Photographs: Rich Fee

Bob Streit, a crop consultant, used a dial penetrometer for years but recently switched to this digital type because it displays and records data in 1-inch increments.

Soil penetrometers

Probing for compaction

By Rich Fee
Crops and Soils Editor

Buying a soil penetrometer won't make you a soil scientist anymore than buying a telescope will make you an astronomer. But a soil penetrometer will give you a glimpse of what's going on in the ground just like a telescope will give you a glimpse of what's happening in the heavens.

The chart on the next page briefly describes four widely available soil penetrometers, also called soil compaction testers. Although they vary in design and price, each of them can help you get a better handle on soil conditions.

Also included is a sophisticated and much more expensive machine from Veris Technologies. It combines a soil penetrometer with a device that measures the electrical conductivity (EC) of the soil. (Under some circumstances, EC reveals information about the texture of a soil.)

This rig gives a glimpse of the future when it comes to exploring root zones. Most of these machines still belong to scientists, although some crop consultants have also used them.

Scientists were also the first people to use soil penetrometers, starting some 70 years ago. In recent years, farmers and crop consultants have been using them to check fields for tillage pans and wheel track compaction. Their goal is typically to correlate compaction, if any, with crop root growth and yields.

Bob Streit, an independent crop consultant from Boone, Iowa, has used a penetrometer for 20 years. It's kind of a second line of defense.

"If we see plant health problems, we know that a poor root system may be the basic problem," he says. "We find both deep and shallow compaction from machinery traffic. Field cultivator smear layers are very detectable. Long-ago livestock traffic also shows."

Standardized penetrometers

Most of the penetrometers used in agriculture meet American Society of Agricultural Engineers (ASAE) standards adopted in 1999. These penetrometers have a cone angle of 30º. That tip design was selected because it mimics crop roots.

Thanks to that standardization, it is easier to compare soil compaction readings from different fields, farms, and research projects. (Penetrometers used outside of ag meet different standards and have a 60º cone.)

Despite the standardization of ag penetrometers, it's still problematic to compare readings taken at different times and in different locations because of all the factors in play.

Peter Motavalli, a researcher in the Department of Soil, Environmental and Atmospheric Sciences at the University of Missouri, says, "Pen-

Soil penetrometers

Manufacturer	Specifications	Price
DICKEY-john Corporation Phone: 800/637-2952 GO agriculture.com/go/5707	The Dickey-john Soil Compaction tester features a stainless steel rod and a color-coded stainless steel dial, which is filled with liquid to reduce shock. It can be ordered through farm equipment dealers. Call the 800 number to find a dealer. It's also available through Shoup (800/627-6137) and Spectrum catalogs.	$206.00
ELE International LLC/SOILTEST Phone: 800/323-1242 GO agriculture.com/go/5708	SOILTEST makes a Proving Ring Penetrometer, which is a 30° cone penetrometer. It features a brake-type dial that holds the final reading until manually released. Its capacity is 250 pounds. Order by phone or through their online catalog. If ordering through the catalog, go to the Soil Classification section.	$716.00
Spectrum Technologies Phone: 800/248-8873 GO agriculture.com/go/5709	Spectrum's Field Scout SC-900 is a digital penetrometer. Data is recorded and displayed at 1-inch intervals in psi or kPa. It has a built-in data logger.	$1,495.00
	Spectrum also makes an economy model, which is an analog penetrometer. It has an ASAE standard cone. Both can be ordered through the Spectrum catalog.	$178.50
Veris Technologies Phone: 785/825-1978 GO agriculture.com/go/5710	The Veris Profiler 3000 is a penetrometer and soil electrical conductivity (EC) probe in one unit. This trailer-mounted unit also has its own power source, cabling, and data-logging instrument. Although a few consultants have purchased these since they were introduced in 1999, most are in the hands of researchers.	$14,000.00

GO LINKS save clicks by taking you directly to the intended product page, rather than the site's home page.

etrometers have always been difficult to use because there are several factors that will affect a penetrometer reading – particularly soil water content and soil texture. Consequently, there's often a lot of spatial variability.

