Soil Sampling

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Outline

- Soil Basics
  - Background
    - Texture
    - Nutrients
- How to Soil Sample
- Why Soil Sample?
- Understanding a Soil Sample

Why care about soil?

- Growing medium for plants!
- Plants are essential!

http://cdn.modernfarmer.com/wp-content/uploads/2013/04/science-of-soil-hero-image.jpg

Plants!

- All things depend on plants
  - Agriculture
  - Ecosystems
- Healthy plants depend on healthy soil
  - Texture
  - Water holding capacity
  - Nutrients
  - Biology
- Plants keep soil stable…

What Do Plants Need?

- Light
- Water
- Nutrients

Soil Basics

- Soil - what is it?
  - Not dirt!
  - And yes still dirt…

Soil Definition

- **soil** - (i) The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants.

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280

Soil

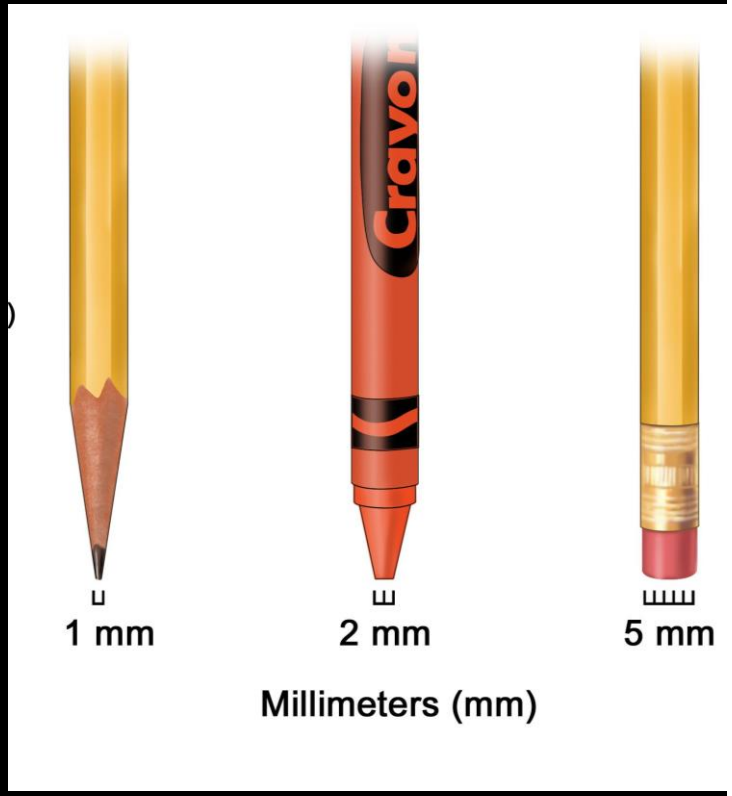
- The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and micro-organisms, conditioned by relief, acting on parent material over a period of time. A product - soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280

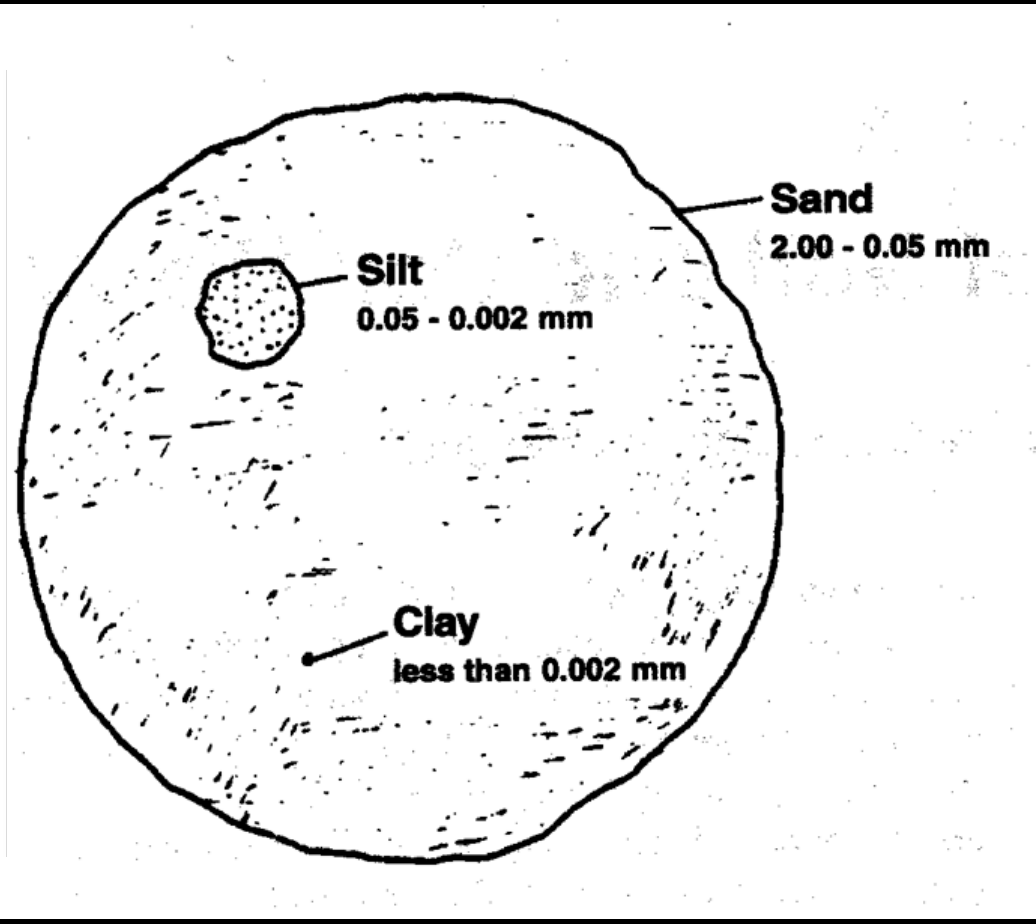
Soil

- Pedogenisis - process of soil development/ formation
- Factors that influence soil
  - Rock type
    - Sedimentary
    - Igneous
    - etc.
  - Time
  - Climate
  - Topography
  - Biological processes

