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Interpreting Soil Phosphorus and Potassium Tests

Amy L. Shober, Karen L. Gartley, and J. Thomas Sims

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Introduction and Purpose

The University of Delaware (UD) has rated soils in terms of the likelihood of profitable responses to additions of phosphorus (P) and potassium (K) from fertilizers, manures, and other soil amendments for more than 50 years. Our soil test categories and fertility recommendations are based on research conducted in Delaware or in nearby states with similar soils, crops, and climates. Despite the fact that soil testing has been successfully used by farmers and others for many years, there is still often confusion about the interpretation of soil test P and K results. This confusion primarily occurs because soil testing laboratories use different soil test methods and different reporting units to express the results of these tests. The purpose of this document is to describe the method for interpreting soil tests used by UD, and to illustrate how to compare and convert soil test P and K results from laboratories using different soil testing methods and reporting units to the equivalent UD reporting units.

Interpreting Soil Tests

Soil test interpretation is conceptually simple (Figure 1). As soil test nutrient concentrations in the soil increase from "low" to "medium" to "optimum" concentrations, crop yields increase as well. Once soil test nutrients have reached the optimum concentration for crop growth (the "critical level"), further nutrient inputs are rarely needed and are usually unprofitable because yields often do not increase. Over-fertilization of soils with P or K to "excessive" concentrations is also undesirable because this represents a poor use of limited resources. Plus, in the case of P, the likelihood of nonpoint source pollution of surface waters and shallow ground waters by soil P through runoff or leaching is increased when soil test P concentrations are "excessive". While over-fertilization of soils with K to "excessive" levels does not have water quality implications, it is still economically undesirable and could also negatively impact crop and forage quality.

UD uses the Mehlich-3 soil test method for routine fertility testing. Soil test results for the macronutrients P, K, Ca, and Mg are reported as a Fertility Index Value (FIV). UD uses four soil test categories to rate soils in terms of the likelihood of a profitable crop response to nutrient additions in fertilizers, animal manures, or other soil amendments (Table 1).

Table 1. Soil test categories used by the University of Delaware for phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg).

Soil Test Category	Soil Test Value (FIV)
Low	0-25
Medium	26-50
Optimum	51-100
Excessive	> 100

General interpretations are assigned to each soil test category. Specific nutrient recommendations for Delaware crops (i.e., the actual amount of nutrient recommended in lb/ac as a function of soil test value) are provided for crops in the University of Delaware Nutrient Recommendations (available at http://www.udel.edu/008353; Shober et al., 2024) or the Mid-Atlantic Commercial Vegetable Production Recommendations (available at http://www.udel.edu/0012565; Wyenandt et al.,

2024). The general interpretations for each soil test category are:

LOW *(0-25 FIV).* The nutrient concentration in the soil is inadequate for the growth of most plants and will very likely limit plant growth and yield. There is a high probability of a favorable economic response to additions of the nutrient.

MEDIUM *(26-50 FIV).* The nutrient concentration in the soil may be adequate for plant growth, but should be increased into the optimum range to ensure that plant growth and yield are not limited. There is a low to moderate probability of a favorable economic response to additions of the nutrient.

HIGH *(50-100 FIV).* The nutrient concentration in the soil is in the range recommended for the growth of all plants. Since there is a very low probability of a favorable economic response, nutrient additions are rarely recommended.

EXCESSIVE *(>100 FIV).* The nutrient concentration in the soil is above the range recommended for the growth of all plants. Additions of the nutrient will be unprofitable and are not recommended. Erosion, runoff, and leaching from soils that are excessive in P can have negative effects on water quality. Applications of P (e.g., fertilizers, manures) are not recommended, with the possible exception of starter fertilizers for some crops.

Comparing and Converting Soil Test Results from Different Laboratories

Several soil tests are used by laboratories analyzing soil samples from Delaware (Table 2). Depending on the method used to extract P and K from a soil and the units used to report test results, numerical values for soil test P and K may differ between laboratories. This means results from labs that use different methods or units must be converted before they can be compared numerically and interpreted accurately.

While it is preferable to use fertilizer recommendations developed using a specific soil test method, it is sometimes necessary to convert between soil tests and then develop a fertilizer or manure application rate recommendation. Equations for converting soil test results between soil test methods, which are based on research conducted by the UD Soil Testing Program (Gartley et al., 2002), are available in the University of Delaware Nutrient Recommendations (available at http://www.udel.edu/008353; Shober et al., 2024). This page also contains information on converting soil test data for other nutrients, such as calcium (Ca) and magnesium (Mg). The following tables provide the estimated numerical equivalent to UD-FIV for soil test P (Table 3) and soil test K (Table 4) for the most common soil test methods and reporting units used by labs providing services to Delaware growers.

