THE DIRT ON DIRT

Understanding, Evaluating, and Maintaining Your Soil

What is soil, and why does it matter?

- ***Soil***, not dirt
  - Dirt is what you clean out of your carpet or from under your nails, something to throw away
  - ***Soil*** is a dynamic system that is the very foundation of plant growth
  - ***Soil*** has important physical structure, chemical structure, and biological components that control the ability of plant roots to develop and obtain water, air, and nutrients necessary for plant survival
  - ***Soil*** is developed over time – years, decades, in some cases centuries
  - ***Soil*** changes over time, and is impacted by the things we do - for good or for bad

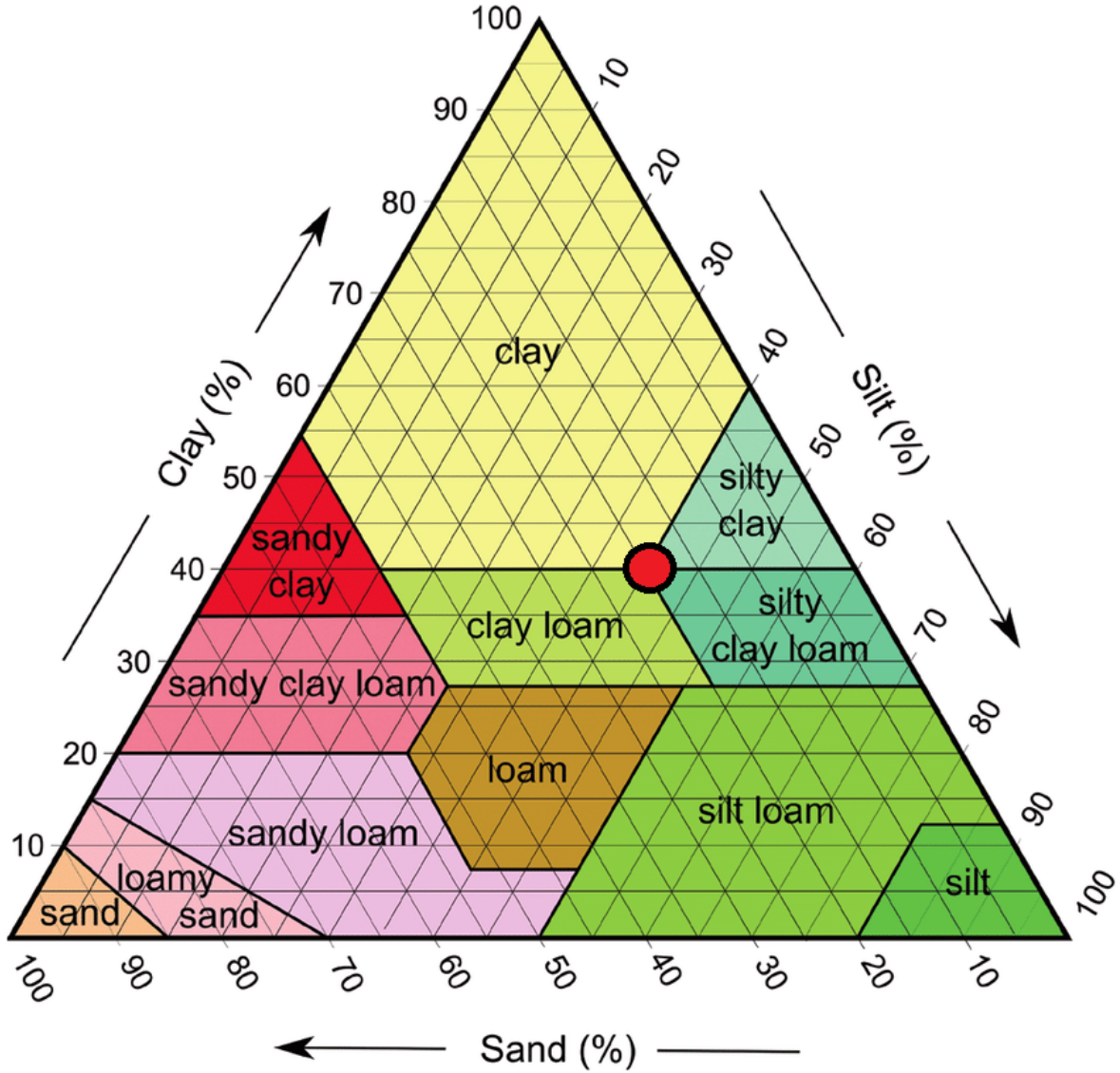
Soil Structure part 1

Three particle sizes:

- Sand - largest particle, little root resistance, poor water and nutrient holding/availability

