



The FRST national soil fertility database

By DJ McCauley

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The FRST National Soil Fertility Database, CSA News

- The Fertilizer Recommendation Support Tool (FRST) is a database and online tool in development to bring together soil fertility information on a national scale.
- A core team conducted the first nationwide soil fertility and philosophy survey since 1998 to develop minimum requirements for data inclusion in the database.
- The tool will not only help all those involved in making soil fertility recommendations but will conserve historical soil test data.

I work with farmers with land on both sides of the state line—in Arkansas and Louisiana,” says Nathan Slaton. “They might send a soil sample to a land grant

university in each state and get a different fertilizer recommendation from both. Then they send it to a private lab and get a third recommendation. The system can be very confusing for the end user.”



Source: United Soybean Board.

Slaton is the Assistant Director of the Arkansas Agricultural Experiment Station, a CCA, and a ASA, CSSA, and SSSA member; his research focuses on soil test correlation and calibration in Arkansas. He neatly points out the flaw at the heart of America’s soil fertility research that has been recognized for decades: fertilizer recommendations differ

across state lines, even when using the same soil-testing methods.

A recently published commentary in *Agricultural & Environmental Letters* lays out a plan for addressing this disparity in the form of a national database, the Fertilizer Recommendation Support Tool (FRST), that brings together soil test data from the lower 48 states (and Puerto Rico) in an easy-to-use online format (<https://doi.org/10.1002/ael2.20008>).

Deanna Osmond of North Carolina State University—the “backbone” of the whole operation, as Slaton describes her—has coordinated a stellar team in record time. Since 2018, Osmond, an ASA and SSSA member, along with the other members of the FRST core team—Nathan Slaton, John Spargo, Peter Kleinman, Josh McGrath, Sarah Lyons, and Dan Arthur—have put a four-part plan into action. Along with the help of more than 70 collaborators from 30 land grant universities, the Agricultural Research Service, the Natural Resources Conservation Service, and two not-for-profit organizations, the seven-member core team has made great strides toward

developing a nationwide soil-testing tool.

The Survey

In 1994, a researcher named Regis Voss collected soil fertility recommendation data on a national scale through a survey of land grant universities (see

<https://bit.ly/3OFH2WD>). That's the last time a national soil fertility survey was conducted.



Source: Adobe Stock/H_Ko

As a starting point for the project, the FRST team put together a questionnaire based on a recent survey conducted by SERA-6, a soil fertility group in the Southern region of the U.S. The team gathered input and feedback from colleagues all over the U.S., expanding the scope of the survey to include information relevant to other regions. ASA and SSSA member John Spargo, the Director of the Agricultural Analytical Services Lab at Penn State, coordinated this effort.

“We’re looking to collect objective information about how recommendations are made across the United States,” Spargo says. “We’re being really cognizant that some of the things we might think of as critical metrics in the Southeast might not be so important in the West, and vice versa.”

So far, survey participants include nutrient management and soil fertility faculty from 48 states.

The survey will help the team and their collaborators develop minimum dataset requirements—that is, a list of the variables the team will require for a dataset to be considered complete enough to enter as a part of the database. Submitted datasets will also be publishable; researchers can obtain a DOI for their work.

The team wants to ensure it collects the right soil fertility information to make the FRST decision support tool useful on a national scale.

The survey will also clarify how land grant universities are using fertilizer philosophies to make their recommendations. Though Spargo emphasizes that soil fertility tests often return similar phosphorus and potassium values—extractants and tests are well coordinated—the recommendations may still be very different based on philosophy.

“Sometimes the differences in [fertilizer] recommendations make sense, like where you have changes in climate, soil type, or cropping system,” Spargo says. “But too often, you just cross the state line and all of a sudden, a high soil test becomes a medium test, and the recommendations differ by a pretty large factor.”

Here, the team hopes that a better understanding of fertilizer philosophies held by land grant universities in different states across the U.S. will help them get to the heart of these differences in recommendations.

The Minimum Dataset

The database will integrate information from a certain subset of agricultural research: soil test correlation and calibration studies.

Correlation studies focus on identifying when nutrient concentrations in the soil reach a “critical” range. Once nutrients are added beyond that critical range, you will not see a crop response like increased yield. If nutrient concentrations are below the critical range, adding additional nutrients will inspire increased yield.



Source: USDA NRCS South Dakota.

Calibration studies, then, look at how much additional fertilizer is needed at varying ranges below that critical level. You can think of this like a curve where soil extremely low in nutrients requires much more fertilizer input while soil just below the critical range might require just a little fertilizer.

Usually shown as calibration curves, the team intends to use the data collected to create much more precise calibration curves with smaller windows of fertilizer recommendations for given soil test results to reach optimum yields.

The minimum dataset requirements, then, use the information gleaned from the nationwide survey to set basic rules for variables to include.

Moving forward, the team will use these requirements as guidelines for future soil test correlation and calibration studies and as minimum requirements for data inclusion in the database.

The Legacy Dataset

But for now, the team is reliant on the soil test data that already exists. It is for this reason that the biggest step forward in creating the FRST tool is collecting a healthy set of data points supplied by past research to create integrated soil test correlation datasets.

This mammoth task has fallen to a recent hire: ASA, CSSA, and SSSA member Sarah Lyons.

