INTERPRETING YOUR UVM SOIL TEST RESULTS

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Soil tests measure the level of plant nutrients, soil pH, and organic matter content. The results are used to estimate whether soil amendments should be added to optimize crop growth and yield. Because there can be a lot of variability across a field or garden, soil samples submitted to the lab should be made up of subsamples taken from at least a dozen locations in the area being tested, taken evenly down to 6 to 10 inches deep, where most crop roots grow.

Testing starts with extraction of available nutrients from the soil sample, to simulate what may become available to plants over the growing season. Labs use different extraction methods so do not compare results from tests that don't use the same methods. UVM's tests use the modified Morgan's extract.

Soil test recommendations are estimates, based on test results, of how much of each nutrient needs to be added, if any, to get a good (average) yield of a specific crop. If higher-than-average yields are expected--where growing conditions are optimized using practices like high-density planting, irrigation, row covers, and productive varieties--recommended application rates of all nutrients should be moderately increased. If you are growing in-ground in a high tunnel or greenhouse, growing conditions and expected yields differ significantly from those in a field. UMaine offers a high tunnel soil test package of both modified Morgan's extract and a water based saturated media extract ("greenhouse media test") with recommendations specifically tailored to tunnel growing conditions.

Recommendations are provided as total quantity of individual nutrients needed, in lbs./acre. Figuring out how much of a specific type of fertilizer to apply requires some arithmetic. For example, to apply 100 lbs./acre of a nutrient using a fertilizer containing 10% of that nutrient by weight, then 1,000 lbs. of that particular fertilizer is needed. To convert from lbs./acre to lbs./1,000 sq. ft., divide by 43. *See the table below for help selecting quantities of specific fertilizers, based on their nutrient content.*

Soil pH affects the availability of nutrients. A soil pH of 6.5 to 6.8 is ideal for most vegetable and berry crops, and most crops will still grow pretty well with a soil pH of 6 to 7.5. Outside that range, yields are likely to drop. To raise soil pH, lime is added; to reduce soil pH (often necessary for blueberries, for which the ideal pH is 4.5-5.2), elemental sulfur can be added. More lime (or sulfur) is required to achieve the same change in soil pH in 'heavier' soils with a lot of clay and organic matter, compared to those that are 'lighter' textured (sandier).

Broadcast (spread evenly) and thoroughly mix in lime or sulfur, well in advance of planting if possible, as it takes time for the chemical reactions that change soil pH to occur completely. Use regular, high-calcium lime (calcite) if the soil is already high in magnesium; if not, use high-mag lime (dolomite) which is a low-cost way to add magnesium.

Wood ash can be used in place of lime, though it requires roughly 2 to 3 times more ash by weight to achieve the same increase in pH; wood ash can vary in its lime equivalence. Generally, no more 2 tons/acre should be top-dressed (spread on the surface) at once, and no more than 3 tons/acre applied when mixed into the soil. Ash is also a source of P and K as well as a number of micronutrients; on average it is like a 0-1-3 fertilizer. See: http://umaine.edu/publications/2279e/.

Soil Organic Matter (SOM) is made up of carbon-containing materials in various stages of decomposition, including compost, manure, leaves, roots, and microbes. Humus, the end-product of decay, is the most durable part of SOM; it is resistant to further breakdown. (Organic molecules adsorbed onto clay and organic particles (fragments) inside small aggregates may be inaccessible to organisms and so are also resistant to breakdown.) Native SOM content of most agricultural soils is usually less than 6% and typically in the 2 to 4% range. Sandier soils are low in SOM while clay soils are relatively high. This is due in part to rapid decomposition favored by sandy soils that are well-drained and well-aerated. Even at low levels, SOM is important for nutrient supply, water holding capacity, cation exchange capacity, and soil structure (physical condition).

SOM supplies nutrients through mineralization, when organic compounds are decomposed by microbes into carbon dioxide and minerals. Soil microbes are most active in warm, moist soils with good drainage and a pH between 6 and 7, so nutrient release from SOM is rapid under these conditions. Mineralization has a strong influence on the availability of nitrogen, phosphorus, sulfur, and most micronutrients. SOM absorbs a lot of water for its weight, improving the water-holding capacity of soil. It also improves soil structure by helping to create 'aggregates' when it bonds with soil particles of different sizes. These are held together by sticky substances microbes produce as they break down the SOM.

Nitrogen (N) is needed in relatively large quantities by plants, but it isn't measured by standard soil tests because its availability changes depending on soil temperature and moisture, and thus, microbial activity. The quantity of N needed for average yields of most crops ranges from 70 to 130 lbs./acre (1.5 to 3 lbs. per 1,000 sq. ft.) depending on the biomass of the crop. Smaller crops like beets or lettuce or need less N than sweet corn or tomatoes, for example.

