Soil-Test Interpretations for Fall Fertilization and Liming Decisions with High Fertilizer Prices and After Highly Variable Rainfall and Crop Yields

Antonio Mallarino, Professor and Nutrient Management Extension Specialist, Department of Agronomy, Iowa State University

The 2021 cropping season had very variable rainfall across Iowa with either drought or excessive rainfall. Highly variable landscape and soil moisture retention capacity in many fields also may cause high within-field yield variability. Reduced potential income due to low yield in some areas combined with currently very high fertilizer prices are creating significant uncertainty among producers about P, K, and liming decisions for the 2022 crop season. Several factors need to be considered.

Criteria for deciding P and K fertilization rates

Soil testing and P and K removal with harvest are used to decide P and K fertilization rates. Results from hundreds of field trials were used to develop soil-test interpretations and suggested fertilization rates in publication PM 1688, A General Guide for Crop Nutrient and Limestone Recommendations in Iowa. This publication was last updated in fall 2013, but results of numerous trials since then showed that soil-test interpretations and fertilizer application guidelines are still current. Soil testing is not a perfect diagnostic tool, but crop yield increases from P and K fertilization are large and likely with test results in the Very Low and Low interpretation categories, small and less likely in the Optimum category, and very unlikely in the High and Very High categories. The soil-test values for these categories assume results since the previous crop harvest, use of test methods recommended in PM 1688, and good soil sampling methods (see publication CROP 3108, Take a Good Soil Sample to Help Make Good Fertilization Decisions). The suggested nutrient application rates are for one crop with the only exception of corn and soybean, for which the one-time two-year rate application before either crop is also suggested.

Suggested P and K for the Very Low and Low categories are based on yield response data and will result in maximum economic yield or maximum yield in most conditions, including high yield levels. These rates are likely to increase post-harvest soil-test levels, although the magnitude of the increase will vary according many factors including actual nutrient removal.

Fertilization rates for the Optimum category are based on P and K removal with harvested plant parts with prevailing yield levels (not on yield goal). These rates will maximize yield and maintain soil-test values at the same time. For the calculation of P and K removal, publication PM 1688 includes nutrient concentrations in harvested products (slightly higher than average) and indicates that actual prevailing yields should be used. Rates included for the Optimum category are based on default yields because laboratories or crop consultants often do not receive yield information. Note that with very high removal levels, a removal-based rate may be similar or higher than rates suggested for the Low soil-test category. This is explained by the different concepts used to suggest rates for the low-testing categories and the Optimum category.

For the High and Very High soil testing categories no fertilization is suggested other than starter with unseasonably cold and wet springs and with thick crop residue cover.
Figure 1 shows net returns from fertilization derived from numerous of corn and soybean field trials for different soil-test P or K values and three grain price scenarios at a single P or K fertilizer price. Note that fertilizer prices used for the figures were not updated to reflect current changing prices.

