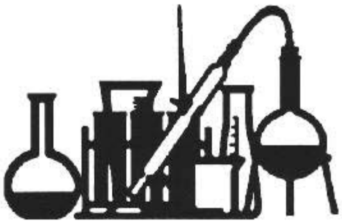

Mining Your Soil Test Reports

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Golf course superintendents' views about soil testing seem to vary widely. Attitudes range from "it's a waste of time and money" to "it's a valuable tool that tells me how I'm doing with my fertilization program". Others turn to soil testing only when they have a problem that they feel may be nutritional in origin.

This article is directed toward those superintendents who do a soil test every few years. If you are one of these and you have kept reasonably accurate records of grades and rates of fertilizer applied, you're sitting on some valuable management information. My purpose here is to show you or your energetic young assistant how to "mine" this information out of your records.

To be more specific, what you need are at least two sets of soil test reports for samples taken at least five years apart and the test results must be from the same soil testing lab or from labs that use the same testing procedures. Different labs often use different procedures and, therefore, get different test results. While two different labs may give quite similar soil test interpretations, the numbers they provide are often quite different. In mining soil test reports we have to be working with all apples or all oranges, not a mix of the two. This, to me, is the strongest argument for not jumping from one soil testing service to another.

The starting point in the mining process is to tabulate your soil test results in a form that gives you a comprehensive picture of where your soil tests are headed and where you stand at the present time. These tabulations are also needed later on in the mining process. Several tabulations are needed. First, the actual soil test results have to be separated out by location (putting green, tee, or fairway) and type of test. An example of such a tabulation for soil test P in the greens of a Madison area golf course is show in Table 1.

Table 1.

Putting green soil test P levels

Green	Soil test P-lb/A		
	1972	1977	1990
1	300	120	-
2	300	300	400
3	90	135	310
4	350	260	400
5	400	400	400
6	250	200	205
7	300	275	400
8	375	400	400
9	160	115	210
10	350	375	360
11	350	120	375
12	400	320	400
13	400	400	350
14	240	185	245
15	250	260	350
16	375	300	360
17	375	325	400
18	46	60	250

The same type of tabulations should be assembled for the soil test interpretations (Table 2). Proper "reading" of such a table requires understanding of what the interpretations really mean. "Very low" or "low" interpretations signify that corrective action should be taken as soon as practical. The supply of this nutrient is so low that it is limiting turfgrass growth and development. A "medium" interpretation says that there is about a 50-50 chance that the turfgrass will respond to a heavier application of the nutrient. Categories such as "normal, high, sufficient or adequate" all have the same meaning—increasing the soil supply of the nutrient cannot be expected to have an influence on turfgrass growth or quality. Then there are the "very high" and "excessive" interpretations. These should be viewed as red flags. They signify potential problems with nutrient imbalances within the turfgrass or, in the case of micronutrients, of outright toxicity. These interpretations also serve as warning of possibly high leaching losses and potential damage to the surrounding environment. Your response to these extremely high soil test values could be as radical as suspending application of the nutrient in question until such time that the tests have decline to "normal, high, sufficient or adequate" levels.

Table 2.

Putting green soil test P interpretations

Green	Interpretations*		
	1972	1977	1990
1	M	N	-
2	H	H	E
3	N	N	E
4	E	H	E
5	E	E	E
6	H	H	H
7	H	H	E
8	E	E	E
9	H	N	H
10	E	E	E
11	E	N	E
12	E	E	E
13	E	E	E
14	H	H	H
15	H	H	E
16	E	H	E
17	E	E	E
18	L	L	H

* L = low; N = normal; H = high; E = excessive

It is against the backdrop of what soil test interpretations signify that the information in Table 2 becomes truly meaningful. The indications are that application of P could be

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suspended in green # 1,2,3,4,6,7,8,10,11,12,13,15,16 and 17 and possibly in the rest of the greens as well! If you're a conservative Republican rather than a liberal Democrat, stay with me and I'll show you how you can gently let your very high or excessive soil tests slide down to more reasonable values.

In looking at the soil tests in Table 1 and their interpretations in Table 2, there is something else you need to be aware of. Note that in Table 1 there are a lot of soil test vales of 400 lb P/A, but none higher. There is a good reason for this. Soil test procedures are such that there is a maximum amount that can be detected without modifying the procedure. In the present case that amount for P is 400 lb/A. In actual fact, some of the greens represented in the tables may have 600 lb. P/A or more! If you're encountering increasing problems with weeds and algae in your pond or ponds and soil test P levels on the golf course are frequently excessive, there is a very good chance that the two are directly related.

