

## UPDATE TO IOWA PHOSPHORUS, POTASSIUM, AND LIME RECOMMENDATIONS

Antonio P. Mallarino and John E. Sawyer, Professor, Department of Agronomy, Iowa State University

This article highlights revisions to Iowa State University (ISU) soil-test interpretations and application guidelines for phosphorus (P), potassium (K), and lime in an update of Extension Publication PM 1688 "A General Guide for Crop Nutrient and Limestone Recommendations in Iowa". The printed version of this publication will not be ready until later in the fall and the online version should be posted by early October at <https://store.extension.iastate.edu/> and on the Soil Fertility web site at <http://www.agronext.iastate.edu/soilfertility/homepage.html>. Field research is conducted continuously to assure that nutrient management suggestions are up to date. This research has indicated that some recommendations should not be changed, but other recommendations needed significant changes in order to optimize nutrient management to improve the profitability and sustainability of crop production.

### What was not changed?

The recommendations that did not change are summarized in the following points:

1. The general concept of P and K recommendations are for long-term profitability and reduced risk of yield loss, by emphasizing crop response-based applications for the very low and low soil test classes, and removal-based maintenance based on estimated crop removal with harvest for the optimum soil test class.
2. Interpretation categories for the Bray-P1, the colorimetric version of the Mehlich-3 test, and the ICP (inductively-coupled plasma).
3. Amounts of P and K recommended for grain production in the very low and low soil test interpretation categories.
4. The soil pH considered sufficient for crops.
5. Interpretations for micronutrients, which currently include only recommendations for zinc (Zn) in corn or sorghum. Ongoing research studying several micronutrients for corn and soybean has not been completed.

### What are the changes?

The most significant changes are to include interpretations for the new moist-based test for K (field-moist or slurry analyzed), changes to soil-test interpretation categories for K using dried soil samples, and adjustments to both crop nutrient concentrations and default crop yields needed to estimate nutrient removal for maintaining soil-test levels in the optimum category.

### *Interpretation categories*

Table 1 shows the new interpretation categories for P and K soil-test results by several methods and for various crops. The most significant changes are summarized in the following points.

1. Eliminated interpretations for soil-test P and K results for soil associations with high subsoil P and K. Research during many recent years showed no clear differences in soil test requirements

between soil associations with the low or high subsoil P and K levels that were established in the 1960s.

2. Included interpretations based on many recent years of field crop-response research for the new moist-based (un-dried samples) test for K by the ammonium-acetate and Mehlich-3 tests, and significantly increased interpretation categories to higher test levels for the ammonium-acetate and Mehlich-3 tests for K with dried soil samples.

Testing dried or field-moist soil does not change P soil-test results by any method, but can greatly affect K test results with the ammonium-acetate and Mehlich-3 tests (these two tests give similar results no matter the sample handling procedure). Therefore, different interpretations are provided for K testing of moist or dried samples. The moist K test can be performed either on field-moist samples or on a slurry made with field-moist soil and water, and both versions give similar results. Research has indicated that the moist K test is more reliable than the test based on dried samples and is a better predictor of crop K fertilization need. Improved interpretations are provided for the K test based on dried samples because some laboratories offer both tests, and some still offer only the dried test. Although the new interpretations improve the performance of the dry K test, we encourage use of the moist test for K.

The amounts of K extracted can differ greatly between moist and dried samples, and the differences change greatly across soil series, the soil-test K levels, and soil conditions related to drainage and moisture content cycles. There is no numerical factor that can be used to transform test results between moist and dried testing procedures. Laboratories should not transform soil-test results obtained by one procedure to express values by the other procedure. When switching to the new moist test, the K test results may be lower, approximately similar, or higher than results in previous years based on the dried test. The moist test will tend to be lower at the lower soil K levels and in soils with fine textures and more poor drainage, but may be similar or higher at high soil K levels and in well drained soils or dry sampling seasons.

3. There is a minor adjustment to interpretation categories for the Olsen P test. Research during recent years has shown that the upper boundary levels for the categories low, optimum, and high were too high by one to two ppm.

### ***Suggested crop P and K concentrations and default yields***

The amount of P and K removed with harvest is a very important criterion to determine the rate needed to maintain soil-test values in the optimum interpretation category. The probability of a crop yield increase in this category is 25% or less and the magnitude of the expected increase is small. So maintaining this level is recommended based on the amounts of P and K removed, which is determined by the prevailing yield levels (not the yield goal) and the nutrient concentration in the harvested crop portion.

Table 2 shows the new crop P and K concentrations and the suggested default yield levels that laboratories could use when they do not get yield information with the soil sample submitted for analysis. Some default crop yield levels were increased, especially corn yield, to reflect

increasing yield over time. We must emphasize that the prevailing yield level should be provided to the laboratory for a more accurate maintenance recommendation, but actual yields will provide a better estimate of removal.