Table 2. The most common soil tests used by laboratories that analyze samples from Delaware and the Delmarva Peninsula.

Laboratory	Soil Test Method	Reporting Units
University of Delaware (UD)	Mehlich-3	UD-FIV
AgroLab	Mehlich-3	ppm, UD-FIV (for P only)
Brookside Laboratories, Inc	Mehlich-3 Bray-1 P Ammonium acetate K	ppm
Penn State University	Mehlich-3	ppm
Rutgers University	Mehlich-3	lbs/a or ppm
Spectrum Analytical Laboratories	Mehlich-3	lbs/a or ppm
Virginia Tech	Mehlich-1	lbs/a
Waters Agricultural Laboratories, Inc	Mehlich-1	lbs/a
Waypoint Analytical	Mehlich-3 Mehlich-1 Bray-1 P Ammonium acetate K	ppm

Table 3. Conversion chart for the Mehlich-3, Mehlich-1, and Bray-1 soil tests for phosphorus (P).

Soil Test P UD-FIV	Mehlich-3		Mehlich 1	Bray-1
	lb P/ac	lb P_2O_5/ac	lb P/ac	ppm P
5	10	23	5	4
10	20	46	10	8
15	30	69	15	12
20	40	92	20	16
25	50	115	25	20
30	60	138	30	24
35	70	161	35	28
40	80	184	40	32
45	90	207	45	36
50	100	230	50	40
60	120	276	60	48
70	140	322	70	56
80	160	368	80	64
90	180	414	90	72
100	200	460	100	80
125	250	575	125	100
150	300	690	150	120
175	350	805	175	140
200	400	920	200	160
225	450	1035	225	180
250	500	1150	250	200
275	550	1265	275	220
300	600	1380	300	240
325	650	1495	325	260
350	700	1610	350	280
375	750	1725	375	300
400	800	1840	400	320

Table 4. Conversion chart for the Mehlich-3, Mehlich-1, and ammonium acetate soil tests for potassium (K).

Soil Test K UD-FIV	Mehlich-3			Mehlich-1	Ammonium Acetate
	ppm	lb K/ac	lb K_2O/ac	lb K/ac	ppm
5	9	19	22	14	9
10	18	37	44	28	18
15	27	56	67	42	27
20	36	74	89	56	36
25	45	93	111	69	45
30	55	111	133	83	55
35	64	130	156	97	64
40	73	148	178	111	73
45	82	167	200	125	82
50	91	185	222	139	91
60	109	222	267	167	109
70	127	259	311	194	127
80	145	296	356	222	145
90	164	333	400	250	164
100	182	370	444	278	182
125	227	463	556	347	227
150	273	556	667	417	273
175	318	648	778	486	318
200	364	741	889	556	364

Summary

Nutrient recommendations are developed based on research that relates the probability of a profitable plant response to application of a nutrient compared to the amount of that nutrient in the soil as measured by a soil test. However, different soil testing laboratories may use different soil test methods or report results in different units, making it difficult to compare results between laboratories. The UD

nutrient recommendations for P, K, Ca, and Mg are based on the Mehlich-3 soil test, with results reported in UD-FIV. Research based equations are available to convert soil test P and K results from laboratories using different soil testing methods and reporting units to the equivalent UD-FIV. Conversion of soil test data allows for comparison of soil test results across laboratories and for use of UD nutrient recommendations with soil test results from other laboratories.

It is important to note that even at a given soil test value, recommendations for the amount of nutrient to apply can vary due to differences in nutrient sources selected, the timing and method of application, the crops to be grown, yield goal, tillage practices, and other factors, regardless of the soil test method used. Consult the laboratory conducting the soil test for questions about the test performed and your nutrient management consultant for the most appropriate nutrient management recommendation for your situation.

References

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About the Authors

Amy L. Shober (corresponding author), Professor and Extension Specialist, University of Delaware, Newark, DE (ashober@udel.edu)

Karen L. Gartley, Director, University of Delaware Soil Testing Program, Newark, DE

J. Thomas Sims, Professor (retired), Environmental Soil Management, University of Delaware, Newark, DE

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Peer Reviewers

Lyndsie Mikkelsen, Extension Agent, University of Delaware Extension, Georgetown, DE

Sydney Riggi, Extension Agent, University of Delaware Extension, Dover, DE