The next step in mining your soil test reports is where time, patience and a calculator come into play. What we need to know is how much phosphate and potash have been applied during the period of time between soil tests. If your fertilization records show actual rates of fertilizer applied and the grade (information you have to have in any case), the calculation of the rates of P_2O_5 and K_2O applied is easy. You merely multiply the fertilizer rate by the percent P_2O_5 or K_2O in the fertilizer. Most of the time, however, what gets recorded is the rate of N applied. In this case, the calculations are a bit more complex. What you have to do is multiply the rate of N applied by the ratio of percent P_2O_5 or K_2O in the fertilizer to the percent of N. To give you an example, assume we've applied 0.5 lb N/M as an 18-3-12 fertilizer. The amount of P_2O_5 applied was (0.5 lb N) 3 ÷ P_2O_5/18 ÷ N) or 0.08 lb/M. Likewise, the amount of K_2O applied was (0.5 lb N) (12 ÷ K_2O/ 18 ÷ N) = 0.33 lb/M.

Table 3.

Nitrogen, phosphate and potash applied to putting greens in 1980.

Fertilizer grade	N Rate	P_2O_5 Applied	K_2O_5 Applied
18-5-5	0.45	0.12	0.12
20-26-6	0.72	0.94	0.22
18-5-5	0.45	0.12	0.12
6-2-0	1.00	0.33	0
18-5-5	0.45	0.12	0.12
18-5-5	0.45	0.12	0.12
0-0-50	0	0	3.00
22-0-16	0.45	0	0.33
18-5-5	0.45	0.12	0.12
24-5-3	0.50	0.10	0.06

What these calculations lead to is many tables, each one showing how much P_2O_5 or K_2O was applied in a single season to your greens, tees or fairways. An example of such a tabulation is shown in Table 3. If you've been fertilizing different greens, tees and fairways differently, then you'll wind up with that many more tables. Having assembled these year-by-year P_2O_5 and K_2O application tables, you then need to calculate the total amounts applied for the time interval between soil samplings and the average amounts applied per season over this time interval. The P_2O_5 totals and averages for the putting green soil tests being used here as an example are shown in Table 4.

Table 4.

Phosphate applied to putting greens between soil tests.

Green	1973 to 1977 Total P_2O_5	1973 to 1977 Ave/yr	1978 to 1990 Total P_2O_5	1978 to 1990 Ave/yr
1	3.68	0.74	18.70	1.44
2	3.68	0.74	19.38	1.49
3	4.62	0.92	22.06	1.70
4	4.62	0.92	20.51	1.58
5	3.68	0.74	19.51	1.50
6	3.68	0.74	18.70	1.44
7	4.62	0.92	21.93	1.69
8	3.68	0.74	18.90	1.45
9	4.62	0.92	21.93	1.69
10	3.68	0.74	18.70	1.44
11	3.68	0.74	18.82	1.45
12	3.68	0.74	19.38	1.49
13	3.68	0.74	18.92	1.46
14	4.62	0.92	22.06	1.70
15	3.68	0.74	18.92	1.46
16	3.68	0.74	18.70	1.44
17	3.68	0.74	18.70	1.44
18	5.05	1.01	21.71	1.67

Now we need to work with Tables 1 and 4 to tabulate the annual average changes in soil test P that occurred between samplings and the average annual amounts of phosphate applied over the same time intervals. These tabulations are shown in Table 5. Note the many blank spots. These are where at least one of the pairs of soil test values involved a test of 400 lb P/A. We cannot use these values because they are soil test procedure maximums and the actual amounts of P that were present are unknown.

The next step is to place the data in Table 5 in graphical form. As shown in Figure 1, soil test change per year is plotted on the vertical axis and annual average P_2O_5 rate on the horizontal axis. Graphing the data is important for two reasons. One is to give us a visual image of the data that quickly shows whether or not we have some "oddball" data points. As indicated by the two arrows, we do have two strange looking data points. When this happens we have to decide whether to use these points or not. In this particular case, I feel we're justified in not using those two points. These points are from greens #1 and 11. I strongly suspect that the two greens were reconstructed sometime between 1973 and 1977. What this would do is invalidate the 1972 soil test results and give us a new starting point in soil test P that was much lower than the values of 300 to 350 lb P/A found in 1972.

Table 5.