The suggested concentrations were changed because (1) lower grain nutrient concentrations in samples from research studies have been observed in Iowa and other states, (2) we have better information of nutrient concentrations for many crops and harvested plant parts, and (3) previous publication versions had concentrations expressed on a dry matter basis that resulted in too high removal estimates when they were directly multiplied by crop yield expressed on standard moisture content basis. Therefore, the suggested nutrient concentrations better reflect the observed concentrations and have been adjusted so that they can be directly multiplied by yield expressed using common moisture content standards.

### ***New suggested P and K application rates***

Recent research has shown a need to change the P and K amounts recommended to maintain the optimum soil-test category for several crops, due to adjustments in nutrient concentrations of harvested plant parts or default yield levels. Also, adjustments were made to, P and K amounts recommended for corn silage and some forages when soil-test results are in the very low or low categories. The new application rates cannot be possibly shown in this short publication. Also, the updated publication includes equations to calculate P and K rates that are useful for variable-rate application for corn, soybean, and the two year rotation.

### ***Lime recommended for soil association areas with calcareous subsoil***

Previous recommendations indicated that soil pH 6.5 was sufficient for corn and soybean in soil association areas with low subsoil pH, but that 6.0 was sufficient in areas with high (calcareous) subsoil pH. However, a target pH of 6.5 was suggested for all areas when calculating the amount of lime to apply. This apparent incongruence could be justified, but it created confusion. Therefore, the recommend target pH is 6.0 for areas classified as having calcareous subsoil. The classification of Iowa soil association areas according to subsoil pH was not changed. The updated publication includes the equations based on buffer pH test results used to determine the amount of lime needed to raise soil pH to desired values that are useful for variable-rate lime application.

**Table 1. Interpretation of soil-test values for phosphorus (P) and potassium (K) determined using recommended sample handling procedures and analysis methods (6-inch deep soil samples). Samples analyzed either field-moist or in a slurry (not dried) or after drying at 95 to 105 °F.**

Relative Level	PHOSPHORUS		POTASSIUM
	Alfalfa or Wheat	All Other Crops	All Crops
	Bray P <sub>1</sub> or Mehlich-3 P		Ammonium-Acetate or Mehlich-3
	Field-Moist and Slurry or Dried Samples		Field-Moist or Slurry Samples
Very low (VL)	0–15	0–8	0–50
Low (L)	16–20	9–15	51–85
Optimum (Opt)	21–25	16–20	86–120
High (H)	26–35	21–30	121–155
Very high (VH)	36+	31+	156+
	Mehlich-3 ICP		Ammonium-Acetate or Mehlich-3
	Field-Moist and Slurry or Dried Samples		Dried Samples
Very low (VL)	0–20	0–15	0–120
Low (L)	21–30	16–25	121–160
Optimum (Opt)	31–40	26–35	161–200
High (H)	41–50	36–45	201–240
Very high (VH)	51+	46+	241+
	Olsen P		
	Field-Moist and Slurry or Dried Samples		
Very low (VL)	0–9	0–5	
Low (L)	10–13	6–9	
Optimum (Opt)	14–16	10–13	
High (H)	17–19	14–18	
Very high (VH)	20+	19+	

**Table 2. Nutrient concentrations to calculate removal with crop harvest and amounts of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O for the optimum soil-test category.**

Crop †	Unit of Yield and Moisture Basis	Pounds per Unit of Yield ‡	
		P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Corn	bu, 15%	0.32	0.22
Corn silage	bu grain equiv., 15%	0.44	1.10
Corn silage	ton, 65%	3.5	9.0
Corn stover	ton, 15%	4.8	18
Soybean	bu, 13%	0.72	1.2
Soybean residue	ton, 10%	4.7	23
Oats	bu, 13%	0.29	0.19
Oats straw	ton, 10%	6.4	36
Wheat	bu, 12%	0.55	0.27
Wheat straw	ton, 10%	3.7	23
Sunflower	100 lb, 10%	0.75	0.65
Alfalfa, alfalfa-grass	ton, 15%	13	43
Red clover-grass	ton, 15%	11	31
Trefoil-grass	ton, 15%	11	31
Smooth bromegrass	ton, 15%	7.9	41
Orchardgrass	ton, 15%	12	60
Tall fescue	ton, 15%	11	58
Timothy	ton, 15%	7.9	28
Perennial ryegrass	ton, 15%	11	30
Sorghum-sudan	ton, 15%	11	33
Switchgrass	ton, 15%	11	58
Reed canarygrass	ton, 15%	7.9	41

† Nutrients in corn stover, soybean residue, and small grains straw reflect content at grain harvest time approximating the proportion of cornstalks, cobs, stems, or leaves when baling immediately after harvest, but include little soil contamination. Nutrients in forages reflect content of good quality hay.

‡ Nutrient concentrations adjusted from a dry matter basis to a value suitable for multiplying by harvested crop yield, based on the standard moisture content of the crop component harvested. Values used to obtain appropriate nutrient removal estimates.