Soil Texture



https://www.cancer.gov/images/cdr/live/CDR578121.jpg

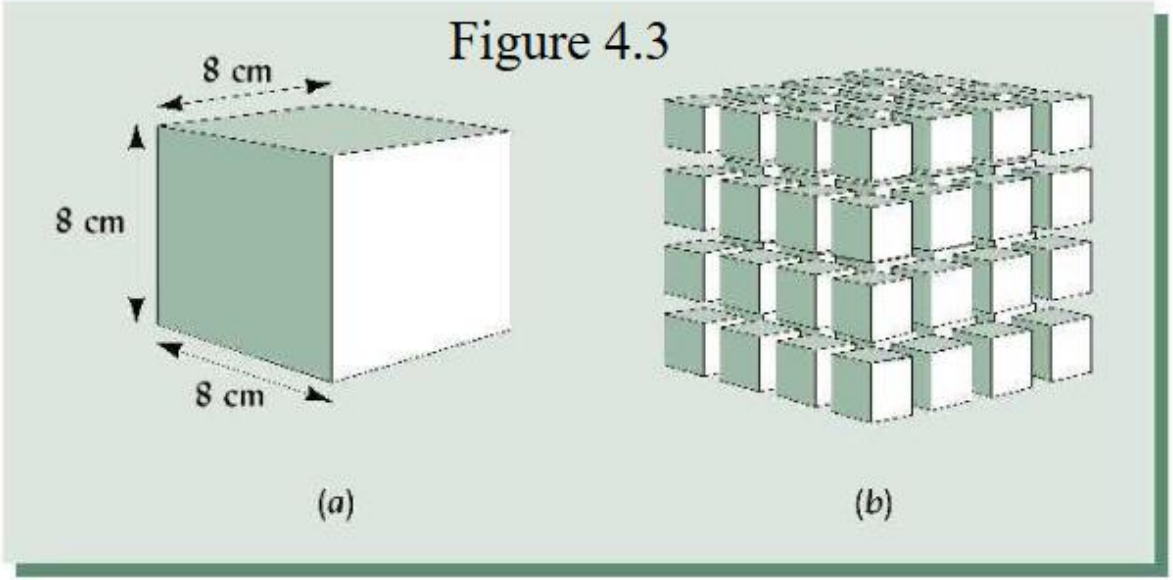


http://passel.unl.edu/UserFiles/File/Crp.%20Prod.%20Nat.%20Res.%20Mngmt/Soils%20lesson%202/Fig-2.2.gif

Surface area

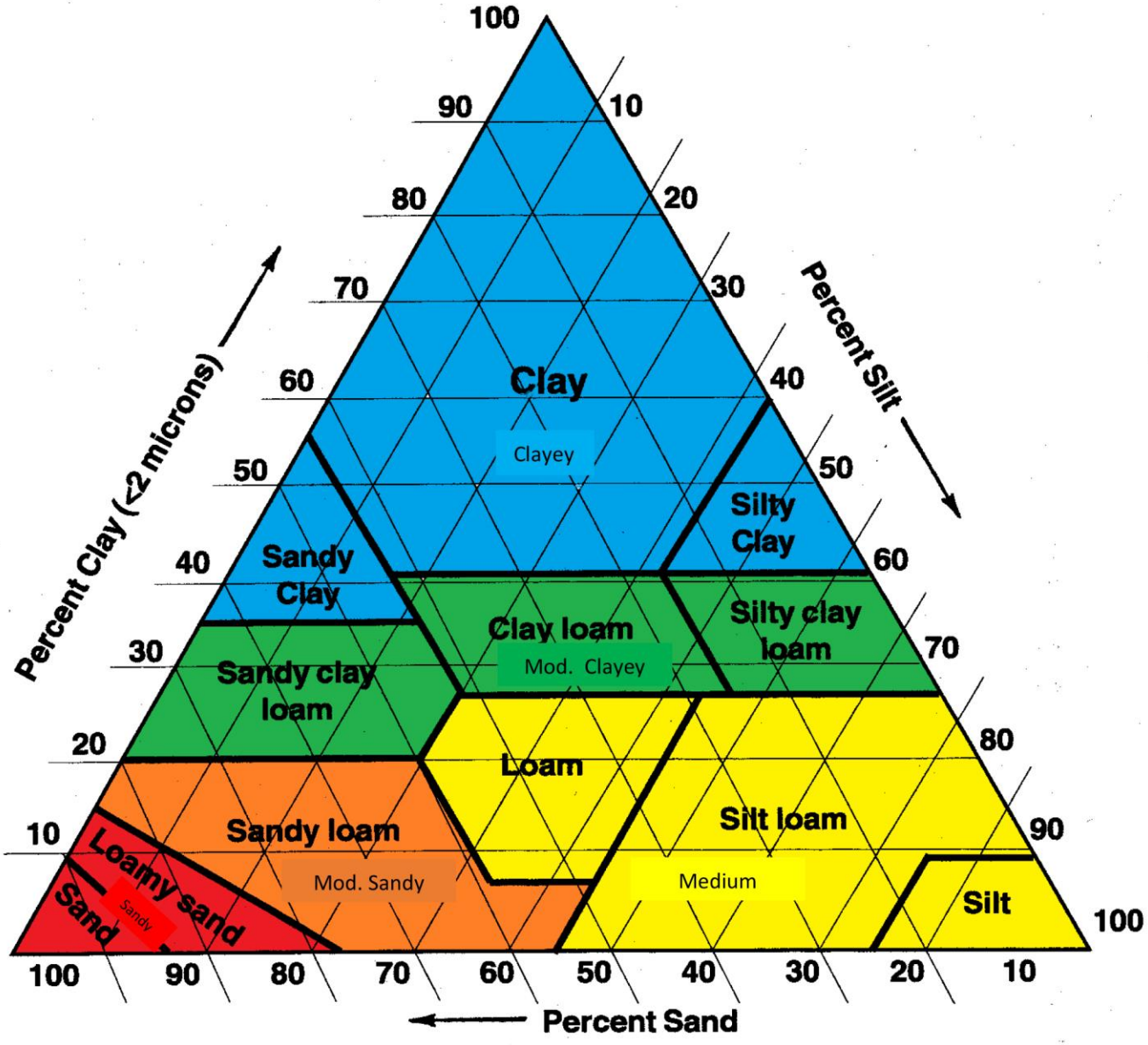
Why is soil surface area important?

