Defining Relative Yield

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.

The FRST decision tool will derive the relationship between crop yield and soil test nutrient concentration to help users understand when nutrient applications are needed to maximize crop growth and yield. Soil test correlation datasets are comprised of trial results from many years and locations (site-years) for a single crop and nutrient of interest (a national soil test correlation database is being compiled by FRST). Directly comparing crop yields from multiple trials and researchers is difficult since site-specific crop yield potential is affected by temporal, management, and environmental factors. Therefore, the individual site-year yield data are typically normalized to a relative yield value.

Relative yield is a ratio of yields for which the numerator is the yield without the nutrient of interest and the denominator represents the maximum attainable yield. Relative yield is often converted to a percentage by multiplying by 100 and can range from 0-100% or exceed 100%, depending on the method for determining maximum attainable yield. Most, but not all, soil fertility researchers accept relative yield as the best metric for soil test correlation and calibration analyses. Research has failed to document whether the relative yield calculation method affects the outcome of soil test correlation.

Six published relative yield calculation methods were selected by a FRST committee and applied to the yield data for five published correlation datasets and a generalized linear plateau model was fit to each. Statistical analysis demonstrated that the predicted critical soil test values were not significantly affected by the relative yield calculations for

Example 1. MAX relative yield calculation for a hypothetic trial with 5 fertilizer-nutrient rates

Fertilizer rate	Corn Yield Mean	Relative Yield
lb K_2O/acre	bu/acre	%
0	155	85
40	168	92
80	174	95
120	183	100
160	181	99

$$Relative\ Yield = \frac{Treatment\ Yield}{\substack{Numerical \\ Maximum \\ Yield}} \times 100$$

$$MAX = \frac{155}{183} \times 100 = 85\%$$

any of the five datasets. The FRST committee who worked on this analysis thoroughly debated, promoted, and criticized each of the recommended methods for quantitative and theoretical strengths, weaknesses, and statistical defensibility to gain consensus support for a single method that best served the overall goal and individual objectives of FRST.

A method named "MAX" was selected as the most appropriate method for calculating relative yield in the FRST decision tool. Using the MAX method, relative yield for each treatment is calculated as the mean yield of the treatment (e.g., control with no fertilizer K for a K fertilization trial) divided by the numerically highest mean yield of any treatment, which can be the control or a treatment receiving some rate of the nutrient of interest (Example 1). A relative yield of 100% or near 100 (>95%) indicates the nutrient of interest was not likely yield-limiting in that soil. As the relative yield value of the control treatment declines, the crop's responsiveness to fertilization in that soil increases. The relative yield calculation can be applied to all treatments in a trial and used to calibrate the fertilizer-nutrient rate that optimizes crop yield.

The MAX definition was selected for FRST because it represents the maximal fertilized yield for nutrient-responsive sites, is inclusive of data from trials for which only treatment means were reported as well as trials having a range in treatment numbers, allows for relative yield data transformation required for certain soil test correlation models, and is easy to implement on a large dataset.

For more detailed information on relative yield calculation selection, please see: Pearce, A. W., Slaton, N. A., Lyons, S. E., Bolster, C. H., Bruulsema, T. W., Grove, J. H., Jones, J. D., McGrath, J. M., Miguez, F. E., Nelson, N. O., Osmond, D. L., Parvej, M. R., Pena-Yewtukhiw, E. M., & Spargo, J. T. (2022). **Defining relative yield for soil test correlation and calibration trials in the fertilizer recommendation support tool**. Soil Science Society of America Journal, 00, 1–16. https://doi.org/10.1002/saj2.20450

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For more information visit soiltestfrst.org.

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