

Field Experience Validates On-The-Go Soil pH Sensor

By Bruce Erickson

The commercial introduction of an automated, on-the-go soil pH sensor signaled a new stage in site specific management. Veris Technologies held its first public field demonstration of the sensor at the Top Farmer Crop Workshop in July 2003, and sold the first units that fall. The system originates from several years of development research conducted in Purdue's Department of Agricultural and Biological Engineering. Prior to its introduction, soil testing meant collecting individual samples and sending them to a laboratory for analysis.

The Veris sensor adapts and automates lab technology for field use. In the lab, a soil sample is mixed with a specific amount of water, then an electrode is placed in the solution to read the pH. With the on-the-go sensor, a device scoops a small amount of soil, presses it against an electrode, waits for a moment for the electrode to stabilize, records the reading, and then rinses the mechanism to prepare for the next sample. The apparatus is mounted on a toolbar pulled by a pickup truck or small tractor. The sensor is marketed as the pH Manager option when purchasing the Mobile Sensor Platform (Figure 1), which includes the EC Surveyor 3150 to measure soil electrical conductivity.



Figure 1. Veris Mobile Sensor Platform (MSP) equipped with pH Manager.

Justification for On-the-Go Sensing

An on-the-go sensor greatly increases the capacity for measuring the variability that is inherent in all agricultural fields. In years past, it was recommended that soil samples be a composite from areas not exceeding 10 acres. Global positioning system (GPS) technology introduced in the 1990's brought the ability to more easily keep track of smaller sub-field areas, and 2.5 acre (1 hectare) grid sampling became common. But while geographic locations could be pinpointed, grid sampling still relied on labor-intensive manual sampling and laboratory analysis. And, in many fields there was nearly as much variability within the 2.5 acre grid cells as among them, raising questions about the utility of the grids in capturing actual field variability. As a result, adoption of grid soil sampling, and the variable rate liming and nutrient applications that depend on them, has been slow.

To demonstrate the concerns with resolution, consider the soil pH results from a 40-acre field near Ames, Iowa. A map created from an on-the-go sensor is shown in Figure 2, left. Results from the same field sampled in 2.5 acre grids are shown at right. As can be interpreted visually, the 2.5 acre grid was not detailed enough to capture the variability that existed in this field.

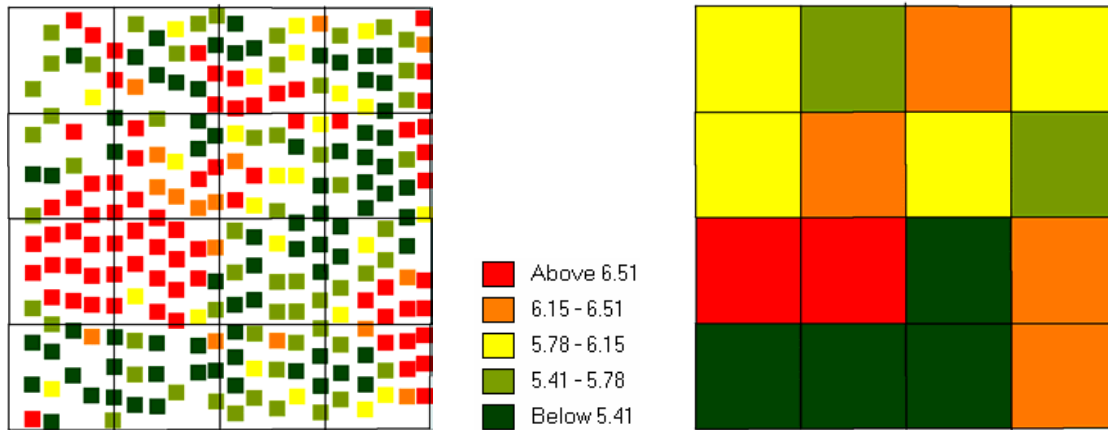


Figure 2. Left: Soil pH map of a 40-acre Iowa field created using the Veris MSP with pH Manager. Right: 2.5 acre grid sample map of the same field (Veris Technologies).

The automated sensor has the potential to solve the problems of sampling labor and expense and the number of sampling points in the field. If driven 6-8 mph in passes 60 feet apart, the sensor takes a reading about every 60 feet, or up to about ten per acre. With large open fields, one operator can cover up to 500 acres per day.

On-Farm Experience

Although just introduced last fall, Veris Technologies has numerous units working across the Midwest. Veris' Eric Lund estimates over 50,000 acres have been mapped, and some individual units have completed over 10,000 acres.

Daryl Starr, of Starr Farms in Fayette County, Indiana is a co-owner and operator of one of those units. He is a partner with Agri-Plan CFI, which contracts mainly through fertilizer dealers to provide field mapping services to growers. He's used the MSP with pH Manager on his own farms and on several thousand acres for clients in Indiana and Ohio. They operate at about 10 mph in 60 ft swaths, and usually can map 300-400 acres in a day, resulting in about six samples per acre. After they go through a field, they provide the grower and/or fertilizer dealer with a card that they can use to variable-rate apply lime on the mapped fields. Starr says that the pH readings from the MSP calibrate well with the soil samples that they routinely send to a lab for reference.

Purdue research has shown economic benefits for variable rate lime application in the eastern Corn Belt. On the variable soils in their area, Starr says that they can save 700 lb/A of lime by being more efficient in application. At a lime cost of \$20/T, this can quickly pay for the soil testing.

Limitations

One of the limitations of the on-the-go sensor is that it only measures active pH, not reserve acidity. In the lab, the standard pH test measures active pH and is accompanied by a simple additional test where a second reading is taken after a chemical buffer solution is added. The second reading is buffer pH, and gives a measure of the reserve acidity in the soil, which is important in determining how *much* lime to apply. Reserve acidity is related to soil texture and organic matter, which can also be measured on the go. Soil texture correlates well with electrical conductivity measurements (EC), and soil organic matter is directly related to soil color, which can be measured via infrared sensors. The lime rate that Starrs calculate for their customers is based on soil pH readings, soil electrical conductivity readings from the MSP, and their reference soil samples sent to a lab.

Future Work

With the successful introduction of an on-the-go soil pH sensor, the on-the-go detection of crop nutrients using similar technology will likely follow—scientists have seen the most promise with nitrate and potassium sensors. And besides the electrochemical and electrical conductivity technologies available on the Veris MSP, soil properties can be measured using a host of other sensor types, as shown in Table 1. In addition, the future may see more development of real-time systems—where the variability is sensed and the input applied accordingly in the same operation.

Table 1. On-the Go Soil Sensor Types and Applications

Sensor Type	Example Applications
Electrochemical	Soil pH, nitrate, potassium
Electrical and Electromagnetic	Soil texture (sand, silt, clay), soil moisture content, soil depth variability (depth of topsoil, depth to hardpan), cation exchange capacity
Optical and Radiometric	Soil organic matter, soil moisture
Acoustic and Pneumatic	Soil texture (sand, silt, clay), soil bulk density (compaction), soil depth variability (depth of topsoil, depth to hardpan)
Mechanical	Soil compaction, compacted soil layers

For More Information

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