Interpreting Soil Sample Results

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I always encourage farmers to do an annual soil test. Pick a time of year to test, and a lab, and do it every year at that time with that lab. Only by using the same lab at the same time of year can you start to be able to see changes in your results over time. Base your fertility applications on the soil test. For a good general resource on fertility needs of vegetable crops consult Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota from the U of M, this whole publication is valuable and you should read it all, but this article will provide you with some real-life application and that can be your reference book.

I think sometimes that when people take soil tests, they get back the results and put them in a drawer and forget about them. How do you turn your soil test results into actionable practices on your farm? If you google 'Interpreting soil test results' you get a webpage from every land-grant university that starts out by saying how complicated and confusing soil test results are and then they proceed to go on for twenty paragraphs in a complicated and confusing way. This is like asking the doctor to explain the numbers on your blood test, most of us just don't have the underlying science background to follow some of the explanations. But, you do have something soil scientists don't have, and that's experience growing crops in your soil, on your farm.

There are a lot of soil labs, and you need to find one you like and stay with them, that way you can compare numbers from year to year. I've been using Midwest Laboratries in Omaha for almost 20 years. I do their S3C test, which costs $26 plus shipping. I like it because I get more information for my $$ than a sample that I would send to the U of M. Midwest also has good resources like their Agronomy Handbook, which has some great information. I also don't like results with graphs and charts, I prefer numbers. The numbers generally come in one of two units: parts per million (ppm) or pounds per acre (lbs/ac). Interestingly, it's easy to convert between these two, double the ppm to get lbs/ac, or divide lbs/ac by two to get ppm. For example, 100 lbs/ac of nitrogen is the same as 50 ppm. Once you choose a lab, and do your first sample, start a spreadsheet so that you can plug in your numbers each year and see how it changes over time.

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IDENTIFICATION **TGA HIGH TUNNELS 3617**

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SOIL ANALYSIS REPORT

INFO SHEET: 890764

LAB NUMBER *311*	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I. percent	RATE	PHOSPHORUS P1 (WEAK BRAY) 1:7 ppm	RATE	PHOSPHORUS P2 (STRONG BRAY) 1:7 ppm	RATE	PHOSPHORUS OLSEN BICARBONATE P ppm	RATE	POTASSIUM K ppm (NEUTRAL AMMONIUM ACETATE (EXCHANGEABLE))	RATE	MAGNESIUM Mg ppm	RATE	CALCIUM Ca ppm	RATE	SODIUM Na ppm	RATE	pH SOIL pH 1:1	pH BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
39517	TGA-HT1	4.2	H	144	VH	145	VH			839	VH	477	VH	2165	M	84	M	8.0		17.3	12.4	23.0	62.5	0.0	2.1
39518	TGA-HT2	4.0	H	101	VH	112	VH			544	VH	449	VH	2211	M	59		8.0		16.4	8.5	22.8	67.1	0.0	1.6

LAB NUMBER *311*	NITRATE-N (FIA) SURFACE ppm	SURFACE lbs/A	SURFACE depth (in)	SUBSOIL 1 ppm	SUBSOIL 1 lbs/A	SUBSOIL 1 depth (in)	SUBSOIL 2 ppm	SUBSOIL 2 lbs/A	SUBSOIL 2 depth (in)	Total lbs/A	SULFUR S ICAP ppm	RATE	ZINC Zn DTPA ppm	RATE	MANGANESE Mn DTPA ppm	RATE	IRON Fe DTPA ppm	RATE	COPPER Cu DTPA ppm	RATE	BORON B SORB. DTPA ppm	RATE	EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm	RATE
39517	30	54	0-6							54	37	VH	14.8	VH	7	L	48	VH	2.3	VH	1.4	H	L	0.6	L
39518	14	25	0-6							25	32	VH	10.8	VH	7	L	43	VH	2.7	VH	1.3	H	L	0.4	L

