How Reliable is Soil Testing?

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Who hasn't heard the phrase "Don't guess, soil test!", or listened to a speaker tout the importance of soil testing prior to planning out a fertility program? But the truth is a soil test is only as good as the method used and the research data supporting it. And unfortunately, the methods are not always appropriate and the data behind the soil test interpretations is thin or non-existent. But soil testing can be an effective part of your fertilizer program when used properly. In this article we'll cover the most common soil testing mistakes and how to avoid them.

One of my favorite quotes on soil testing comes from O.J. Noer's book The ABC of Turfgrass Culture (1928). O.J. worked under Emil Truog, a Soil Science Professor at the University of Wisconsin who pioneered soil testing as we know it today. So as a turfgrass agronomist with at great deal of technical knowledge about soil testing, O.J. said:

"There is a tendency to place undue emphasis upon the value of chemical soil tests. This is true of some technical workers as well as salesmen. These methods have a promising future but their present usefulness is limited by imperfect [methods] and for a lack of definite correlation with field experience."

Although this was written 85 years ago, many aspects of this quote still ring true. We'll go through the three highlighted parts individually and I'll try to explain their continued relevance to our situation today.

"Imperfect Methods"

Soil testing is a relatively straight forward practice. You collect some soil, you send it to a laboratory. The laboratory dries and grinds the soil, then takes a pinch and adds a half ounce or so of a chemical extractant and shakes the soil/liquid solution for a few minutes. Next, the solution is poured through a filter and the clear solution is analyzed for the nutrients in the soil. The chemical extractant is usually some sort of acid (ph < 7) combined with salt. The acid is used to extract the plant available phosphorus, while the salt is used to measure the exchangeable cations like potassium, calcium, and magnesium.

For acidic soils, commonly used extractants include the Bray-1 and the Mehlich-3. For high pH soils, the Olsen extraction is a good choice. Often, soil testing labs will use several different extractants on the same soil. For example, they may use the Bray-1 for phosphorus and ammonium acetate for potassium and other cations. Soil testing laboratories usually use the tests that are most appropriate for the soils in their region, so if you are sending samples across the country it makes sense to make sure the proper extractant is being used on your soils. Table 1 gives some general guidelines, although exceptions may apply. Some soil test reports do not list the extractant that was used. In that case, simply call the laboratory and ask. You'll notice that Mehlich-3 shows up in every category in Table 1. While Mehlich-3 may not be the best test for all situations, it is regarded by many as the most versatile extractant and it's the one we have the most calibration data for here in Wisconsin, with the Bray coming in a close second.

Assuming the correct extractant is chosen, there is another important but overlooked step in getting good results: pulling the sample properly. Nutrients aren't uniformly distributed in the soil like they are in agricultural fields. Because we usually apply fertilizers to the soil surface and do not till them in, over time certain nutrients, especially phosphorus, accumulate near the surface and are at lower levels deeper in the soil. This means that that the deeper you push the probe into the soil, the lower your soil phosphorus levels will appear. I have fielded many phone calls where the manager explained that the soil phosphorous levels rose rapidly from one year to the next, even though the manager applied no phosphorus fertilizer. This could be attributed to a shallower testing depth than the year before. For this reason, it is critical to maintain a consistent sampling depth over the years. Use a sharp tool to score a line on the probe at your desired testing depth - I recommend something between 10 and 15 cm – and make sure you use a consistent sampling depth from year to year.

Table 1. General guidelines for appropriate soil tests for low and high pH soils.

