707-709.
- Ping, C.L., and G.J. Michaelson. 1988. Soil fertility research: A final report on Alaska statewide phosphorus soil test field calibrations for 1984-87. submitted to Tennessee Valley Authority January 30, 1988.
- Ping, C.L., and G.J. Michaelson. 1986. Phosphorus sorption by major agricultural soils of Alaska. *Commun. Soil Sci. and Plant Anal.* 17:299-320.
- VanderZaag, P., R.L. Fox, R. DeLaPena, W.M. Laughlin, A. Ryskamp, S. Villagarcia, and D.T. Westerman. 1979. The utility of phosphate sorption curves for transferring soil management information. *Trop. Agric. (Trinidad)* 56: 153-160.

## APPENDIX: List of Soil Survey Reports

### Kenai Peninsula

- Hinton, R.B. 1971. *Soil survey of Homer-Ninilchik area, Alaska.* USDA-SCS. U.S. Government Printing Office, Washington D.C.
- Rieger, S., G.W. Allen, A.D. Backer, E.G. Link, and B.B. Lovell. 1962. *Soil survey of Kenai-Kasilof area, Alaska.* USDA-SCS. U.S. Government Printing Office, Washington D.C. Series 1958.
- Van Patten, D. 1988. *Soil Survey of Deep Creek Area, Alaska.* USDA-SCS. Anchorage, Alaska. (in preparation)

### Anchorage and Susitna Valley (and part of Pt. MacKenzie)

- Schoephorster, D.B., and R.B. Hinton. 1973. *Soil survey of Susitna Valley area, Alaska.* USDA-SCS. U.S. Government Printing Office, Washington D.C.
- Soil Conservation Service. 1979. *Anchorage area soil survey.* IN: Metropolitan Anchorage Urban Study. Alaska District. U.S. Army Corps of Engineers, and Municipality of Anchorage.
- Clark, M.H. 1988. *Matanuska-Susitna Valley Soil Recorrelation.* USDA-SCS. Anchorage, Alaska. (in preparation)

### Matanuska Valley (and part of Pt. MacKenzie)

- Schoephorster, D.B. 1968. *Soil survey of Matanuska Valley area, Alaska.* USDA-SCS. U.S. Government Printing Office, Washington D.C.

### **Copper River Basin**

Clark, M.H.. and D. Kautz. 1988. *Soil survey of Copper River Basin area, Alaska*. USDA-SCS. U.S. Government Printing Office, Washington D.C. (in press)

### **Tanana Valley**

Furbush, C.E., and D.B. Schoephorster. 1977. *Soil survey of Nenana-Goldstream area, Alaska*. USDA-SCS. U.S. Government Printing Office, Washington D.C.

Furbush, C.B.; B.B. Koepke, and D.B. Schoephorster. 1980. *Soil survey of Totchaket area, Alaska*. USDA-SCS. U.S. Government Printing Office, Washington D.C.

Koepke, B. 1988. *Soil survey of Delta-West area, Alaska*. USDA-SCS. U.S. Government printing Office, Washington D.C. (in press)

Rieger, S., J.A. DeMent, and D. Sanders. 1963. *Soil survey of Fairbanks area, Alaska*. Mimeograph suppl. issued April 1974. USDA-SCS. U.S. Government Printing Office, Washington D.C.

Schoephorster, D.B. 1973. *Soil survey of Salcha-Big Delta area, Alaska*. USDA-SCS. U.S. Government Printing Office, Washington D.C.

White, J. 1988. *Soil survey of Fairbanks-North Star Borough, Alaska*. USDA-SCS U.S. Government Printing Office, Washington D.C. (in preparation)

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