- Silt – intermediate particle, some root resistance, good drainage – subject to compaction

- Clay – small particle, heavy root resistance, holds water (often too well) – very subject to compaction



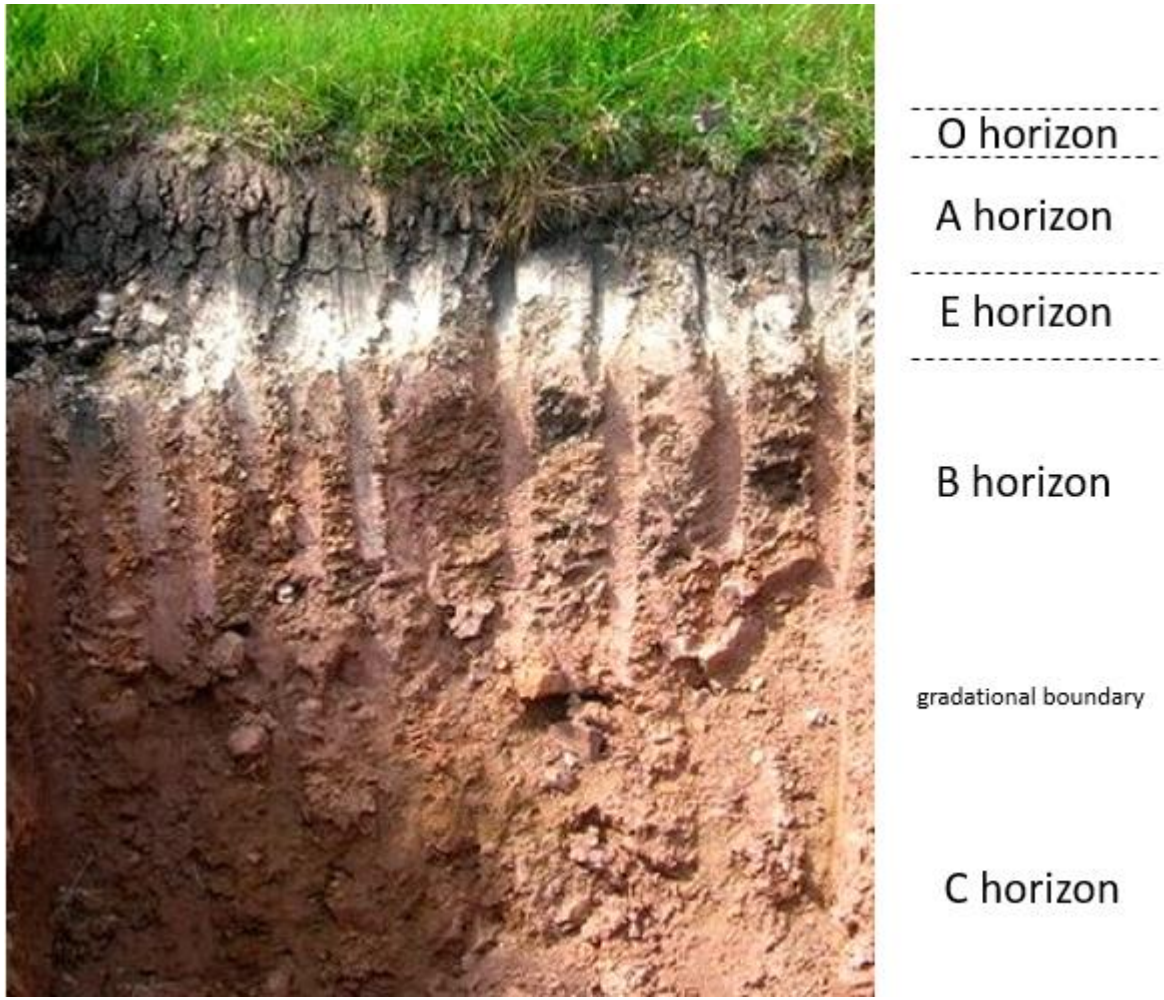
US Dept Agriculture Soil Texture Compass

Soil Structure part 2

The three particle types come together, or “aggregate”, chemically, physically, and through biological activity, producing the major classic soil types:

- Sand
- Sandy Loam
- Loam
- Silty Loam
- Clay Loam
- Clay
- Heavy Clay

- These soil types occur in layers



BCcampus Opentext – Physical Geology 2nd Edition

https://opentextbc.ca/physicalgeology2ed/chapter/5-4-weathering-and-the-formation-of-soil/

Soil Biology

Soil biology can change how particles aggregate, and also contribute to soil's ability to retain and release water and nutrients. The biological components of soil are:

- Live organisms – including plant roots, bugs, worms, fungal and bacterial organisms
- Recently "dead" mass – decomposing plants and creatures, large, small, and microscopic
- Older and older "deader" mass

The rate at which recently dead materials decompose and release nutrients is influenced very heavily by environment (temperature and moisture), chemistry, the activity of living organisms, and the inherent physical structure of the soil

"Deader" mass can take decades or more to release nutrients

Soil Chemistry

Soil chemistry is a very complex topic, for today's talk let's focus on a few key concepts:

- From a garden standpoint, we are talking about the presence and availability of major nutrients (N, P, K), minor nutrients (Ca, Mg, S, Fe), and micro-nutrients (including Cu, B, Zn, Mn, Mo)
- It is as important to know if these nutrients are available in forms plants can use as it is to know at what level they are present
- Availability is affected by a number of variables

Major Nutrients

- **N** – nitrogen, for leaf and green tissue growth.
- **P** – phosphorus, for root and flower development
- **K** – potassium, for maturation, fruit development, water and sugar transportation, toughness

Minor Nutrients

- **Ca** – calcium, influences soil pH, affects availability of other nutrients, improves cell structure and disease resistance

- **Mg** – magnesium, influences soil pH, affects availability of other nutrients, essential for chlorophyll

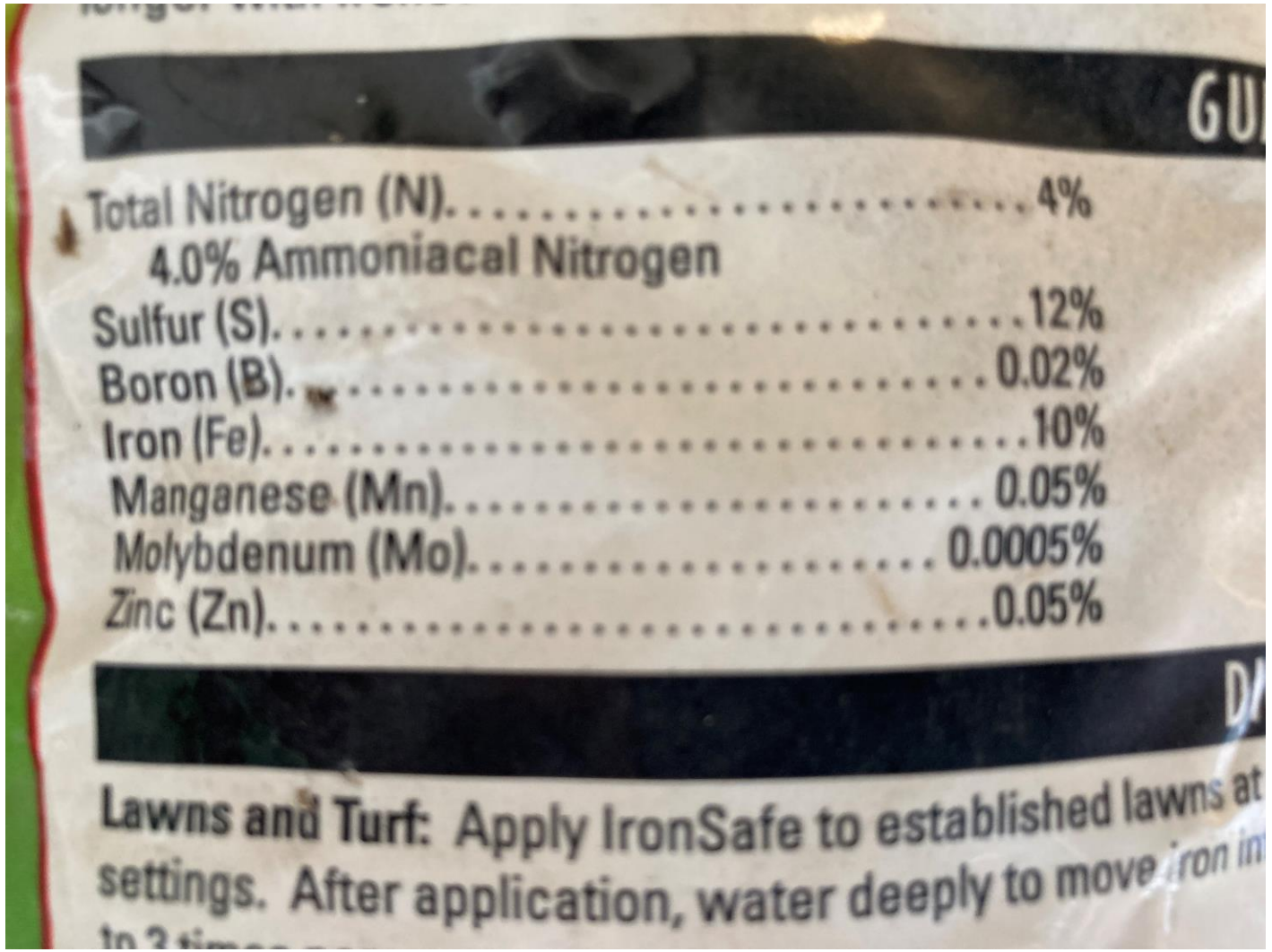
- **S** – sulfur, influences soil pH, affects availability of other nutrients, essential for photosynthesis and protein building (amino acids)