First, the team received a small USDA–NRCS Conservation Innovation Grant providing funding for FRST project team members to meet in person in 2017 to organize the project. In 2019, a USDA–ARS grant funded a full-time post-doc researcher. Sarah Lyons, fresh from a Ph.D. at Cornell University, was chosen for the job.

Lyons is tasked with collecting data from researchers across the United States, organizing it, and entering it into the nascent database. Plus, the team is saving valuable information that is at risk of being lost.

“A lot of folks in soil fertility that have developed these state-specific tests are retiring and moving out of the system,” Osmond says. “A lot of the time, their data leave with them. They have information in their own personal filing cabinets or in their heads that isn’t anywhere else. We wanted to capture all that information before it disappears forever.”



Photo by Kyle Spradley. © 2014–Curators of the University of Missouri.

Osmond has been contacting soil fertility researchers across the states, asking for that legacy data.

“Virginia Tech, for instance, had a bunch of dissertations with soil test correlation and calibration results that they didn’t know what to do with,” Lyons says. “Some of them went back as far as the 1920s—now we’re preserving some of that historical data.”

But one of the things that the team is combatting is data quality issues. Older papers often fail to mention key information, particularly in the methods section.

“They just kind of assume you knew what they were talking about. They might just say, ‘The field was tilled,’” Lyons says. “A modern paper would list the disc size, depth, and the distance between everything. That’s one thing we have to consider.”

This legacy dataset, curated by Lyons, will be the backbone of the FRST tool. By collecting as much information as they can about current soil tests, potassium, and phosphorus levels, the tool can then show relationships among location, soil type, fertilization, and yield outcomes for a certain crop.

Even though Lyons has a backlog of about 100 papers, by her estimation, to comb through for valuable data points, her enthusiasm is unflagging.

“We’ll never reach the point where we say we have enough,” Lyons says. “But we’re finally starting to build the database.”

Creating in the Cloud



Source: Design Pics Inc /Alamy Stock Photo.

Luckily, the team is not starting from scratch as they decide how to build an online fertilizer recommendation tool.

It’s following the lead of a team in Australia that put together a fertilizer decision-making tool, called “Making Better Fertilizer Decisions for Cropping Systems in Australia,” or BFDC for short (bfdc.com.au).

The core team learned a great deal from the Australian tool, which debuted in 2013—particularly about how it wanted to host the FRST tool.

“Right now, there’s nobody actively managing the BFDC database,” Lyons says. “It’s privately hosted and subject to fluctuations in funding. We wanted to make sure our database has staying power—we want this project to last beyond our little bit of funding and this core team.”

The FRST tool will be on AgCROS, hosted by USDA. Hosting the site through the USDA presents advantages, like connecting FRST to the National Agricultural Library, integrating NOAA weather information, linking NRCS soil series classifications, and housing data in the cloud.

Another core member, ASA and SSSA member Peter Kleinman of the USDA-ARS, has been instrumental in connecting land grant institution faculty with other individuals in the ARS, ensuring that everything comes together smoothly.

“We really value the contributions of the ARS in this project,” Osmond says. “We wouldn’t have made it nearly so far without their fantastic support.”

Once the tool is up and running, the team will open it up for data submissions from current researchers. The core team will moderate submissions and review data before it is added to the system.

The team sees FRST as a key tool for researchers, agronomists, consultants, and even private laboratories conducting soil fertility tests.

“Ideally, if you logged onto the site when it’s all done, you’ll choose your crop, nutrient of interest, soil analysis method, and region,”



Source: USACE photo by Tracy Robillard.

Lyons says. “Based on your inputs, the system could give you yield responses to fertilizer inputs and soil test values. You can then refine the output based on specific management practices.”

All of the members of the core team emphasized the objectivity and clarity that will come from having a comprehensive collection of soil fertility information.



Source: Adobe Stock/Dusan Kostic.

“As research scientists, we’re often trained to work very narrowly, and that means we often work in silos. Soil test correlation and calibration has been as siloed as almost any research activity,” Osmond says. “The importance of the database that then feeds into the FRST decision support tool is that it

allows us to get out of our silos and gives us much more power from our data. We’re taking small data and making it big data—we’ll have a much more powerful understanding.”

Though the tool will initially focus on potassium and phosphorus recommendations, the team is developing infrastructure that will allow expansion to other nutrients and crops as more data is added.

As Osmond neatly sums up: “With more data, we have more power of discernment.” The FRST tool will be a powerful resource, indeed.

Dig deeper

View the article, "FRST: A National Soil Testing Database to Improve Fertility Recommendations," in *Agricultural & Environmental Letters* (

<https://doi.org/10.1002/ael2.20008>). If you are interested in participating in this effort and/or submitting your soil fertility data for use in the database, please contact Deanna Osmond ([Send Message](#)). The team is looking for soil test correlation and calibration data from short-, intermediate-, and long-term trials.

Skye Brugler, Maaz Gardezi, Ali Dadkhah, Donna M. Rizzo, Asim Zia, Sharon A. Clay, Improving decision support systems with machine learning: Identifying barriers to adoption, *Agronomy Journal*, 10.1002/agj2.21432, **116**, 3, (1229–1236), (2023).

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