REV. 12/03

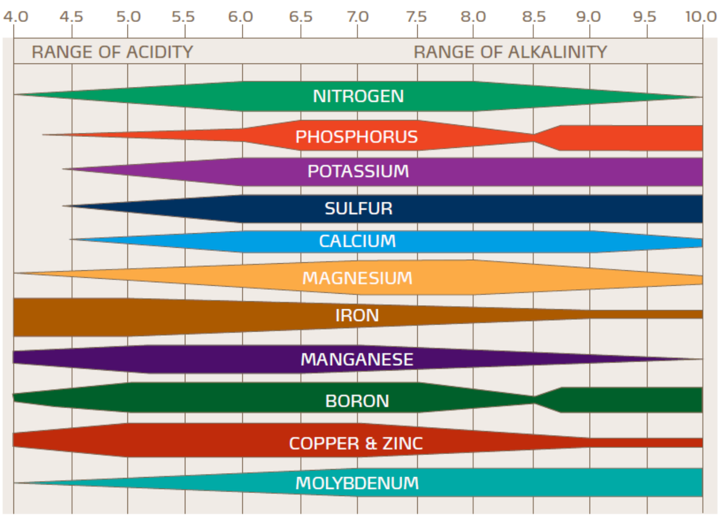
The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.

Soil Report example from my favorite lab, Midwest Laboratories

Let's look at the numbers for the sample TGA-HT1 on the above report. Reading from left-to-right we have the number that the lab assigned to the sample, and the name we gave it before we submitted it. It's always a good idea to map out the samples with the names before you send them in so that you know what came from where. Next we have organic matter (OM), which is the % of the soil that's composed of things other than minerals, I'll talk more about that in a minute. Next we have Phosphorus or P, which has several different methods of testing, but that gets complicated, followed by the rest of the Cations (cat-eye-ons), positively charged ions (K, Mg, Ca and Na).

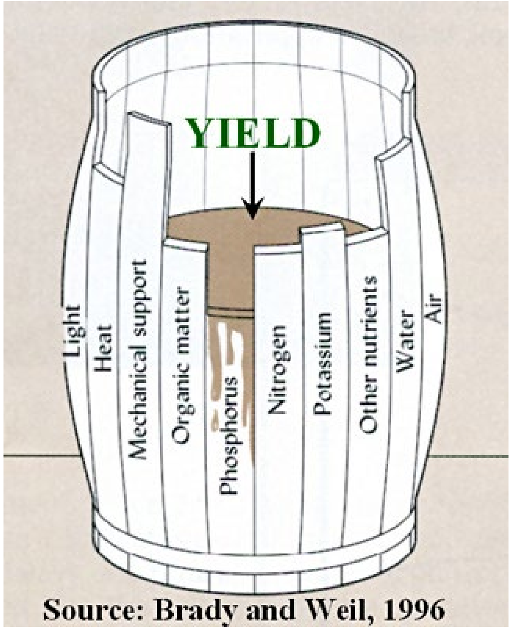
pH is a significant number to be aware of. This is a measure of the acidity/alkalinity of your soil. One thing to know about the pH number is that it's a logarithmic scale, which basically means that a pH of 8.0 is 10 times more alkaline than a pH of 7.0. An ideal soil pH is between 6 and 6.5, so our pH of 8.0 is 50 to 100 times more alkaline than ideal. The pH of battery acid is 1.0 and on the alkaline-side drain cleaner (lye) has a pH of 13.5. The reason that the ideal pH for vegetables is between 6.0 and 6.5 is because that's when the widest range of soil nutrients are available for the plant to uptake. You can see from the chart above that when we get up into 8.0 we're losing access to a lot of the micronutrients. It's an important first step to take your pH into account when planning your fertility needs. On our soil report we show that we have a very high level of Iron (Fe) in the soil, but because of our high pH, we may still see a deficiency of Fe. Also, be careful of advice to lime your soils because of low pH, not all lime is created equal, and if you already have an excess of Magnesium (Mg) in your soils (like many in Western Wisconsin) you are not doing yourself any favors by applying the local dolimitic limestone since it's also high in Mg.

The Influence of Soil pH on Nutrient Availability



The next item on the test, and the last that I'll really go into is the CEC, or Cation Exchange Capacity. This is a measurement of how much availability there is on your soil particles to attach the cation nutrients to. Sandy soils will have a much lower CEC than a loam or clay soil. Organic matter also helps to raise the CEC number. If your soils have a low CEC, like 5, you will have to apply nutrients annually since there are not many places for the cations to anchor themselves in the soil. But a high CEC like 25 you may only have to apply a cation like Potassium (K) every few years, since any excess can be readily stored in the soil. There's a good publication on CEC from Cornell.