- **Fe** – iron, essential for chlorophyll and photosynthesis

Micro-nutrients

Micro-nutrients such as boron, copper, manganese, and zinc are also important for plant development. Unlike the major nutrients, they are usually needed in very small volumes for proper plant health.

While all plants need some quantity of all micronutrients, some are more specifically important to certain plants than to others



Soil Evaluation

Understanding the status of and changes to your soil can help you garden more effectively. Soil evaluations can be observational for many characteristics, but more formal testing can also be done:

- Observational tests you can do yourself, and in many cases can get you headed in the right general direction for soil and garden health
- Quick tests can be done at nursery events or on your own. Usually focused on soil chemistry, they are only so accurate but can give some insights on specific problems
- Formal laboratory tests are not free, but can address more complicated issues such as micronutrients, nutrient availability, biomass composition, and the like. They may require some additional research to understand the results.

Observational Tests

You can learn a lot about your soil by careful, non-technical examination – and even more if you record repeated tests over time.

Willamette Valley
Soil Quality Card

Date: _____ Crop: _____

Field location: _____ Year of planting: _____

Soil moisture: ❑ Good for planting ❑ Too dry for planting ❑ Too wet for planting

Indicator	→ Preferred 1 2 3 4 5 6 7 8 9 10	Observations	Rating the indicator 1	5	10
1. Does the soil have good structure and tilth?			Cloddy, powdery, massive, or flaky	Some visible crumb structure	Friable, crumbly
2. Is the soil free of compacted layers?			Wire flag bends readily; obvious hardpan; turned roots	Some restrictions to penetrating wire flag and root growth	Easy penetration of wire flag beyond tillage layer
3. Is the soil worked easily?			Many passes and horsepower needed	Medium amount of power and passes needed	Tills easily; requires little power to pull tillage implements
4. Is the soil full of living organisms?			Little or no observable soil life	Some (moving) soil critters	Soil is full of a variety of soil organisms
5. Are earthworms abundant in the soil?			No earthworms	Few earthworms, earthworm holes, or casts	Many earthworms, earthworm holes, and casts
6. Is plant residue present and decomposing?			No residue or not decomposing for long periods	Some plant residue slowly decomposing	Residue in all stages of decomposition; earthy, sweet smell
7. Do crops/weeds appear healthy and vigorous?			Stunted growth, discoloring, uneven stand	Some uneven, stunted growth; slight discoloration	Healthy, vigorously and uniformly growing plants
8. Do plant roots grow well?			Poor root growth and structure; brown or mushy roots	Some fine roots; mostly healthy	Vigorous, healthy root system with desirable root color
9. Does water infiltrate quickly?			Water on surface for long periods after light rain	Water drains slowly; some ponding	No ponding after heavy rain or irrigation
10. Is water available for plant growth?			Droughty soil, requires frequent irrigation	Moderate degree of water availability	The right amount of water available at the right time
Other					

How to use the card

1 Enter date, location, crop, year of planting (if perennial crop), and soil moisture level in the field. Select 1–5 representative spots in the field.

2 Use a shovel or a wire flag to probe the soil. Rate each indicator on a scale from 1 to 10. Refer to the rating guide to determine the score for each indicator.

3 Record your observations. Review and evaluate your scoring.

4 On the back page, write down current management practices. Record ideas for changes in management that you will implement as a result of your assessment.

Willamette Valley Soil Guide

Downloads from OSU Extension to guide you through soil self-analysis:

The actual form to keep records on is publication EM8711, looks like the previous slide image

Download publication EM8710 for a guide to taking samples and the criteria for evaluation on structure, compaction, biological components, water infiltration, and “do existing weeds/crops appear robust and healthy?”

This guide will also give soil management tips for problems that are found.