1). Maintain water films
2). Chemical attachment and adsorption
3). Weathering at the surfaces
4). Electromagnetic charges as forces of soil aggregation
5). Microbes tend to grow on particle surfaces.



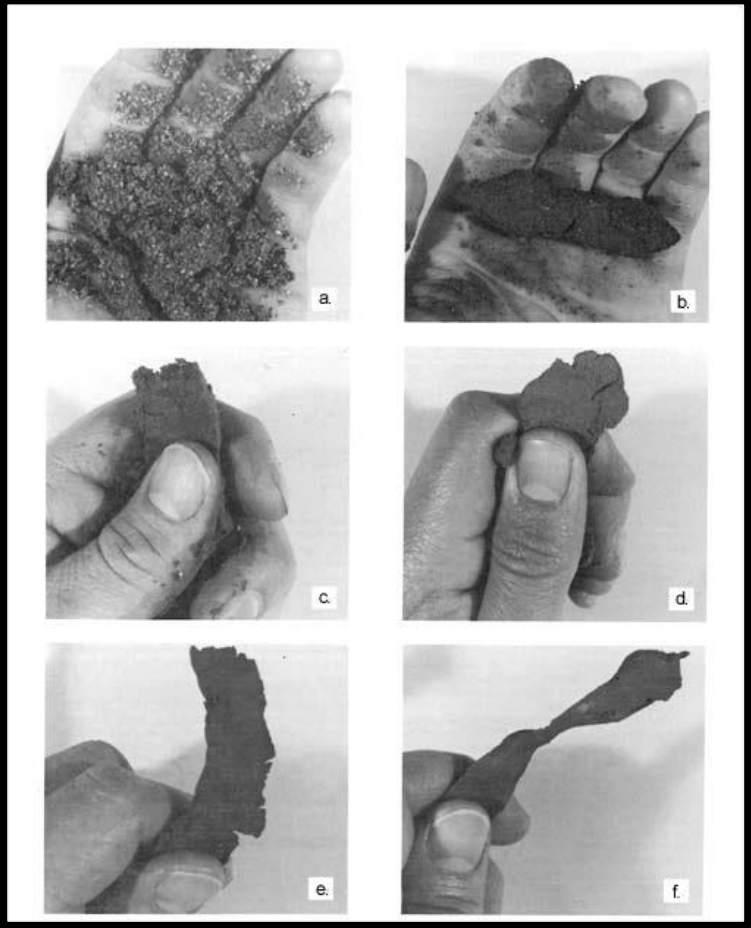
https://ic.ucsc.edu/~wxcheng/envs161/Lecture3/ch4_Physical_properties.pdf

Soil Texture Triangle



https://ag.purdue.edu/agry/agryclub/PublishingImages/Textural%20Triangle%20Final.jpg

Soil Texture - Field Testing



https://www.agry.purdue.edu/soils_judging/manual_unprotected/images/fig17.jpg

http://soilquality.org.au/factsheets/soil-texture

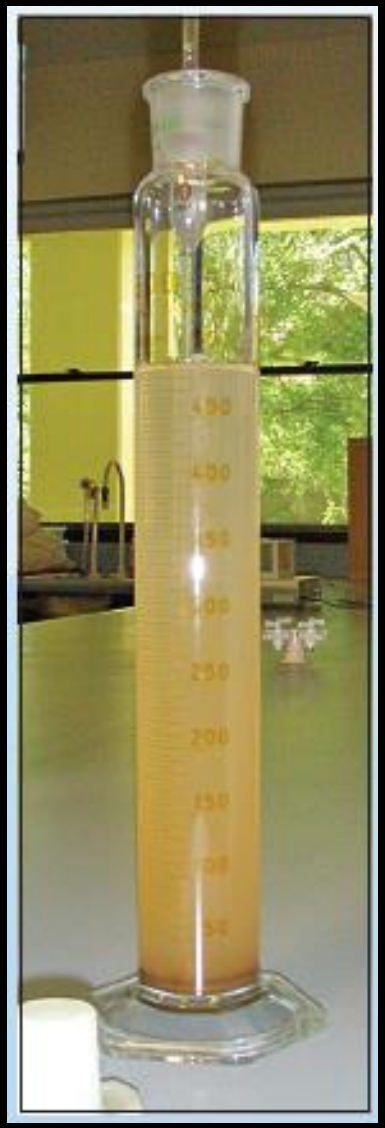
Table 1: *Classification based on field texturing of soils. The combination of 'Behavior of Moist Bolus' and 'Ribbon Length' gives an indication of 'Field Texture Grade'. Adapted from McDonald et al. (1998).*

Field Texture Grade	Behavior of Moist Bolus	Ribbon Length (shearing between thumb and forefinger)	Approximate Clay Content (%)
Sand	Coherence nil to very slight, cannot be molded; single sand grains adhere to fingers.	Nil	<10% (often <5%)
Loamy Sand	Slight coherence.	approx. 5 mm	5-10%
Clayey Sand	Slight coherence, sticky when wet; many sand grains stick to fingers; clay stains the hands.	5-15 mm	5-10%
Sandy Loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are easily visible.	15-25 mm	10-20%
Loam	Bolus coherent and rather spongy; smooth feel when manipulated, no obvious sandiness or "silkiness"; may be greasy to the touch if much organic matter is present.	approx. 25 mm	approx. 25%
Silty Loam	Coherent bolus; very smooth to silky when manipulated.	approx. 25 mm	approx. 25% (with silt)
Sand Clay Loam	Strongly coherent bolus, sandy to touch; medium size sand grains visible in finer matrix.	25-40 mm	>25%
Clay Loam	Coherent plastic bolus, smooth to manipulate.	40-50 mm	20-30%
Clay Loam, Sandy	Coherent plastic bolus; medium size sand grains visible in finer matrix.	40-50 mm	30-35%
Silty Clay Loam	Coherent smooth bolus; plastic and often silky to the touch.	40-50 mm	30-35% (with silt)
Sandy Clay	Plastic bolus; fine to medium sand grains can be seen, felt or heard in clayey matrix.	50-75 mm	35-40%
Light Clay	Plastic bolus; smooth to touch.	50-75 mm (slight resistance to ribbon shear)	35-40%
Light Medium Clay	Plastic bolus; smooth to touch.	approx. 75 mm (mod. resistance to ribbon shear)	40-45%
Medium Clay	Smooth plastic bolus; handles like plasticine; can be molded into rods without fracture.	>75 mm (mod. resistance to ribbon shear)	45-55%
Heavy Clay	Smooth plastic bolus; handles like stiff plasticine; can be molded into rods without fracture.	>75 mm (firm resistance to ribbon shear)	>50%