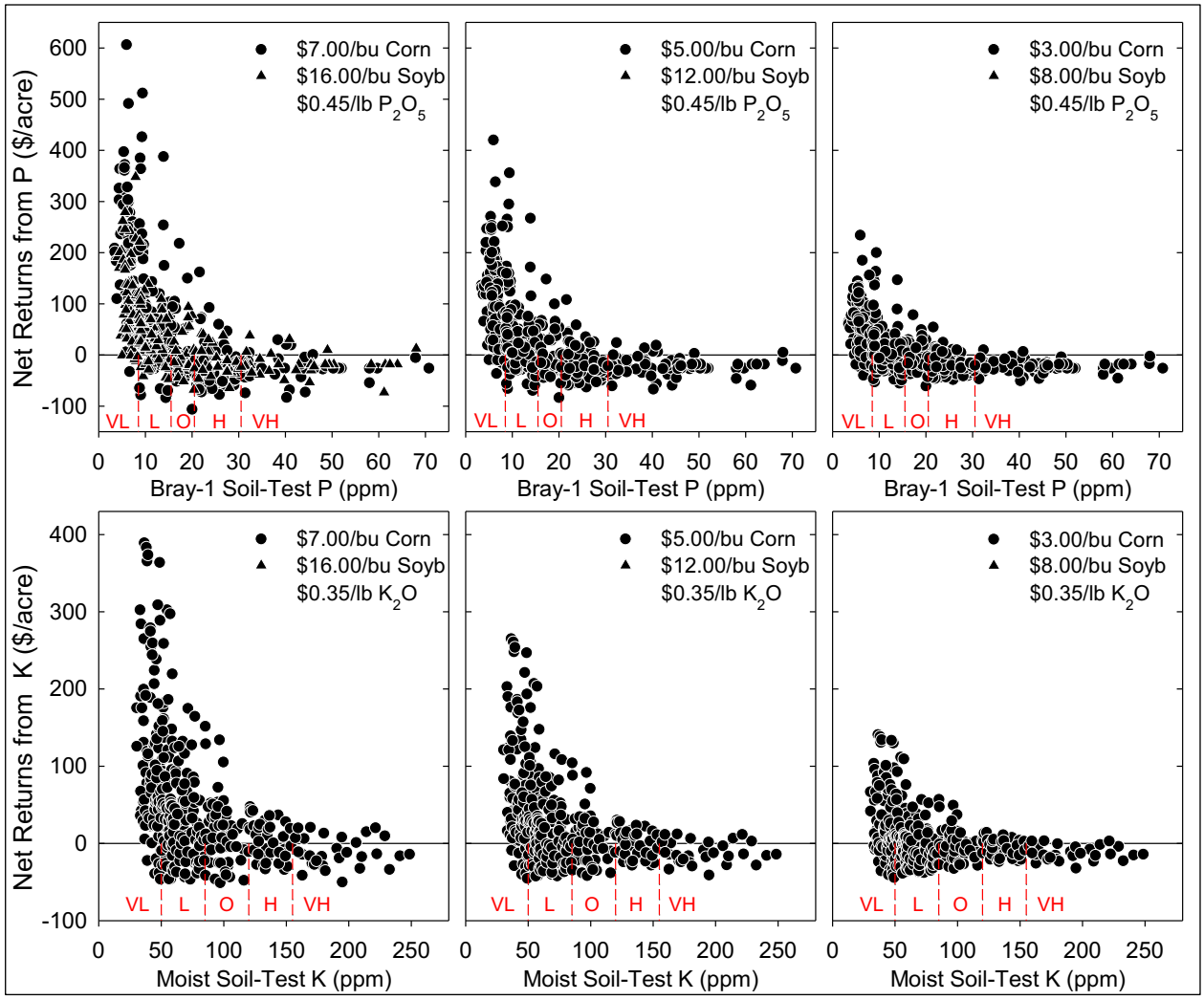

Figure 1. Net returns to P or K fertilization of corn and soybean for different soil-test levels in many Iowa soils for shown prices (Mallarino, 2015). Interpretation categories Very Low to Very High are as VL, L, O, H, and VH, respectively.

With soil tests in the Very Low category, economic benefits from fertilization are very high and very likely for all price scenarios (Fig. 1). With soil tests in the Low category, benefits are lower but still likely and most often above the break-even line. Therefore, producers are advised against reducing recommended P or K application rates for low-testing soils, even those renting,

because the benefits from investing in fertilization are very large and very likely. With unfavorable crop or fertilizer prices producers who would apply the 2-year rate can instead apply only a single rate.

With soil tests in the Optimum category the benefits of applying a removal-based rate are much smaller than for the Low category, but in most cases are still above break-even for the two highest crop price scenarios (Fig. 1). With unsafe land tenure or unfavorable crop or fertilizer prices producers who fertilize each year will increase profits with little risk of yield loss by applying less P and K than a removal-based rate, applying only starter, or even skipping the application one year. Producers who normally apply the two-year rate for the rotation could apply a single year removal-based rate instead. Producers should not over-react to one year lower or higher yield due to drought or excess rainfall when estimating removal-based rates. The suggestion in publication PM 1688 of using the "prevailing yield level in a field or portions of fields" means considering yield levels during the last 2 to 4 years, not a future yield or this year's yield level. This is because, as Figure 2 shows, there is a good relationship between removal with harvest and P or K soil-test levels only over several years. Additional supporting data for relationships between P and K removal with harvest and soil-test values can be seen in the ICM conference proceedings article Corn and Soybean Grain Yield, Phosphorus and Potassium removal, and Soil-Test Trend Responses to Long-Term Fertilization Strategies.