Quick Tests

- The advantage of quick tests are minimal cost and instant results
- Quick tests are not extremely accurate, and only test a few characteristics
  - pH
  - N-P-K
  - Electroconductivity (salts, soil nutrient reactivity)
- Purchase inexpensive test kits/strips/meters, or attend a soil testing event at a nursery or lecture

Laboratory Tests

- Lab tests can give you a very comprehensive evaluation of your soil
- Lab tests cost money, and are sent to a lab – you have to wait for the results
- Interpreting the report can be complicated

University of Minnesota
Soil Testing Laboratory

SOIL TEST REPORT
Lawn and Garden

Client Copy
Department of Soil, Water, and Climate
Minnesota Extension Service
Agricultural Experiment Station

JANE DOE
1900 SANDY LANE
MINNEAPOLIS MN 55401

Page 1
Report No. 6
Laboratory No. 114
Date Received 01/31/2007
Date Reported 02/02/2007

Sample/Field Number: 1B

SOIL TEST RESULTS

Estimated Soil Texture	Organic Matter %	Soluble Salts mmhos/cm	pH	Buffer Index	Nitrate NO3-N ppm	Olsen Phosphorus ppm P	Bray 1 Phosphorus ppm P	Potassium ppm K	Sulfur SO4 -S ppm	Zinc ppm	Iron ppm	Manganese ppm	Copper ppm	Boron ppm	Calcium ppm	Magnesium ppm	Lead ppm
Medium	**3.5**	**0.5**	**5.6**	**6.5**			**15**	**89**									

INTERPRETATION OF SOIL TEST RESULTS

Phosphorus (P) PPPPPPPPPPPPPPPP
5 Low 10 Medium 15 20 High 25 V. High

Potassium (K) KKKKKKKKKK
25 Low 75 Medium 125 175 High 225 V. High

pH **********
3.0 4.0 5.0 6.0 7.0 8.0 9.0
Acid Optimum Alkaline

Soluble Salts ****
0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
Satisfactory Possible Problem Excessive Salts

RECOMMENDATIONS FOR: Vegetable garden

LIME RECOMMENDATION: 20 LBS/100 SQ.FT.
TOTAL AMOUNT OF EACH NUTRIENT TO APPLY PER YEAR:*

NITROGEN	PHOSPHATE	POTASH
0.15 LBS/100 SQ.FT.	0.2 LBS/100 SQ.FT.	0.3 LBS/100 SQ.FT.

THE APPROXIMATE RATIO OR PROPORTION OF THESE NUTRIENTS IS: 15-20-30

Use a fertilizer with the percentage of nutrients closest to the above ratio. Apply according to the instructions on the fertilizer bag or container, or determine the amount required from the instructions given on the back side of this report. Since meeting the exact amount required for each nutrient will not be possible in most cases, it is more important to apply the amount of nitrogen required and compromise some for phosphate and potash.

If a fertilizer contains phosphate and/or potash, it can be mixed in the spring or fall into the top 4-6 inches of topsoil. If a fertilizer containing only nitrogen is used, it should be applied in the spring, tilling or raking it into the surface. Nitrogen is easily leached through soil.