I'm not going to go into base saturation % or the micronutrients, because it's too much info for this article. But one thing I would like to point out with micros is that in order to apply a certain micronutrient on a certified organic farm, you have to be able to demonstrate a deficiency, usually by means of a soil test. The problem is that soil tests were not designed for organic vegetable farms, and some nutrient levels need to be higher on organic farms. Boron (B) is a good example, a soil report might say that you have high B when you have a reading of 0.7, but many vegetables need a significant amount of B, and you have to be able to explain to the certifier why your test shows a high reading for B and you are still adding more. And also, if you don't have adequate N, P and K, adding micronutrients will not make any difference.



There's a lot of debate about soil fertility management between the many different kinds of farming that exist. Some liken it to something as simple as a checkbook. You need to have enough nutrients in your bank account to pay the growing crop for the season. Others would argue that it's like a barrel made of wooden staves, and the shortest stave (nutrient) in the barrel is what limits your production. Then there is argument that a soil test doesn't reflect the biological life of the soil, and therefore doesn't represent true nutrient availability. I'm not going to argue for one or the other of these, but will say that they're all important ways to think about fertility management. But I think it's also important to understand that you have to make sure that you have enough of the macronutrients, Nitrogen (N), Phosphorus (P) and Potassium (K) before you worry about whether or not you have enough Zinc (Zn) or any other micronutrient.

The simplest way to approach your soil test is to start with the big numbers, N, P and K and see what those needs are for the crops that you want to grow. Looking at the U of M's Commercial Vegetable Production publication referenced above, we see that for a soil with a medium amount of organic matter, we need 110 lbs/ac of N to grow our tomatoes. Now it's time to do some math, and honestly, I think doing the math is the single biggest factor for people not providing adequate fertility for their crops, people just don't like math. But it's really not hard, you just always need to double-check that you are using the same units (acres, square feet, row feet) everywhere.

Vegetable Crops

Table 28. Nitrogen recommendations for vegetable crops.

Crop	Approximate Yield Goal[2]	Soil Organic Matter Level (O.M.)[1] Low	Medium	High	Organic Soil	Suggested Method of Application[3,4,5]
	cwt/A	N to apply (lb/A)				
Asparagus (New Planting)	–	120	100	80	50	1/3 broadcast, 2/3 sidedress during cultivation
Asparagus (Est. Planting)	40	80	60	40	20	topdress before cutting starts or after harvest
Beets, table	200	100	80	60	30	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Broccoli	120	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Brussels sprouts	175	140	120	100	70	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Cabbage	400	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Carrots	400	120	100	80	50	1/2 broadcast, 1/2 sidedress when plants are established
Cauliflower	150	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Celery	600	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Cucumber	250	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run
Eggplant	250	120	100	80	50	1/2 broadcast, 1/2 sidedress when fruit appear
Endive	180	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Garlic	150	120	100	80	50	1/3 broadcast at planting (Sept./Oct.), 2/3 sidedress when shoots emerge in spring
Lettuce	300	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Mint	–	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Muskmelon	200	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run
Onions (dry)	500	130	110	90	60	1/4 banded, 3/4 sidedress 4-5 wks after emergence
Onions (green)	150	80	60	40	20	1/4 bcst, 1/2 sidedress 4-5 wks after emergence, 1/4 sidedress 4 wks before hvst
Parsley	–	100	80	60	30	1/2 broadcast, 1/4 after first cutting, 1/4 after 2nd cutting
Parsnips	400	120	100	80	50	1/2 broadcast, 1/2 sidedress after plants are established
Peppers	200	140	120	100	70	1/2 broadcast, 1/2 sidedress after fruit appear
Pumpkins	400	70	50	30	20	1/2 broadcast, 1/2 sidedress after vines begin to run
Radishes	70	50	40	30	20	broadcast
Rhubarb (New Planting)	–	100	80	60	30	1/2 broadcast, 1/2 sidedress after plants are established
Rhubarb (Est. Planting)	200	80	60	40	20	1/2 broadcast in spring, 1/2 sidedress after last cutting
Rutabagas	400	100	80	60	30	1/2 broadcast, 1/2 sidedress when plants are 4-6 inches tall
Spinach	150	100	80	60	30	1/2 broadcast, 1/2 sidedress 4-5 weeks after planting
Squash	300	70	50	30	20	1/2 broadcast, 1/2 sidedress after vines begin to run
Swiss Chard	150	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Tomatoes	270	130	110	90	60	1/2 broadcast, 1/2 sidedress when fruit appear
Turnips	300	60	50	40	20	broadcast
Watermelon	300	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run