http://soilquality.org.au/factsheets/soil-texture

Texture in Lab

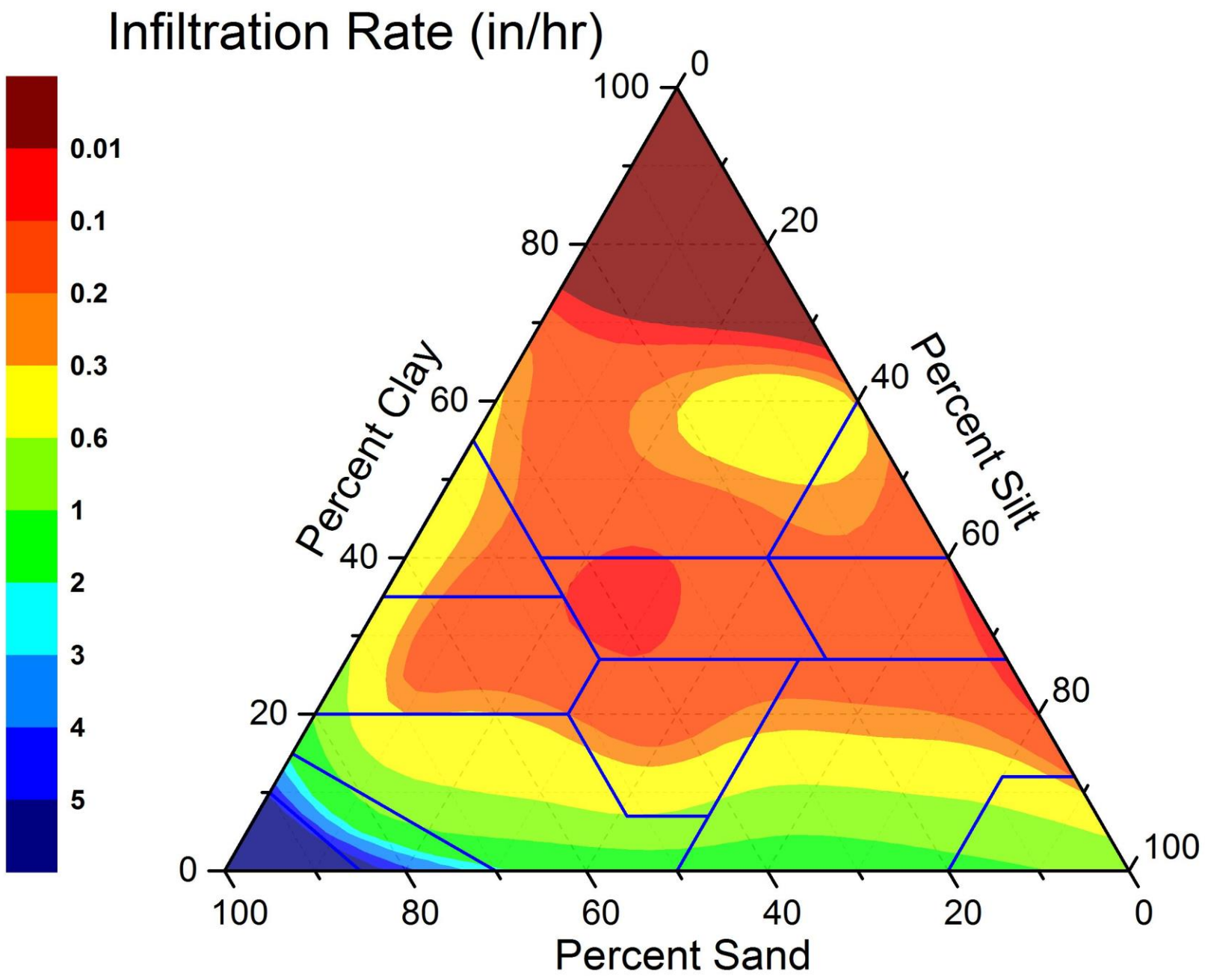
- Settle out in water
- Particles settle
  - Sand first, clay last
  - Dried and weighed