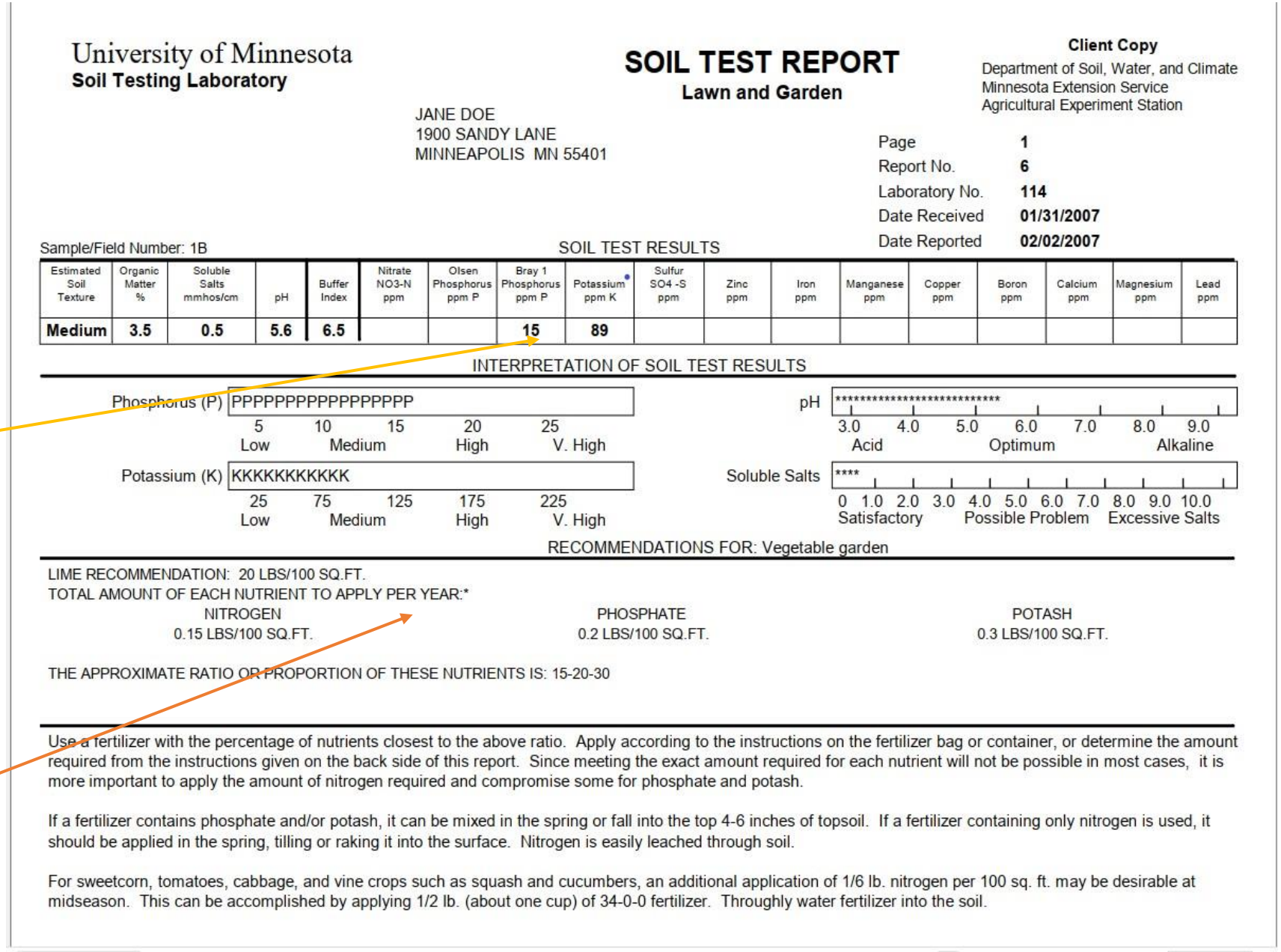
For sweetcorn, tomatoes, cabbage, and vine crops such as squash and cucumbers, an additional application of 1/6 lb. nitrogen per 100 sq. ft. may be desirable at midseason. This can be accomplished by applying 1/2 lb. (about one cup) of 34-0-0 fertilizer. Throughly water fertilizer into the soil.

File courtesy University of Michigan soil lab

https://soiltest.cfans.umn.edu/example-soil-test-report

Macro Nutrient

- Lab tests are much more accurate than quick tests
- Notice – actual test results for P and K but not N. Why?
- Box mid page: fertilizer recommendation – note N is here – it is dependent upon crop, soil N is very difficult to evaluate