Some N will be supplied from SOM as it breaks down, and N is also provided by new applications of compost, manure and cover crops. These sources of N should be accounted for, and fertilizer N application reduced accordingly. Conservative estimates of the N made available to a crop during a growing season are: 10 lbs. N/acre for each 1% of SOM, up to 40 lb. total; 4 lb. N/cubic yard of finished compost; 5 lb. N/ton from fresh dairy manure; 100 lbs. N/acre from plow down of a good stand of alfalfa or hairy vetch; 50 lbs. N /acre from a good clover stand, and 30 lbs. N/acre from lush green winter rye. Actual amounts of N released from these sources will vary with soil and weather conditions, tillage practices, etc. For more information see: https://nevegetable.org/cultural-practices/nitrogen.

N fertilizer type, placement and timing. Some N fertilizers are highly soluble, and others require microbial action to release their N. Soluble fertilizers are best "spoon-fed" or applied in small quantities over the growing season, so the N is not lost to leaching with rainfall. No more than 1/3 should be applied before planting, and then another 1/3 applied each month or so after crop emergence. Less soluble, "slow-release" fertilizers can be applied prior to planting. Mixing N fertilizer in the rows or in the beds rather than broadcasting over the entire field will improve N recovery by crops and avoid feeding weeds in between the crops. In early summer, if additional N is needed to optimize growth, soluble N fertilizer can be applied as a sidedressing or topdressing, next to or over, most crops. This is most beneficial if not enough pre-plant N was applied, after heavy rains occur, or if high-carbon soil amendments such as unfinished compost, leaves, or wood chips were added to the soil, and are using up N as they decompose. Typically, N is sidedressed at about 30 lbs./acre (3/4 lb. per 1,000 sq. ft.)

Phosphorus (P) is relatively immobile in soil, and even when applied as a fertilizer, tends to get tied up chemically rather quickly, binding with iron and aluminum in the soil. Phosphorus availability decreases when soil pH is not in the optimal range, and also under cool, wet conditions. To optimize P availability, adjust soil pH to the optimum range, and make P applications close to crop rows rather than by broadcasting. Once soil test levels are in the optimum range, only a small amount of P is needed to replace crop removal and maintain soil levels. Because plants take up less P than N or K, when fertilizers containing all 3 nutrients are applied repeatedly, P tends to build up in the soil.

Applying P when soil test levels are above optimum can contribute to pollution as soil moves from gardens or fields via erosion into surface waters such as brooks, lakes, rivers and streams. Large fields with exposed soil pose greater concern than small fields and gardens. Cover crops, mulches and permanent sod around cropped areas can reduce erosion. Phosphorus recommendations are expressed as phosphate (P_2O_5) to correlate with fertilizers.

Applying a soluble P "starter fertilizer" may be beneficial early in the season, especially to provide some soluble P, even if soil P test levels are optimum or slightly above. When soils are cool and root growth is slow, plants cannot take up P very well. Applying 20-30 lb./acre of phosphate in the row when planting can be beneficial to early season growth. Mix starter fertilizer into the crop rows or beds, apply as a band near the seeds or transplants, or water-in when setting plants. If applying other nutrients in a starter fertilizer do not exceed 20-30 lbs./acre each of N and K, to avoid salt injury in seedlings.

Potassium (K) is absorbed in large amounts by plants, and is moderately prone to leaching, so K fertilization is often needed to maintain optimum yields. The availability of K varies with the type of minerals found in different soils. In general, soils with higher clay content have higher available K levels. Sandier soils tend to be low in K, and do not retain added K very well, so it should be added close to the time of planting, and sidedressing K during the season may be beneficial. Unlike N and P, K poses little environmental concern in that it is not a significant threat to water quality. By convention, potassium recommendations are expressed as potash (K_2O) to correlate with fertilizer analysis.

Many agricultural soils are high in P, and require only N and/or K for good crop growth. Fertilizers containing all 3 major nutrients (N-P-K) should be avoided in this situation.

Calcium is typically adequate for crop growth so long as soil pH has been optimized and plants have a good supply of soil moisture. In sandier soils the Ca level may still be low, below about 1,000 ppm. In this case Ca can be added as gypsum, typically at rate of about 1 ton/acre, or 50 lbs./1,000 sq. ft.

Magnesium like Ca, is ordinarily supplied by liming. If Mg levels are low and lime is required, then dolomitic lime (high-mag) is recommended. If Mg is low and lime is not required, then K fertilization with sul-po-mag (0-0-22 plus 11% Mg) is recommended to provide both Mg and K. If neither liming nor K fertilization are recommended, then Epsom salts (magnesium sulfate, 10% Mg) can be used to provide Mg, typically at a rate of a few hundred pounds per acre.

Sulfur deficiencies are rare in Vermont and an optimum range has not been defined, so your report shows what is typically found. If S levels are below average, which may occur on sandier soils, use potassium sulfate (0-0-50, containing 18% sulfur) or sul-po-mag for K fertilization (0-0-22, containing 18% sulfur) to also add S. If K is not recommended, then adding elemental sulfur at 200 lbs./acre (5 lbs./1,000 sq. ft.). Epsom salts and gypsum, as well as animal manure and compost, are also sources of sulfur.