First we need to look at how much N is already available in our soils from our soil sample. The S3C sample from Midwest does test for Nitrate Nitrogen, but I don't generally use this number, especially in an organic system. I would rather calculate available N by looking at the amount of organic matter (OM) that we have in our soil. In the case of the above sample results, we see that we have 4.2 % OM for the sample TGA-HT1. A simple shorthand is to credit 20 pounds of N for each % of OM shown on the soil test. So I would estimate that we have 84 pounds of available N from our organic matter, leaving only 26 more pounds of N needed per acre of tomatoes we grow.

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We're not actually growing an acre of tomatoes, but let's say that we're growing 3 200-foot long beds of tomatoes. The beds are 4-feet wide, but the center-to-center spacing on the tractor tires is 5 feet. I use the whole center-to-center measurement for my width and the length for the other measurement. So each bed is 5 x 200, or 1,000 square feet. 3 beds is 3,000 square feet. An acre is 43,560 square feet (you can google this number anytime). So our 3 beds are 3,000 divided by 43,560 or .07 of an acre (3,000 ÷ 43,560). If we need 26 pounds of N per acre and we have .07 acres, we actually only need 1.8 pounds of N for our 3 beds of tomatoes (26 x .07).

Here's the critical piece though—that's 1.8 pounds of straight N. All fertilizers are labeled with the *percentage* of N, P and K on the bag, so with a fertilizer like Suståne's 8-2-4, it's 8% N, 2% P and 4%K. That means for every 100 pounds of 8-2-4 there is 8 pounds of N, 2 pounds of P and 4 pounds of K. If we want to figure out how much we need, we just divide the amount we need by the percentage of the nutrient in whatever fertilizer we are using, so for this example we'd divide 1.8 by 8% (1.8 ÷ .08) and see that we need 22.5 pounds of 8-2-4 to supply 1.8 pounds of N on our three beds.

Sometimes this can be challenging with organic fertilizers, since they may have a combination of nutrients, and we don't want to add too much of one nutrient. You should never add too much N, it can make a plant susceptible to pests and produce too much vegetative growth. Too much P can run off into streams and lakes and result in damage to the environment. Too much K is not as much of a problem.

Nitrogen is the most important nutrient, without enough N you will not have good results, but the other nutrients are important too, but just like the leaky barrel. Figure out your needs for P and K the same way that we looked at N, there will be separate charts for each of them. Once you have these nutrient levels accounted for then you can start thinking about other cations and micronutrients.

Full disclosure: I am not a soil scientist, just a farmer who has learned from books and my own observations. Soil science is an incredibly complex topic, compounded by the fact that we still are just beginning to understand the complex interactions of soil microorganisms, plants and minerals. Here are a few books I would recommend, and if you ever see an opportunity to take a 1 or 2 day seminar on soil fertility, I strongly recommend it, single workshops at farm conferences are not in-depth enough to be of much benefit.

Kinsey, N., & Walters, C. (1999). *Neal Kinsey's Hands-On Agronomy*. Austin, TX: Acres USA.

Lowenfels, J., & Lewis, W. (2010). *Teaming with Microbes: The Organic Gardener's Guide to the Soil Food Web,* Revised Edition (Revised ed.). Amsterdam, Netherlands: Amsterdam University Press.

Zimmer, G. F., & Zimmer-Durand, L. (2016). *The Biological Farmer* (2nd, revised and expanded ed. ed.). Austin, TX: Acres U.S.A.