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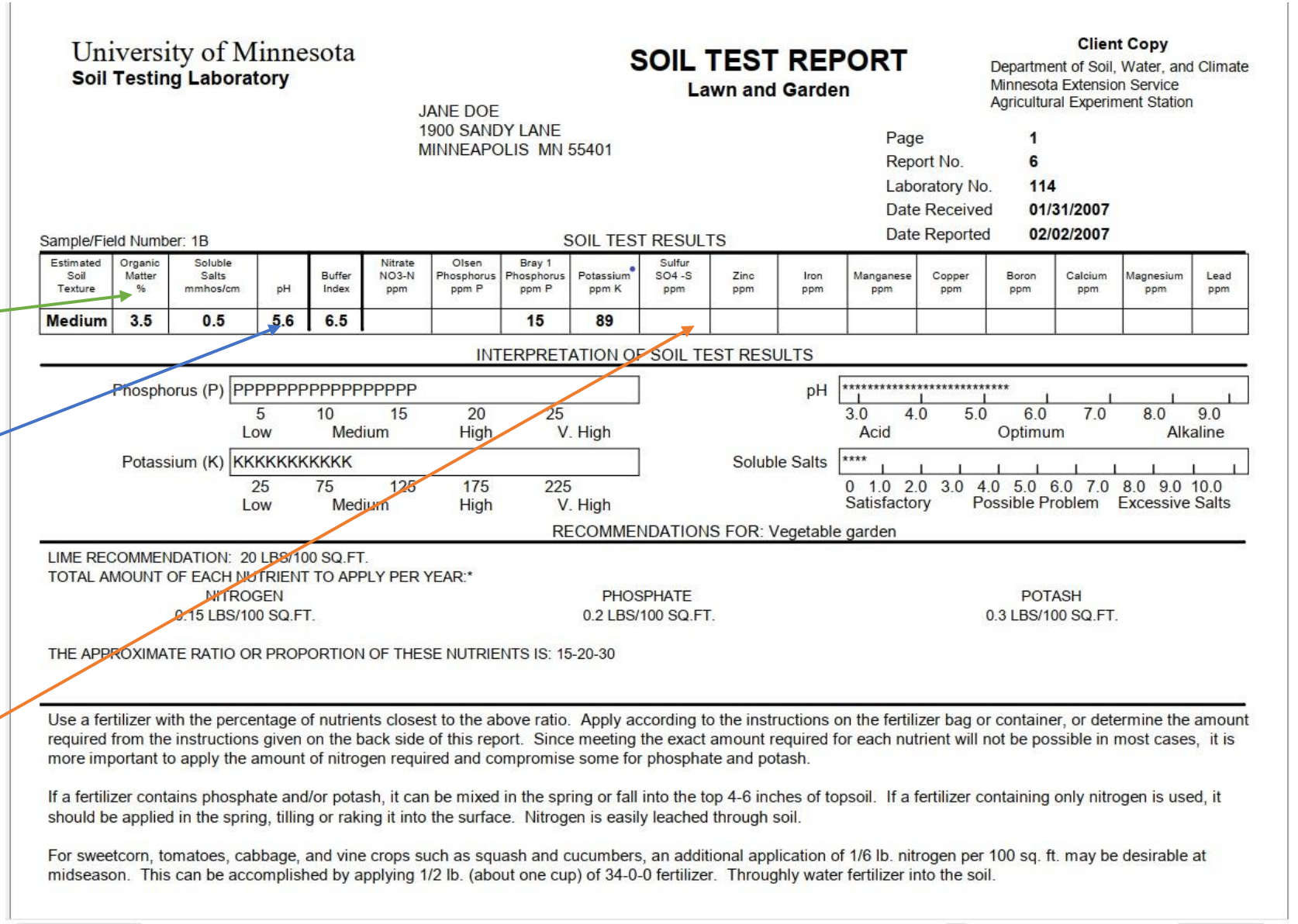
Additional Information

- Organic material – too high can be just as bad as too little, and harder to correct
- pH test will be much more accurate
- Minor and micronutrients can be tested for, at additional cost – usually only needed to resolve very specific problems/symptoms, or for specific agricultural crops



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Sources for soil tests

- Soil tests are available through the OSU soil lab, and through private test companies
- Many different tests are offered, so choose one that will suit your needs
  - Recommend – P, K, Ca, Mg, pH, organic matter
  - Soil N analysis can be useful, but has limits – better a test that you can specify crop (vegetable garden) which will give you a nitrogen recommendation for that crop
  - A very thorough test for micros etc will cost much more, and is not likely to provide actionable info for a home garden

- OSU soil lab – review the test options or contact them:
  - https://cropandsoil.oregonstate.edu/shl/testing-services/soil-testing

- Information about other certified labs can be found through the extension publication EM8677
  - https://catalog.extension.oregonstate.edu/em8677

Taking a soil sample

- For gardens, soil sample 6” deep
- Turn a shovel of soil, then for your sample cut ½” facing from the hole, and take the central 1 to 1-1/2 inches of that cut as your subsample
- Take multiple subsamples from the same garden – 5-6 or twice that for a very large garden
- Remove vegetation and mulch
- Break up and mix together all the subsamples and fill plastic bag (or container supplied with test package or kit)
- For tracking over time, take subsamples in the same approximate locations each time, and at the same time of year
- Tests do not need to be made frequently – every 3-5 years is plenty in most cases
- Test instructions may vary – follow instructions precisely, even if they differ from what I tell you here.

Soil Management

Soil is an essential and precious resource. How we handle it – the things we do (or in some cases choose not to do) matter:

- Tilling, when to till, or choosing not to till
- Adding organic material
- Watering habits
- Fertilizing habits
- Mulches and cover crops
- Crop rotation and fallowing
- Creating soil in a raised bed

Tilling

- Tilling soil is a choice, not a requirement
- If you till, do it only when soil moisture is just right – neither too dry nor too wet
- There are positive and negative effects from tilling
  - Incorporate organic or mineral material
  - Disrupt weeds and pests
  - Can disrupt beneficial organisms
  - Can *increase* weed problems
  - Soil compaction and till-pan
  - Speeds release – and depletion – of organic nutrient resources

Image by ikaika on Freepik

https://www.freepik.com/free-photo/tilling-machine_925668.htm

Adding Organic Material

- Biological components of soil break down over time, releasing their component nutrients for plants to absorb
- If these biologicals break down too fast, soil structure and chemistry change for the worse
- If too much material decomposes too slowly, nutrients remain trapped and plants can’t use them
- Materials can be tilled in, turned in, or layered on top

