FRST Fact Sheet: Defining the Correlation Model for the Fertilizer Recommendation Tool (FRST) to Identify a Critical Soil Test Value

Fact Sheet #6: Modeling Soil Test Correlation Data

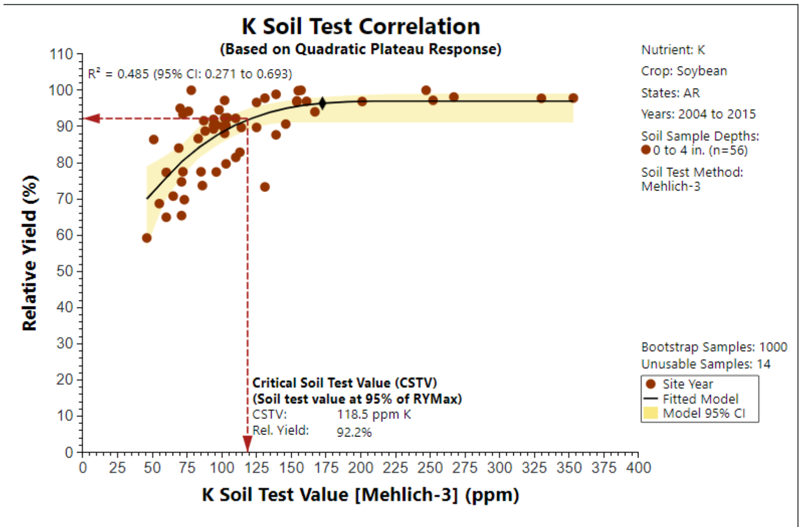
Soil testing and fertilizer nutrient management are at the core of modern agriculture. The majority of soil test correlation and calibration trials and development of fertilizer recommendations occurred from the 1950's to 1970's. Despite many changes and advancements in agronomy and increases in crop yield, little soil fertility research has been conducted in the last several decades. Today, the imperative of upgrading soil test fertilizer recommendations is highlighted by global supply chain disruptions and concerns over the fate of fertilizer nutrients in the environment.

The Fertilizer Recommendation Support Tool, or "FRST", is a national initiative to modernize fertilizer recommendations by pooling expertise and soil test correlation and calibration data from across the country into an accessible decision support tool. Researchers working as a national team rather than within individual states and institutions will reduce ambiguity while optimizing nutrient use across state lines through the development of the FRST. Users will select specific conditions, such as soil, crop, geographic region, and soil test extractant, to provide tailored soil test recommendations that are expected to save farmers millions of dollars annually while reducing excess nutrient losses to the environment.

Correlation is the first step of the soil test correlation and calibration process. The primary soil test correlation goals are to 1) determine whether a soil test method is capable of distinguishing between soils that do and do not require fertilization with a specific nutrient for maximum crop yield and 2) to identify a critical soil test value (CSTV) that separates fertilizer-responsive from non-responsive for specific crops. Soil test correlation involves fitting an empirical model to a dataset and interpreting the model to identify the CSTV. Model fitting requires enough site-year observations to document crop response to fertilization across a wide range of soil-nutrient availability values, calculating the relative yield of each trial's control treatment (receiving no-fertilizer for the nutrient-of-interest), and applying a model to the site-year data to describe the relationship between soil test and yield response. Several mathematical models and interpretations have been used to determine CSTVs, and the best model for FRST was unclear. The ultimate goal of this activity was to select a single model and CSTV interpretation for the FRST.

Four models [Arcsine-log Correlation Curve (ALCC), Exponential (EXP), Linear Plateau (LP), & Quadratic Plateau (QP)] were fit to three example datasets extracted from the FRST national database. The three datasets included corn response to Olsen-P from the Midwest USA, soybean response to Mehlich-1 K from Virginia, and Mehlich-3 K from Arkansas. The CSTV was identified as 95% of the maximum predicted yield for the ALCC, EXP, and QP models and the join point (100% of the maximum) of the LP and QP models for a total of five soil test correlation modeling approaches. The predicted CSTVs were compared using relative yield as the dependent variable. The response frequency of significant yield increases to fertilization was also examined as a companion metric to communicate the frequency of false positive and false negative predictions above and below the CSTV.

Figure 1. Example correlation between soybean relative yield and Mehlich-3 K using the quadratic plateau model with the critical soil test value (CSTV) interpreted at 95% of the plateau yield.



Variable	Median	Description
STVJP(♦)	172.4	Nutrient soil test value (ppm) above which crop yield is unlikely to increase
STVJPRY(♦)	96.4	Relative yield (%) at STVJP
RYMax	97.0	Relative yield (%) value when soil nutrient is non-limiting to crop yield
Int	46.4	Relative yield (%) at nutrient soil test value of 0

After the models were applied to the datasets, the five CSTVs ranged from 7-16 mg kg^{-1} for the Olsen P dataset, 46–66 mg kg^{-1} for the Mehlich-1 K dataset, and 116-168 mg kg^{-1} for the Mehlich-3 K dataset. Each empirical model had strengths and weaknesses but after evaluating the models, the QP model with the CSTV interpreted at 95% of the maximum predicted relative yield was selected as the modeling approach for FRST. There is no single modeling approach or dependent variable that is best for the correlation of all soil test datasets. However, all soil test correlation activities can use a standard relative yield calculation and modeling approach to compare outcomes and establish consistency and transparency in the process. Researchers are encouraged to simultaneously explore novel methods of soil test correlation with other relative yield definitions, models, and dependent variables to improve upon the process. A uniform modeling approach defining the CSTV will help provide transparency to soil-test-based fertilizer recommendations and highlight where soils start and stop benefiting from fertilization.

We would like to thank the individuals who worked tirelessly for two years to develop the CSTV modeling methods and all FRST collaborators who provided feedback on data management, modeling, and CSTV decisions. We would also like to thank our funders, USDA-NRCS (grants 69-3A75-17-45 & NR233A750011G016) and USDA-ARS (grant 58-8070-8-016). Supported by agInnovation, The State Agricultural Experiment Stations, and Hatch Funds provided by the National Institute of Food and Agriculture, U.S. Department of Agriculture.

For more information visit soiltestfrst.org.

Authors: N. Slaton (University of Arkansas Division of Agriculture), A. Pearce, L., Gatiboni, and D. Osmond (NC State University)