Nutrient	High pH Soils (>7)	Low pH Soils (<7)
Phosphorus	Olsen, Mehlich-3	Bray-1, Bray-2, Mehlich-1, Mehlich-3, Morgan, Modified Morgan
Potassium, Calcium, Magnesium, Sodium	Buffered ammonium acetate (pH=8.5), Mehlich-3	Neutral ammonium acetate (pH=7), Mehlich-3
Micronutrients	DTPA, Mehlich-3	DTPA, Mehlich-3

"Lack of definite correlation with field experience"

In general, soil test reports do not offer a user-friendly experience. In fact, most people understandably skip the details and decimal points and go straight to the section where says either low, optimum, or excessive. The often overlooked question, however, is how was the assessment of low, optimum, or excessive developed? Soil test data are specific to a crop type and a soil type. That means the "optimum" number for corn on a Batavia silt loam will be different from that of corn on a Miami silt loam. Or, the "optimum" level for soybeans on a Batavia silt loam will differ from that of corn on the same soil. That means that we need to run a whole bunch of studies for each crop type and each soil type to have reliable data. Much of this work has been done in agriculture because of the economic significance of food production. But soil testing research for turfgrass is hard to find. The little work that has been done is only specific for a particular grass species (or even variety), and the soil type that is was growing on. For example, we ran the study shown in Figure 1 to show that for a high pH sand root zone with 'A4' creeping bentgrass the optimum Mehlich-3 phosphorus is above 7 ppm. Under no circumstances could I assume that 7 ppm would be ideal for a loam soil growing Kentucky bluegrass. We'd need to run another study for that number which we haven't done yet. So, to get around this issue, we take the data we have (in this case 7 ppm) and round it up for safety. At the Wisconsin state soil testing laboratory, any Mehlich-3 soil test less than 25 ppm will say "low" – even though the true definition of "low" is probably much lower.

In essence, I suppose you could say most soil test interpretations for turfgrass are simply educated guesses. If you sent the same soil sample to six different labs, chances are you'd get at least three different interpretations. Now you can fully appreciate the irony embedded in the phrase "Don't guess, soil test". Turfgrass researchers continue to improve the soil testing recommendations, but that type of research is time consuming and expensive. It is also worth noting that every time a researcher conducts one of these studies, they tend to find that the levels required are lower than what we previously thought – meaning that "low potassium" you got on your last soil test report might be optimum down the road.

"Undue Emphasis"

Without understanding all the limitations that we just covered, it's easy to see how one could get carried away by attempting to find the "ideal" level of every nutrient in the soil. One common over-interpretation is when soil test reports recommend balancing the soil cations using the base cation saturation ratio or BCSR. BCSR-style interpretations use the same methods as described above, but recommend that the soil cations (calcium, magnesium, and potassium) are balanced in an "ideal" ratio. Unfortunately, after years of research we still have no evidence that this approach works, but we do know that someone who follows this approach ends up spending a lot more money . (1)

To avoid over-interpretation or relying solely on your laboratory's (or consultant's) interpretations of your soil-testing results, I recommend you compare your results with PACE Turf's Minimum Level for Sustainable Nutrition guidelines which can be found here: www.paceturf.org/PTRI/Documents/1202_ref.pdf.

Instead of drawing their interpretations from a single study, these minimum levels are based on a very large database of soil testing results where the turf was deemed to be performing average or above average (all soil samples from poor performing turf were thrown out).

The "minimum level" was set at the lower one-third of the dataset.(2) That means about 33% of the soil samples with good turf had soil test levels (for potassium or phosphorus, etc.) below that minimum level. While you could argue this remains a conservative approach, the minimum levels published by PACE are drastically lower than many traditional soil test interpretations, and likely more accurate.

In conclusion, soil testing can be useful for fertilizer planning, but is far from a perfect system. More research is required to continue to defining and re-defining optimum soil test levels for the multitude of soil types and grass varieties. While our soil testing methods have come a long way in the last 85 years, there is still a tendency to place undue emphasis on the value of soil testing.

For best results:

1. Make sure you have a consistent depth when you pull your soil samples.
2. Send your samples to the same reputable laboratory year after year, and ensure they are using a proper extractant based on your soil pH.
3. Don't over interpret your soil test results. Avoid balancing cations and double check the laboratory or consultant's recommendations with the PACE Turf's MLSN Guidelines before making decisions on corrective action.