Organic (Biological) materials

Faster decomposition

- Manures
- Many organic fertilizers
- Cover crops

Slower decomposition

- Straw
- Wood chips
- Bark fines

Watering

- Too little water can be bad for the soil, as well as for plants – changes decomposition rates, increases compaction risk, can disrupt structure (cracking), and may lead to wind erosion

- Too much water is worse for soil than for plants – changes decomposition rates, increases compaction risk, can strip out valuable nutrients, and may lead to erosion

- Best watering practices can reduce these effects, but there is always some trade-off

Watering practices – general principles

GOOD WATERING

- Water when soil is dry to about 1” (may change some for certain crops and for new seedings)
- Water infrequently but deeply – many crops need much less than you think
- Water with drippers, soakers, or with light (small droplet) sprayers
- Water in the coolest part of the day

BAD WATERING

- Water every day regardless of soil moisture
- Water a little bit at a time but very often
- Water with impact sprinkler or a hose and wand
- Water in mid-day heat

Fertilizing

- Plants can only absorb the nutrients they need in certain forms – fertilizers are given in those forms, or as nutrients that soil chemistry and biology will break down into those forms

- Organic fertilizers work with the soil biology : feed the soil, let the soil feed the plants. They tend to be slower without large and fast fluctuations

- Synthetic fertilizers bypass soil biology for the most part; they can be a fast and effective way to fertilize, but they often have negative impacts on soil chemistry and biology

- In most cases and for most crops, Nitrogen is the most significantly limiting factor

Mulches and Cover Crops

Soils often suffer decline during seasons when we are not managing them. Wind, drought, rain, frost, and snow all impact soils.

- Mulches seek to reduce this decline by covering bare soil and suppressing undesirable plants (weeds). Mulches can be organic (bark, compost, manure) or synthetic (cardboard or plastic mulches). Organic mulches add nutrients and biological material to the soil as they decompose – rapidly or slowly, depending upon the material

- Cover Crops are living mulches. They displace weed growth and control erosion and compaction. Because they are rooted in the soil, they also impact soil structure to deeper layers than simple mulches. In addition, some cover crops add N (nitrogen) to the soil, and others scavenge nutrients in the soil before they can wash away from winter rains. Cover crops are usually but not always tilled in.

Crop Rotation and Fallowing

Intensive, repetitive, and mono-culture planting can be very hard on soil, even when biomass and nutrients are replenished.

- Crop rotation is avoiding planting the same or closely related crops in the same location every season. This can help plants in many ways, and helps soils by diversifying soil microbes and bugs, changing the nutrient demand, and varying the root density and depth

- Fallowing is taking a season or a year or even more to let soil recover between intensive plantings. It often includes using a cover crop or a rotation of different cover crops to help rebuild.

Building soil in a raised bed

Put simply, there is no perfect, fast, inexpensive way to build a good raised bed soil. Here are some general guidelines to lead you to increased success:

- Provide adequate drainage. A layer of loose gravel or round rock about 2” deep is one way, there are alternatives.
- Combine some form of mineral soil (sandy loam, “top soil”, or if you are re-grading some existing native soil) with organic material. This can be as rich as half and half, but I usually look for about 1 part sandy loam to 3 parts organic material
- Use a mixture of coarser (slow to break down) material and finer and more finished composts/ manures. Be cautious of very fresh manures or lots of very woody materials – both will give you challenges for a while
- Generally I prefer bagged soil products – more consistent, but much more expensive
- The soil development process takes time. Even with good materials and careful sourcing, the first year or two can be rough – particularly with settling and with nutrient availability (consider liquid fertilizers)

Managing soil in a raised bed

Once established, raised bed soils can be maintained like other soils:

- Watering needs to be more frequent, but otherwise similar
- Organic fertilizers work quite well after biology gets going
- Cover crops and mulches can still be used, and rotation is even more important
- Easier to practice no-till than in-ground gardens
- A raised bed, without the full mass of native soil, is more likely to settle, change, and oscillate than an in-ground garden. You will have to water, feed, and add fresh material more

Top strategies for good soil management

- Reduce or eliminate tilling
- If you till, be very careful about when
- Monitor changes in soil pH and organic matter
- Use cover crops or mulches to reduce erosion and compaction
- Add quality organic material with organic mulches and cover crops
- Use organic fertilizers instead of synthetic
- Practice crop rotations or fallow periods to reduce impacts
- Water as deeply and infrequently as soil and crop will allow
- Reduce soil compaction from high-impact watering
- Understand the benefits and limits of soil tests