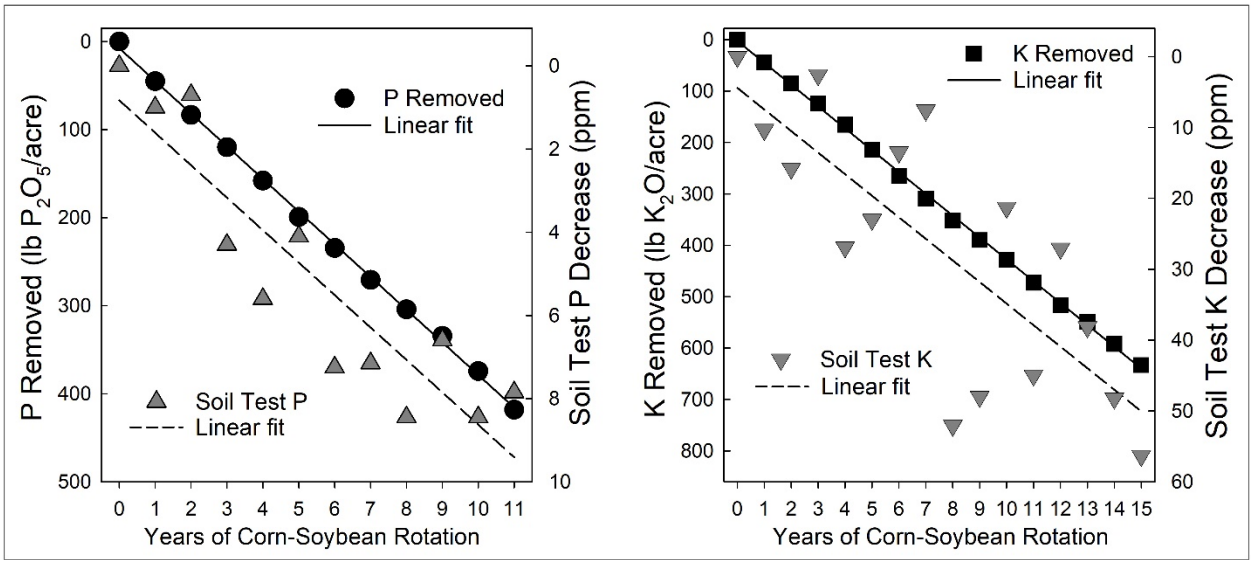

Figure 2. Relationship between cumulative P and K removed with grain harvest and soil-test change over time for plots not fertilized with P or K. Bray-1 for P and ammonium-acetate or Mehlich-3 tests for K (Mallarino, 2016).

Criteria for deciding when to lime and the lime application rate

Soil pH should be used to decide if a soil is too acidic and liming is needed. However, the buffer pH measurement indicates the amount of effective calcium carbonate equivalent (ECCE) to apply with aglime or other materials to raise pH of a defined depth to a desirable level.

Publication PM 1688 includes optimum pH values for groups of crops or soils of the state. The optimum pH is 6.9 for alfalfa or alfalfa/grass mixtures 6.9 and 6.0 for other forages across the entire state. For corn and soybean however, recent research confirmed that pH 6.5 is optimum for soils with low subsoil pH (mostly in eastern and southern Iowa) but pH 6.0 is optimum for soils with high-pH (calcareous) subsoil. Results of recent liming research can be seen in the ICM conference proceedings article Liming research update and application strategies with low crop prices.

Soil-test P, K, and pH interpretations when sampling during a drought

Results of P and K, and pH soil tests may be misleading when sampling during drought since about late August until the sampling time. Most areas of the state, even those with drought in late spring or summer have received sufficient rain, but there may be small dry pockets. This topic was discussed last fall in the ICM News article Be Cautious When Interpreting Fall Soil-Test Results Following Drought. In dry conditions, soil-test K is the most affected, with lower values than should be expected when using the dry or moist sample methods. Soil-test P values also may be lower but are not impacted as much as soil-test K. Reasons for lower than normal P and K results are that plants take-up P and K from the soil available pool until about physiological maturity, drought drastically slows down soil normal reactions that resupply the available pools, and little or no rainfall delays the normal nutrient recycling to the soil (leaching) from maturing plants and residue after harvest. These processes affect K much more than P.

Drought effects are different for soil pH and buffer pH. Soil pH is used to decide if liming is needed whereas the buffer pH measurement indicates the amount of effective calcium carbonate equivalent (ECCE) to apply with aglime or other materials to raise pH of a defined depth to a desirable level. Publication PM 1688 includes optimum pH values for several crops and Iowa regions as well as how to calculate ECCE application rates for different depths and buffer-pH test results.

With prolonged drought, soil tends to be more acidic than normal (lower pH values) and, therefore, the lower pH suggests liming is needed when actually it may not yet be needed. The pH may be 0.2 to 0.5 units lower, but this is difficult to predict. The main reason for lower pH during drought is increased soluble salts in the soil solution, which normally are removed by plant uptake or leached out down the soil profile by rainfall. However, it is very important to note that the buffer pH measurement is not affected by drought because it is measured with a highly saline buffered solution. The key point is not to make a hasty decision to apply lime based on soil pH from samples taken with drought.

Therefore, to get more accurate fall soil-test results with dry conditions, it is suggested to delay soil sampling until about a week to ten days after there has been at least two to three inches of rain or wait until early next spring. Be aware, however, that it is not possible to accurately predict how much rain will eliminate the effects discussed above.