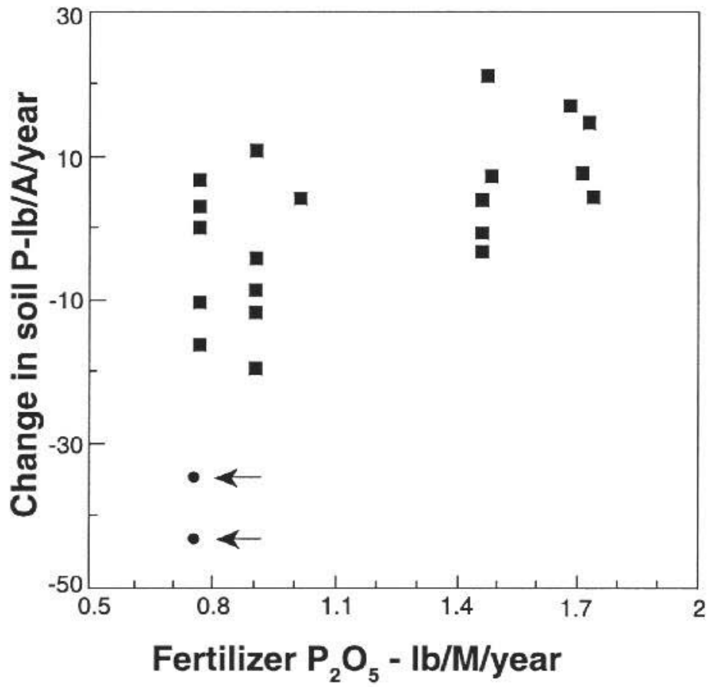
Changes in putting green soil P levels and the average amounts of phosphate per year.

Putting Green	Soil P change/year 1973/77	1978/90	P_2O_5 applied/year 1973/77	1978/90
	lb/A		lb/M	
1	-36.0		0.74	
2	0		0.74	
3	9.0	13.5	0.92	1.70
4	-18.0		0.92	
5				
6	-10.0	0.4	0.74	1.44
7	- 5.0		0.92	
8				
9	- 9.0	7.3	0.92	1.69
10	5.0	-1.2	0.74	1.69
11	-46.0	19.6	0.74	1.45
12				
13				
14	-11.0	4.6	0.92	1.70
15	2.0	6.9	0.74	1.46
16	-15.0	4.6	0.74	1.44
17	-10.0		0.74	
18	2.8	14.6	1.01	1.67

Having prepared the graph shown in Figure 1 and having eliminated the two oddball data points, we now want to draw a line through the remaining points. Here's where it really helps to have a friend that knows the procedure and has a computer with which he can use regression analysis to calculate the mathematical equation for the line we need. You can, however, determine this line yourself with the degree of accuracy needed here. The process is as follows. In looking at Figure 1, you'll notice that there are several data points associated with each of several P_2O_5 application rates. For example, there are 5 data points associated with the P_2O_5 rate of 0.74 lb/M/year. Multiple points are also associated with P_2O_5 rates of 0.92, 1.44 to 1.46 and 1.67 to 1.70 lb/M/year. What you want to do is average the data points associated with each of these P_2O_5 rates and graph the resulting averages. Doing so leads to the graph shown in Figure 2. With only four data points, it's a relatively simple matter to use the old eyeball method to draw a straight line through the points. Note that the scale on the vertical line is such that we can see where this axis is intersected when the P_2O_5 application rate is zero. It is essential that we do this.

Even without going any further in our "mining" process, the graph in Figure 2 gives us a valuable piece of information. Note where the line crosses the point on the vertical axis where there is no (zero) change in soil test P. As shown, if we extend a line straight down from this point to the horizontal axis, this intersects at a P_2O_5 rate of about 1.15 lb/M/year. What this value represents is the annual P_2O_5 application rate needed for these greens to maintain soil P at a constant level. In other words, this is the so-called maintenance P_2O_5 rate for this particular set of putting greens. It is a "customized" phosphate recommendation for this golf course that may or may not apply to other courses.

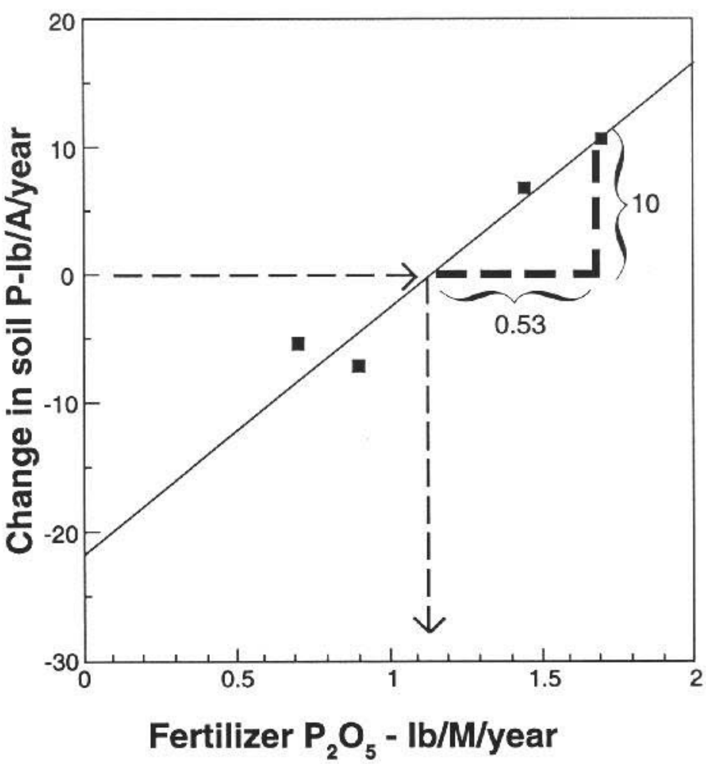
Figure 1.