http://www.soilquality.org.au/factsheets/soil-texture-measuring-in-the-lab

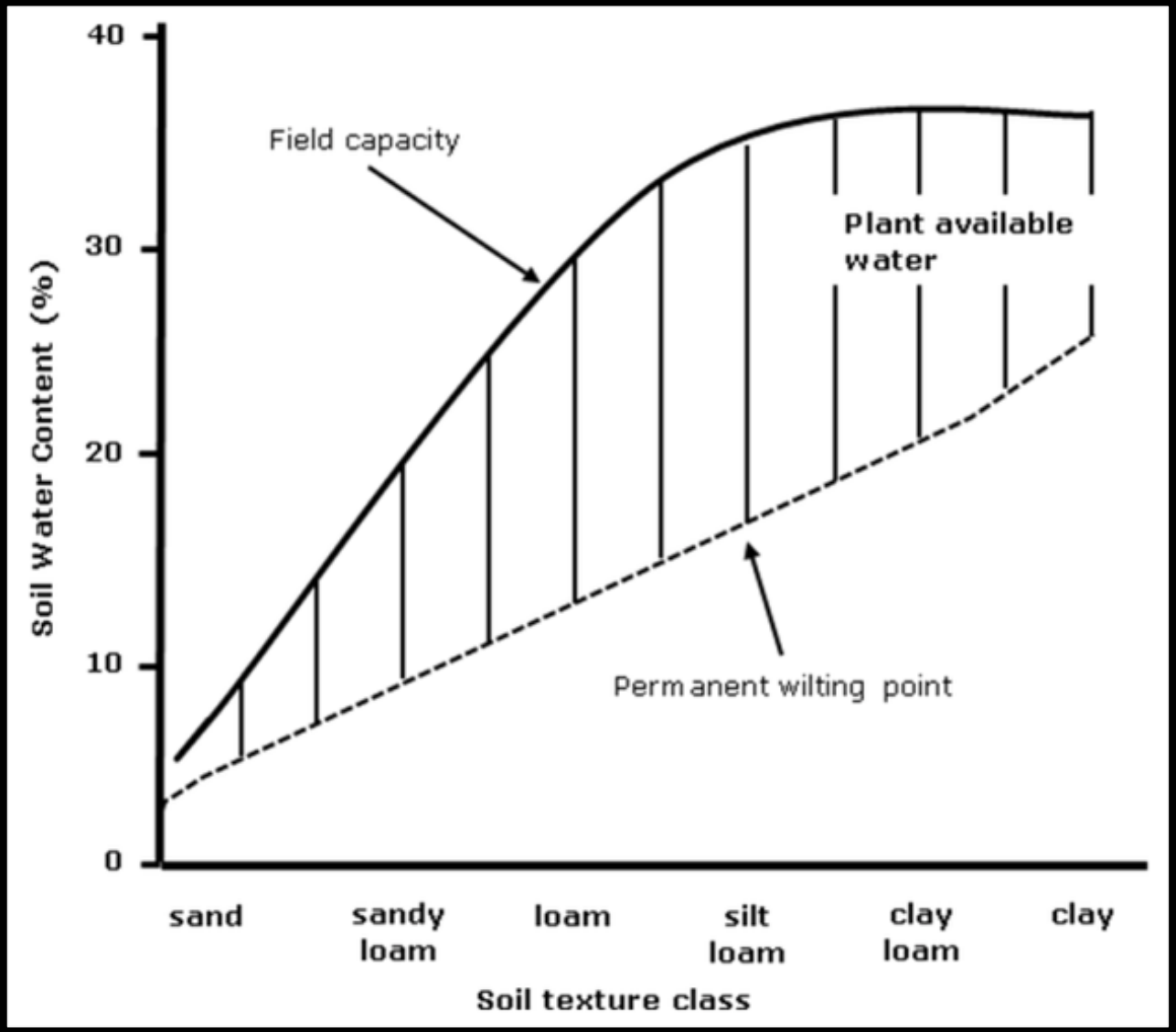
OK, well why does texture matter?

- Affects lots of things…
- Infiltration
- Water holding capacity
- Nutrient holding capacity
- Erosion



http://i.imgur.com/wzcv3zY.jpg

Water Holding Capacity



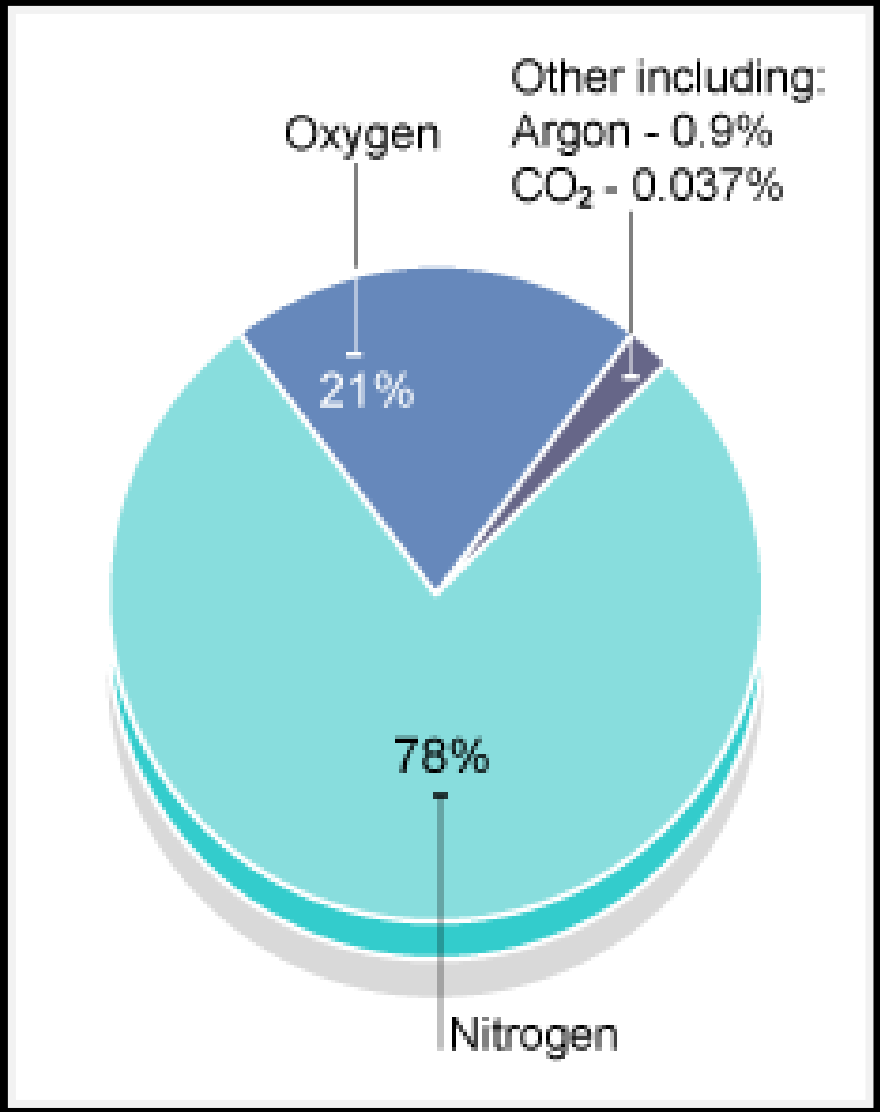
http://www.nature.com/scitable/content/ne0000/ne0000/ne0000/ne0000/59719652/1_2.png

