Interpretation of Soil Test Results

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Soil Test Relationship to Nutrient Availability

1. The concentration of phosphorus (P), potassium (K), zinc (Zn), and nitrate-nitrogen (NO_3-N) extracted from soil and reported in soil test analyses are indices. The reported values are related to the nutrient availability to growing plants and are specific for each soil test method.

2. The procedure for interpreting the meaning of soil test indices is to use data from long-term experiments and to conduct field calibration studies by growing crops in fields with a predetermined soil test value. Fertilizer is added in increments such as 20, 40, 60, or 80 pounds per acre. Each fertilizer rate is applied to specific plot areas or to several randomly selected spots within an area represented by a given soil test. Therefore, it is possible to separate treatment effects from effects due to soil variability.

3. Yield comparisons allow agronomists to determine if a response to added fertilizer occurred. If no response to added fertilizer is found, the soil test is interpreted as at least *adequate.* If a statistically significant yield increase is measured, the soil test is interpreted as *insufficient,* and the amount of fertilizer required to produce the economic optimum or most profitable yield is calculated. When these tests have been conducted many times at numerous locations to account for climatic and soil variation, a basis exists for reasonable interpretation of soil test analyses. Interpretations account for profitability as well as the probability and magnitude of agronomic responses. For example, extra yield is possibly attributable to an addition of fertilizer; however, this yield may not be sufficient to pay for the cost of the fertilizer.

Soil Test Phosphorus, Potassium, and Zinc

1. Soil tests calibrated for use in Iowa are Bray P_1, Olsen, and Mehlich-3 for phosphorus; ammonium acetate and Mehlich-3 for potassium; and DTPA for zinc. The Bray P_1 test is not recommended for soils with soil pH 7.4 or higher (calcareous) because it often underestimates plant-available phosphorus in those soils. Phosphorus interpretations are based on the colorimetric laboratory method to measure P extracted by the Bray P_1, Olsen, and Mehlich-3 P tests, and on the ICP (inductively coupled plasma) analytical method to measure P extracted by the Mehlich-3 ICP test. These tests are targeted for different Iowa soil conditions: phosphorus - Bray P_1 for non-calcareous soils (< 7.4 soil pH), Olsen for calcareous soils (> 7.4 soil pH), and Mehlich-3 and Mehlich-3 ICP for all soils; potassium - ammonium acetate or Mehlich-3 for all soils. Results are expressed on an elemental basis as ppm P, K, or Zn.

2. Tables 1 and 2 list interpretations of test results calibrated for the surface 6- to 7-inch depth of soil based on studies conducted in Iowa by Iowa State University scientists since the late 1940s. For phosphorus and potassium, interpretation categories for Iowa soils are refined to *very low, low, optimum, high,* and *very high.* There is a high probability that an economic response will occur to addition of fertilizer to a soil testing *very low.* The magnitude of such a response will be quite large. As soil tests increase from *very low* to *very high,* the probability of an economic response to addition of fertilizer decreases from very high to very low (approaches zero) - with an accompanying decrease in the magnitude of yield increases from fertilizer addition. Phosphorus and potassium interpretations differ according to tabulated values for subsoil P and K levels of Iowa soils (Table 1).

Table 1. Interpretation of phosphorus and potassium soil test values for surface soil samples (6- to 7-inch depth).

	Bray P_1 or Mehlich-3 P			Olsen P			Mehlich-3 ICP			Ammonium Acetate or Mehlich-3 K	
	Wheat, alfalfa	All crops except wheat, alfalfa		Wheat, alfalfa	All crops except wheat, alfalfa		Wheat, alfalfa	All crops except wheat, alfalfa		All Crops	
		Subsoil P			Subsoil P			Subsoil P		Subsoil K	
Relative level		Low	High		Low	High		Low	High	Low	High
	ppm										
Very low (VL)	0–15	0–8	0–5	0–10	0–5	0–3	0–20	0–15	0–10	0–90	0–70
Low (L)	16–20	9–15	6–10	11–14	6–10	4–7	21–30	16–25	11–20	91–130	71–110
Optimum (Opt)	21–25	16–20	11–15	15–17	11–14	8–11	31–40	26–35	21–30	131–170	111–150
High (H)	26–30	21–30	16–20	18–20	15–20	12–15	41–50	36–45	31–40	171–200	151–180
Very High (VH)	31+	31+	21+	21+	21+	16+	51+	46+	41+	201+	181+

From PM 1688, *General Guide for Crop Nutrient and Limestone Recommendations in Iowa.*

Table 2. Interpretation of Zn soil test values for surface soil samples (6- to 7-inch depth), corn and sorghum crops only.

DTPA Extractable Zn		
Low	Marginal	Adequate
- - - - - - - ppm - - - - - - -		
0–0.4	0.5–0.8	0.9+

From PM 1688, *General Guide for Crop Nutrient and Limestone Recommendations in Iowa.*

Late Spring Soil Nitrate Test

1. The late spring soil nitrate test is used to assess plant-available nitrogen (N) early in the growing season for corn production. Interpretation of this test is based on research conducted in Iowa during the past 15 years and provides an index of N sufficiency for corn production. The test is specific in that it is calibrated only for corn, for soil samples collected when corn plants are 6 to 12 inches tall, and for soil collected from the zero to 12 inch depth (top foot of soil). Because of the potential for rapid changes in soil nitrate concentrations, it is important to adhere to the recommended sampling time. Sample analysis is for nitrate-nitrogen, with results expressed in ppm nitrate-N on a dry soil basis (not ppm nitrate).