Micronutrients are essential to plants but are required in very small amounts. Deficiencies are not common; they are most likely in sandier soils with low organic matter and/or high pH. Responses to added micronutrients are not well documented in Vermont, and optimum ranges have not been defined so soil tests report typical, average levels. When an element is below average, application of manure, compost, or volcanic minerals (e.g. Azomite) may be helpful. Leaf analysis can determine if a deficiency exists and a specific micronutrient fertilizer is needed.

Boron (B) is the micronutrient that is most frequently needed as a fertilizer in Vermont, especially for crops in the cabbage family, and beets. Sandier, low SOM soils can be low in B. If soil test levels are 0.3 ppm or less, adding ~1 lb. B/acre is advisable. This can be provided as 5 lbs. of Sol-u-bor, or 10 lbs. of borax.

Aluminum (Al) is not a plant nutrient, but is tested for because at high levels it can be toxic to plants, though sensitivity varies among crops. Acid-loving plants, such as rhododendrons and blueberries can tolerate moderately high Al but lettuce, carrots and beets are very sensitive. High Al levels are more common when soil pH is low. Liming soils to a pH of 6-7 will lower the availability of Al, and may reduce it to acceptable levels.

Cation Exchange Capacity (CEC) is a measure of soil's ability to act as a "sponge" to hold and supply positively-charged nutrients, or cations. These include Ca, Mg, K as well as one form of N, ammonium (NH_4). Cations are held by negatively charged sites on clay and organic matter. CEC estimates the quantity of those sites, as milli-equivalents per 100 grams of soil (meq/100 g). CEC ranges from below 5 in sandy, low organic matter soils to over 15 in soils high in clay and/or organic matter. Low CEC soils are more susceptible to nutrient loss through leaching.

Base saturation shows the percentage of a soil's CEC made up of by Ca, Mg and K. Recent analysis concludes that percent base saturation has no relevance to managing soil fertility. This is only shown because some farmers still believe that this data is helpful. Following the fertilizer and lime recommendations will typically result in base saturation ratios within normal ranges.

Organic (carbon-containing) soil amendments and fertilizers have relatively low nutrient content, and slower availability compared to many synthetic fertilizers, which are typically soluble in water. Organic materials must be acted on by soil microbes to make nutrients available to plants. Thus, most materials allowed for use on organic farms (such as compost, manure, poultry byproducts or seed meals) are best mixed into the soil prior to planting, so they can release nutrients over several months. The exception is mined minerals, such as Chilean nitrate, potassium sulfate and other soluble 'organic' fertilizers that can be sidedressed.

Fertilizer rates. Soil test recommendations guide the selection of a fertilizer, or combination of fertilizers, to provide the nutrients needed for good crop growth, without adding what's not needed. Avoid fertilizers containing a blend of N-P-K unless all three nutrients are recommended; otherwise, excess nutrients may be applied. For more information see: http://www.uvm.edu/vtvegandberry/factsheets/NutrientManagementonOrganicVegetableFarms.pdf

Fertilizer (typically allowed on organic farms)	Typical analysis (% by weight)	Amount of nutrients (lbs.) added by 50 lb. of fertilizer		
		N	phosphate (P)	potash (K)
alfalfa meal	3-0.5-2.5	1.5	0.25	1.75
blood meal	13-1-0.5	6.5	1.	0.25
bone meal	3-15-0	1.5	7.5	--
Chilean nitrate	15-0-2	7.5	--	1
compost*	1-1-1	0.5	0.5	0.5
greensand	0-0-7	--	--	3.5
'Holly-Tone'	4-3-4	2	1.5	2
poultry manure - dried	4-3-4	2	1.5	2
potassium sulfate	0-0-50	--	--	2.5
'Pro-Booster'	10-0-0	5	--	--
'Pro-Gro'	5-3-4	2.5	1.5	2
rock phosphate**	0-30-0	--	15	--
soybean meal	7-2-1	3.5	1	0.5
sul-po-mag (+11% Mg)	0-0-22	--	--	11 (+5.5 Mg)
wood ash	0-1-3	--	1	1.5

*Nutrient content and availability of compost varies, and only a small portion of N is available in the year of application.
For more information see: http://ag.umass.edu/fact-sheets/compost-use-soil-fertility

**Only about 10% of the total phosphate in rock phosphate is available in the year of application.

Fertilizer (synthetic, or conventional)	Typical analysis (% by weight)	Amount of nutrients (lbs.) added by 50 lb. of fertilizer		
		N	phosphate (P)	potash (K)
"10-10-10"	10-10-10	5	5	5
"5-10-5"	5-10-5	2.5	5	2.5
calcium nitrate	15-0-0	7.5	--	--
diammonium phosphate	18-46-0	9	23	--
'Miracle Gro'	24-8-16	12	4	8
'Osmocote'	14-14-14	7	7	7
potassium chloride	0-0-60	--	--	30
potassium nitrate	13-0-44	6.5	--	22
super phosphate	0-20-0	--	10	--
triple super phosphate	0-46-0	--	23	--
urea	46-0-0	23	--	--

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