Nutrients

- For plants
- Two sources
  - Atmosphere
  - Soil water solution
    - Water between soil particles…

Elements from the Atmosphere and Water

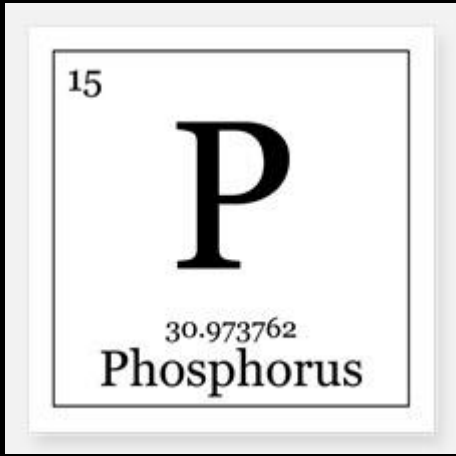
- Carbon, Hydrogen, Oxygen
- 96% dry weight of the plant
- Sugars
- Structures
- Etc.

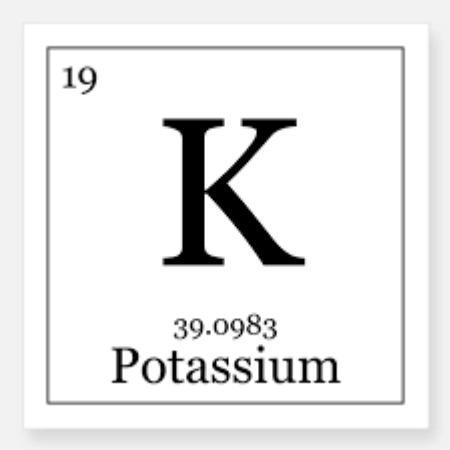


http://www.bbc.co.uk/staticarchive/c0f067f1fda49b3a61d31d9d53b5d11b00c6dd18.gif

Elements from the Soil

- Nitrogen- N
  - Chlorophyll
  - Proteins
  - DNA
- Phosphorus- P
  - DNA
  - Cell division
  - Energy transfer
- Potassium- K
  - Photosynthesis
  - Water transport
  - Sugar transport





www.cafepress.com

Other Macro Nutrients (Soil)

- Calcium
  - Cell wall formation
  - Cell division
  - Signaling
- Sulfur
  - Essential to amino acids
    - (Proteins)
  - Metabolism
- Magnesium
  - Photosynthesis
  - Respiration
  - DNA

Sulfur

https://www.flexicon.com/Materials-Handled/images/sulfur_LG.png

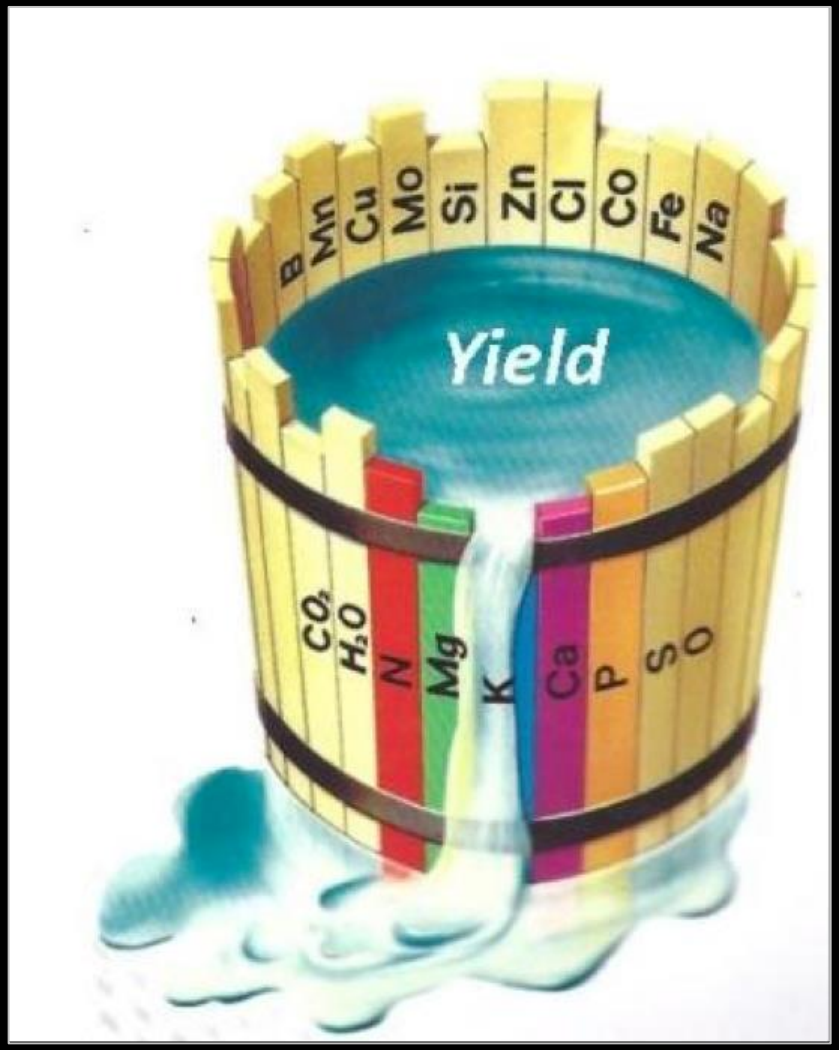
Micro Nutrients

- Iron
- Copper
- Zinc
- Manganese
- Molybdenum
- Boron
- Nickel
- Chlorine

http://images-of-elements.com/molybdenum.php

Liebig's Law of the Minimum!