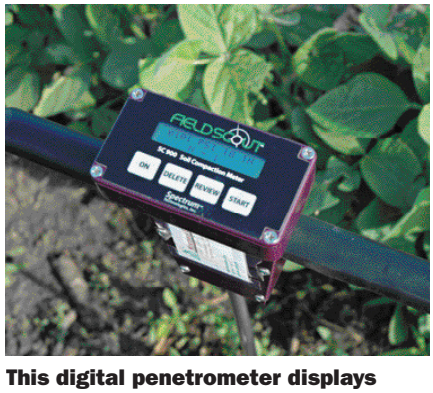
Nevertheless, Motavalli thinks it's beneficial for farmers to use soil penetrometers. "But you have to be mindful of the factors that are affecting the penetrometer," he cautions.

There is general agreement that the best time to use a soil penetrometer is when the entire soil profile is at field capacity for moisture. In many areas, that's most apt to occur in the spring.

Ohio State University ag engineer Randall Reeder agrees that soil moisture is critical. "If it is dry, you won't get good readings," he says. "And if it is muddy, you won't get good readings. The penetration resistance varies with soil moisture.

"In Ohio, it's frequently too wet at planting," he adds. "The best time is often after planting when soil moisture has had some time to stabilize."

Motavalli cautions against comparing different areas of a field that have different moisture levels. "If there's a difference in water content, that could give a false impression that there is compaction in one area compared to the other area.



This digital penetrometer displays readings in 1-inch increments.

"The best thing is to wait for rainfall, then wait a couple more days until everything is on the same basis, at field capacity," he adds. "Then I think you can make some useful comparisons between one area and another."

Penetrometers are being developed that also take soil moisture readings. There's even one that has a porthole through which pictures are taken.

There's a knack to operating a soil penetrometer, and different operators will get different results.

"If you go out there and push it in the ground and I go out there and push it in the ground, we might get a different impression," says Motavalli.

Thus, uniformity of pressure is one advantage of the more expensive hydraulic systems mounted on vehicles. ☛

Penetrometers

Another thing to keep in mind is that there is a lot of variation in many fields. "I could take a penetrometer reading in one place, then move over a foot and get an entirely different reading, says Motavalli. "So, the more sampling points you take and compare, the better."

Eric Lund of Veris Technologies agrees. "You need to collect lots of points to really understand the subsurface," he says. "Consider whether you hit a worm hole, a traffic lane, or where a shank ran."

Veris has a machine that, unlike the machine in the table, only takes EC readings as it is pulled across a field without stopping. Lund says one approach is to get an EC map and use it to help select areas to test with a penetrometer. He suggests taking several readings close together across the entire width of a machine operation.

Rock fragments in a field are another thing that can alter readings.

Motavalli reiterates that the main thing to do when looking for tillage pans is to make sure the reading you are getting isn't being influenced by soil moisture and texture. "If you are probing for a tillage pan, you might just be hitting a layer that is drier and feels like it is really dense," he says.

If he suspects compaction, Bob Streit will usually pull up a root and examine it. Frequently, his next step is to take penetrometer readings.

Rating resistance

Soil penetrometers give readings in either psi (pounds per square inch) or kPa (kilopascal). In USDA-ARS studies, root growth or penetration into soil cores that had been packed to different densities were measured and compared to soil penetrometer readings. Very few roots penetrated soil with penetration resistance of 300 psi or greater. Much of that research was done with cotton, but that figure seems to hold for other crops as well. (There is some research that indicates roots can grow under more compaction.)

Motavalli studies compaction as it relates to nitrogen (N) usage. There are three factors involved, he says. "One, compaction compromises root development to such an extent that the roots don't grow sufficiently to utilize the nitrogen. Two, compaction reduces soil water movement and availability, thereby reducing N transport to the plant. Three, there is greater potential for N to be lost due to compaction."

Motavalli thinks eventually the slow process of using hand-held penetrometers will be replaced by "sensor-based, on-the-go technology that will allow for mapping." In the meantime, we can all keep pushing. SF

Unlike these healthy roots, ones growing in a compacted area are often twisted or thin and flattened.

This soybean root was growing straight down, so it is doubtful that soil compaction was a problem.