"Notes"

(1) For an extensive summary of this research, check out "A review of the use of the basic cation saturation ratio and the 'ideal' soil" by Drs. Peter Kopittke and Neal Menzies in the March/April 2007 edition of the *Soil Science Society of America Journal.*

(2) It's actually a bit more complicated than this, and you can read more here: http://www.plantmanagementnetwork.org/pub/ats/proceedings/2013/rootzones/8.htm

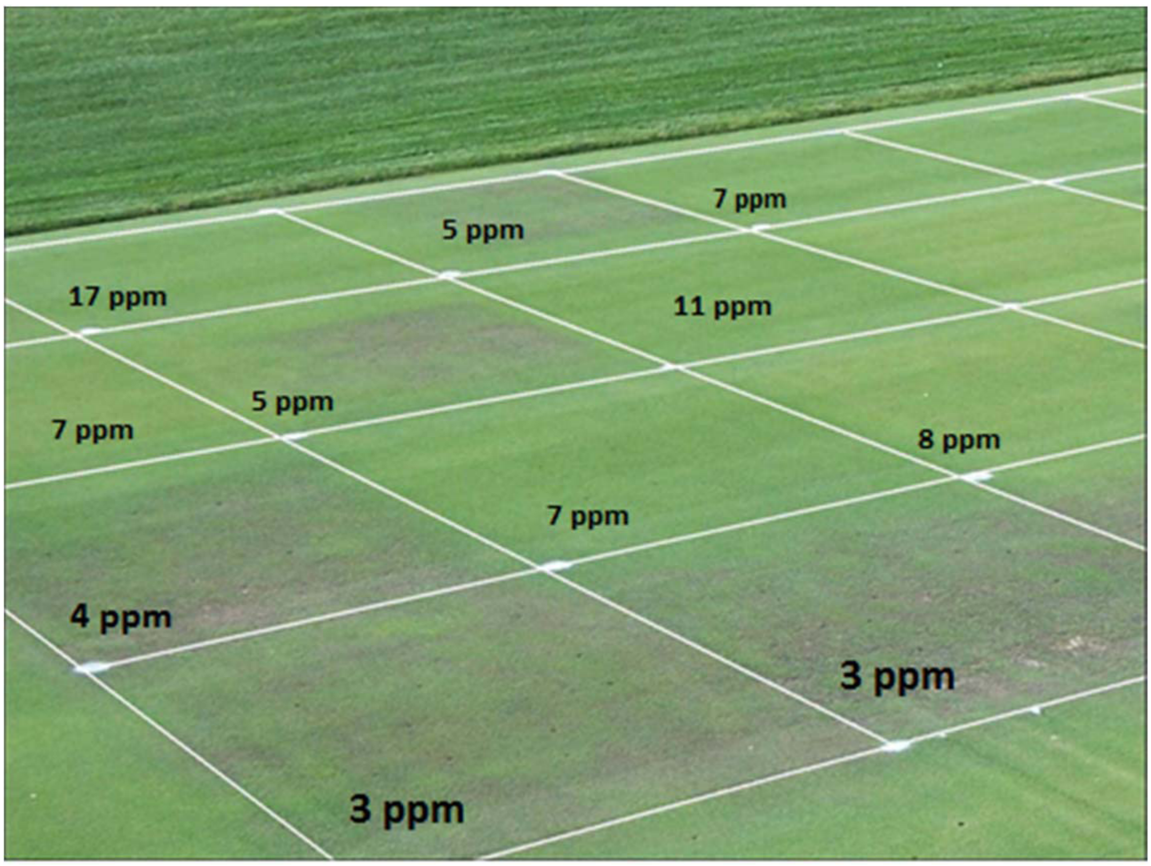

Figure 1. Phosphorus deficiency of creeping bentgrass on a high pH sand based root zone. Deficiency symptoms disappear above 5 ppm Mehlich-3 extractable soil phosphorus.