2. Evaluating nitrogen management programs, or determining the need for additional nitrogen application, is accomplished by comparing the soil nitrate test result to a soil test critical value. This critical value represents the soil test level where economic response to applied nitrogen is no longer expected. The critical test value for the late spring soil nitrate test when corn is grown after corn or after soybean is 25 ppm nitrate-nitrogen (from PM 1714, *Nitrogen Fertilizer Recommendations for Corn in Iowa*). This value is reduced by 3 to 5 ppm if rainfall between April 1 and sampling is greater than 20 percent above normal. No additional nitrogen is recommended when the soil test is above the critical value. The nitrogen fertilization need becomes larger the more the soil nitrate test result falls below the critical value. The critical soil nitrate level for manured soils and for corn grown after alfalfa varies (from 10 to 25 ppm) depending upon several factors including May rainfall and relative grain and fertilizer prices (it is lower with more rainfall and less favorable production prices, and higher with favorable rainfall and prices).

Nutrients in Surface Water

1. One of the major concerns about nutrients in surface water is that nutrients may stimulate nuisance growths of algae and rooted aquatic plants. Phosphorus is of particular importance because biological productivity in fresh water is often limited by its availability. There is a direct relationship between soil test phosphorus level and phosphorus in field runoff water. Stratification of soil test level impacts potential phosphorus losses through dissolved P and soil erosion because of the interfacing between runoff water and the soil surface.

2. Nitrogen, in the form of nitrate, is a concern from a drinking water standpoint. The biological productivity of surface waters (fresh water) is not limited from lack of nitrogen because enough arrives or is generated from natural background sources such as rainfall, organic matter, and biological N fixation by microbes in water.

3. Potassium is a major fertilizer nutrient but is not considered an environmental pollutant.

Nutrients in Groundwater

1. Phosphorus and potassium are quite immobile in the soil so fertilizer forms are usually very minor contributors to phosphorus and potassium found in groundwater, especially compared to surface runoff from sloping ground. In a few specific situations (very sandy soils, continued very high manure applications, or recently tiled fields) however, movement through the soil profile can be significant.

2. Many things happen to nitrogen in the soil, including losses below the root zone. Nitrate, which poses a potential threat to groundwater, is formed readily in soil during much of the year, especially during the growing season. The source may be organic matter that is present in all soils, crop residues, animal manure, rainfall, or fertilizer applications.

3. Nitrate moves through the soil with water. If it is not absorbed by plants or microorganisms, it can move below the root zone and eventually into groundwater. Studies show that the amount of nitrate that moves below the root zone is directly related to the nitrogen fertilizer rate.

4. Over application of nitrogen fertilizer and animal manure in an attempt to produce unrealistic yields or to offset anticipated losses increases the potential for groundwater contamination and should be avoided.

5. Fall applications of nitrogen fertilizers will not be as efficiently used in some years as spring or sidedress applications and can result in larger losses of nitrogen. The efficiency of fall applied nitrogen fertilizer depends on the fall soil moisture situation and spring rainfall, which together determine the probability of losses of nitrogen from the plant root zone. If the soil is wet in the fall, rainfall will cause either leaching or denitrification of nitrate in the soil. Because it is impossible to predict rainfall, it is not possible to estimate the exact probability that losses of nitrogen from fall applications will occur. It is possible to say that when nitrogen fertilizer is applied in the fall, there is a chance that losses will occur, and that chances are significantly less when nitrogen fertilizer is applied in the spring or sidedressed. Nitrogen fertilizer should be spring or sidedress applied whenever possible, and are preferable application timings.

6. Regardless of form applied - green manures, animal manure, or inorganic fertilizer - nitrate is either added or forms in the soil. Nitrate is mobile in soil. Depending on soil properties, soil moisture, and rainfall, it can move below the root zone in a short time.

Pesticides as Potential Pollutants

The potential for contamination of surface and groundwater with pesticides is increased by use that does not conform to label directions when and where needed. Iowa State University Extension recommends that pesticides be selected and applied in accordance with label directions. It is illegal to apply a pesticide in a manner inconsistent with its labeling. Applicators should read and follow all label directions, including use of protective clothing, mixing and handling precautions, rates and methods of application, and environmental hazard warnings.

Other Resources

Several Iowa State University Extension publications can assist with soil test interpretation, making nutrient recommendations, and using manure nutrients for crop production. These can be ordered through ISU County Extension offices or Iowa State University Extension Distribution: call (515) 294-5247, fax (515) 294-2945, e-mail <pubdist@iastate.edu>, or visit the World Wide Web at <http://www.extension.iastate.edu>

PM 1688, *General Guide for Crop Nutrient and Limestone Recommendations in Iowa*
PM 1714, *Nitrogen Fertilizer Recommendations for Corn in Iowa*
PM 1584, *Cornstalk Testing to Evaluate Nitrogen Management*
PM 1811, *Managing Manure Nutrients for Crop Production*
NCR 533, *Soil Cation Ratios for Crop Production*
NCR 221, *Recommended Chemical Soil Test Procedures for the North Central Region* (Rev. 1998)

This publication also is available on the World Wide Web at <http://www.extension.iastate.edu/pubs/so.htm>.

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