- Growth limited by scarcest nutrient!



http://fifthseasongardening.com/wp-content/uploads/2013/02/liebigsbarrel.png

Organic Matter

- Source of nutrients
- Source of carbon for microorganisms
- Other nutrient are released over time!
- Manure
  - Good source of nutrients!
  - Not all available to the plant immediately

Bioavailability

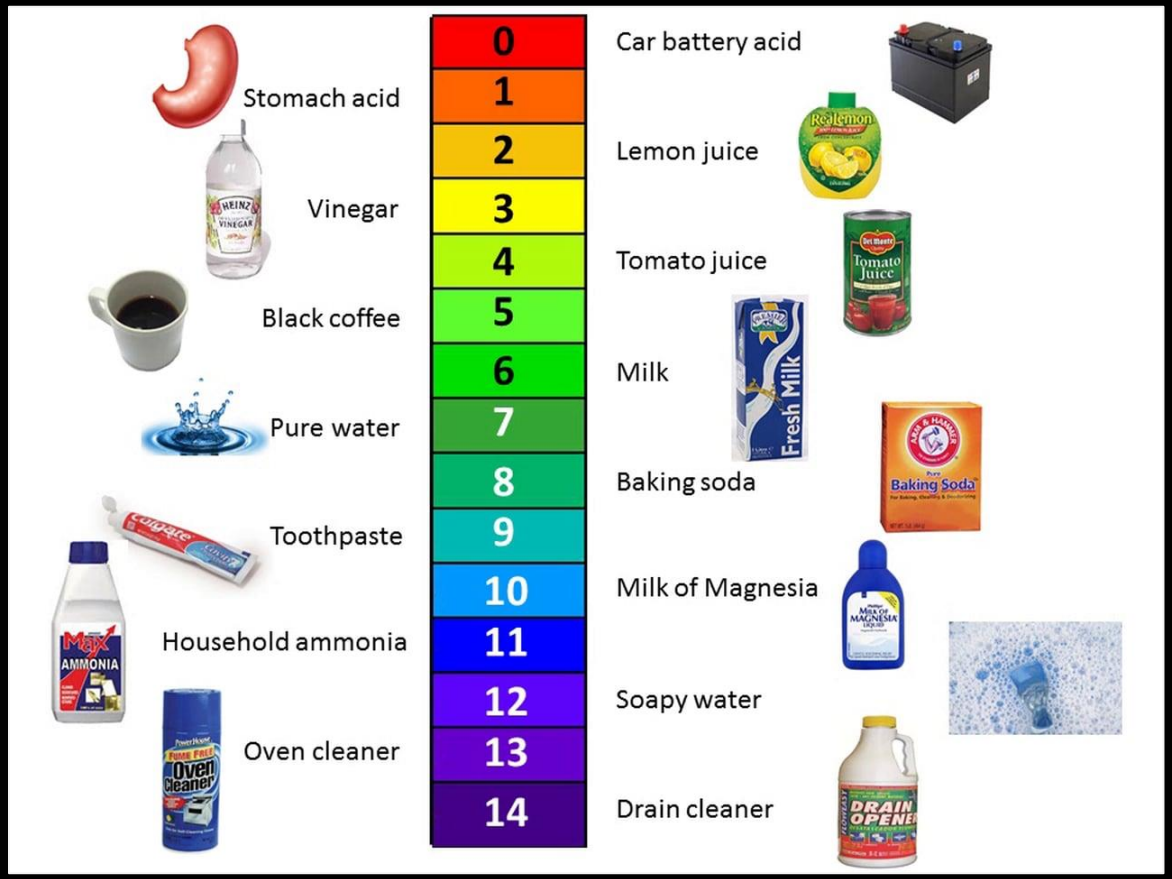
- “Represents the amount of an element or compound that is accessible to an organism for uptake or absorption across its cellular membrane”
- Nitrogen
  - N2
  - 78% of earth atmosphere
  - Not bioavailable…
- Nitrate - N03
- Ammonium Nitrogen - NH4
- *Organic Nitrogen - C-NH2
  - Converted by microbes to Nitrate or Ammonium

http://extension.missouri.edu/p/WQ253

Semple, K. T., Doick, K. J., Jones, K. C., Burauel, P., Craven, A., & Harms, H. 2004. Peer reviewed: defining bioavailability and bioaccessibility of contaminated soil and sediment is complicated. *Environmental Science & Technology*, 38(12), 228A-231A. New York: McGraw-Hill.