Annual changes in soil test P vs. P_2O_5 applied.

The line in Figure 2 can also do something else for us. What this line does is define the relationship between the annual change in soil test P and the annual rate of P_2O_5 application. To make this relationship really useful, we need to express it in mathematical terms. We already have part of this mathematical relationship. It is the change in soil test P when no fertilizer is applied. In short, it is where the line in Figure 2 crosses the vertical axis. For Figure 2 that value is -21.5 lb P/M/year. The other number we need for our mathematical relationship is the slope of the line. To get this, we note in Figure 2 the change in soil test P resulting from a certain change in the rate of P_2O_5 applied. We can use any part of the line in Figure 2 to do this. I arbitrarily chose a segment that could be indicated without conflicting with other lines drawn on the graph. Note in Figure 2 that I came up with a 10 lb change in soil test P for a 0.53 difference in our P_2O_5 application rate. The slope of the line in Figure 2 is the ratio of these two numbers, i.e., 10 lb soil P/0.53 lb P_2O_5 Dividing, we get an 18.9 lb change in soil test P/A/year per 1.0 lb application of P_2O_5/M/year. Finally, we can assemble the mathematical relationship between the change in soil test P and rate of fertilization. The equation, in all its glory is: Soil P change in lb/A/year = -21.5 + (18.9)(lb P_2O_5/M/year).

Figure 2.



Average annual changes in soil P vs. P_2O_5 applied.

This equation is a powerful management tool. Let me illustrate its use. Going back to Table 2, we note that all of the soil test P values are "high" or "excessive" and should be reduced. Let's set as our goal soil P levels around 150 lb P/M. Looking at green #3, we see that it currently contains 310 lb P/A. Thus, we want to reduce the P level by 310 minus 150 or 160 lb/A. First we'll take the Republican approach and bring about the change gradually. In other words, we're going to continue to apply some fertilizer phosphate each year. We know already that if we apply 1.15 lb P_2O_5/M/year we will maintain the 310 lb soil test. So, let's reduce the annual application rate to 0.75 lb P_2O_5/M/year. How fast will the soil test decrease? Our magical equation holds the answer. Simply insert 0.75 lb P_2O_5 and solve the equation like so: soil P change = -21.5 + (18.9)(0.75 lb P_2O_5) = -21.5 + 14.2 = -7.3 lb P/A/year. In this case the time required to reduce soil P in this green from 310 to 150 lb/A would be 160 lb/7.3 lb/year = 21.9 years! A good Democrat would go the more liberal route, not apply any fertilizer phosphate for awhile, and bring about the same change in 160/21.5 or about 7.4 years.

We can also use our equation to tell us how much fertilizer is needed to adjust a new putting green to an optimum soil P level of 150 lb/A. Just a note of caution before we do so. This calculation assumes that the rootzone mix going into the new green is the same as in the existing greens. To come up with this fertilizer requirement, we have to know the P status of the rootzone mix. I've analyzed a commercial mix that's being used in the state and found 35 lb P/A, so let's use that number. To bring this up to 150 lb P/A requires an increase in the P test of 115 lb/A. The amount of P_2O_5 required can be estimated by plugging this number into our equation and solving for the P_2O_5 needed. The calculation is as follows:

$$\begin{aligned} 115 \text{ lb P/A} &= -21.5 + (18.9)(\text{lb } P_2O_5\text{/M}) \\ (115 + 21.5) &= (18.9)(\text{lb } P_2O_5\text{/M}) \\ 136.5 &= (18.9)(\text{lb } P_2O_5\text{/M}) \\ 136.5/18.9 &= 7.2 \text{ lb } P_2O_5\text{/M} \end{aligned}$$

Maybe you don't want to apply this all at once. Let's split it up into five equal annual applications of 7.2/5 = 1.26 lb P_2O_5/M/year. This is fine, but you have to keep in mind that to maintain the P level each year you also have to apply 1.15 lb/M of maintenance P_2O_5. Thus, what you really need to apply each year for five consecutive years is 1.26 + 1.15, or 2.4 lb P_2O_5/M/year.

What I've illustrated here is the process for mining some unique information from your soil test reports and fertilization records. We looked at just P for putting greens. You'll want to do the same for K in your greens and for P and K in your tees and fairways. Doing so will bring you out of the dark as to where you're headed with your present fertilization program and give you the means to exercise unprecedented control over your soil P and K levels. Is it worth the effort? Only you can answer that question.