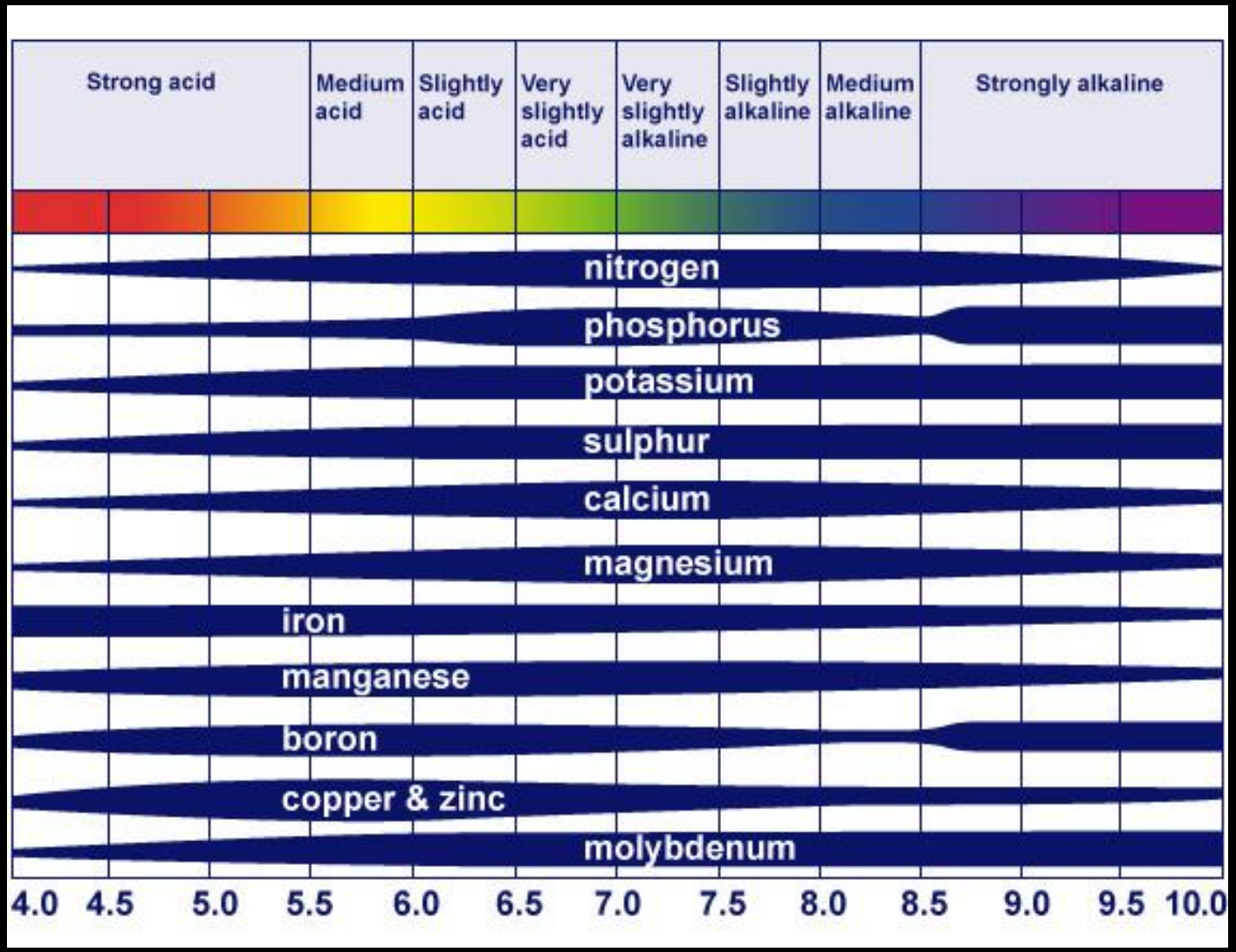
pH

- Measure of Acidity or Alkalinity
- Number of hydrogen ions
- Log Scale



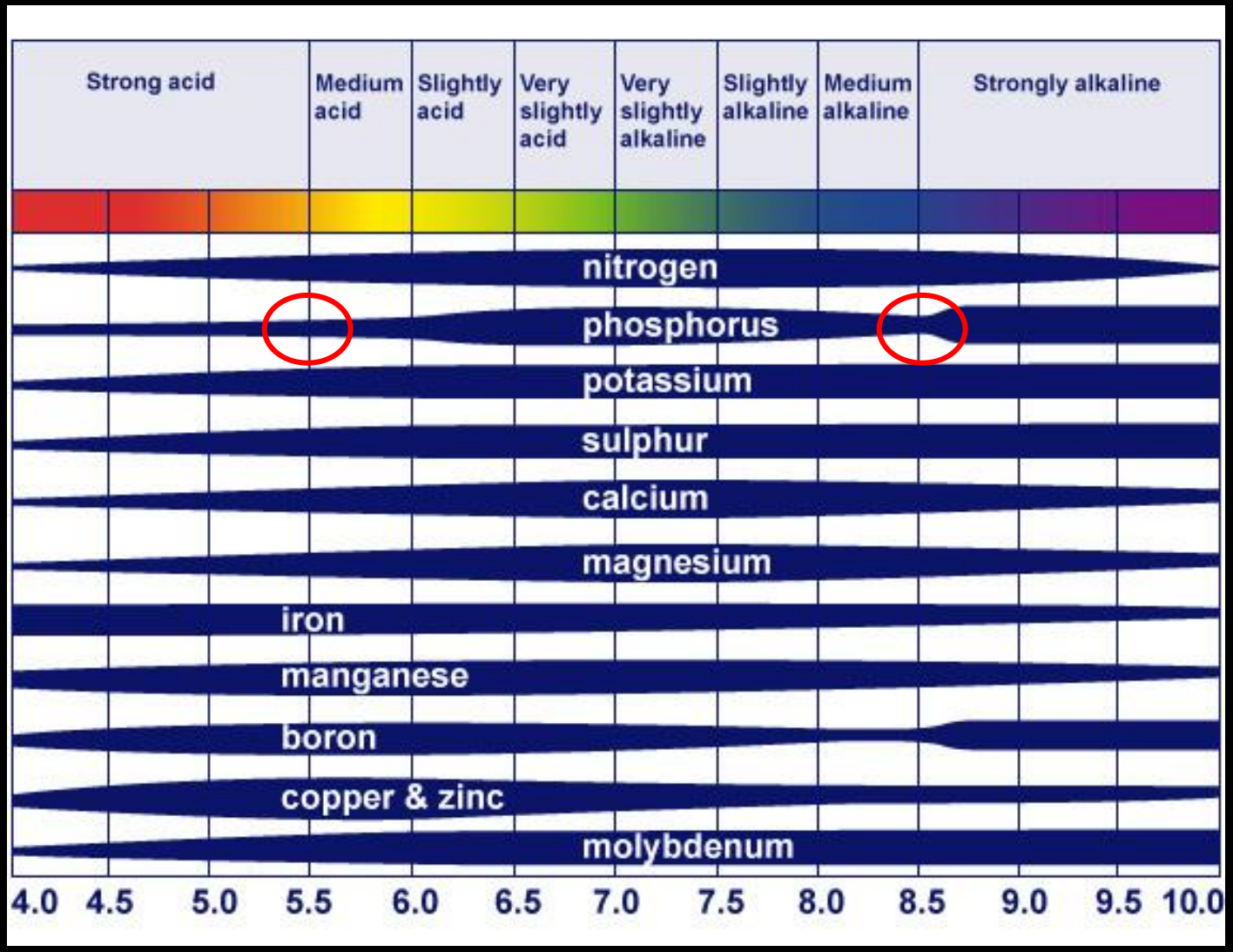
http://i.vimeocdn.com/video/473662386_1280x960.jpg

Ph and Bioavailability



http://www.growing-life.com/shop/gl_soil_ph_table.jpg

Ph and Bioavailability



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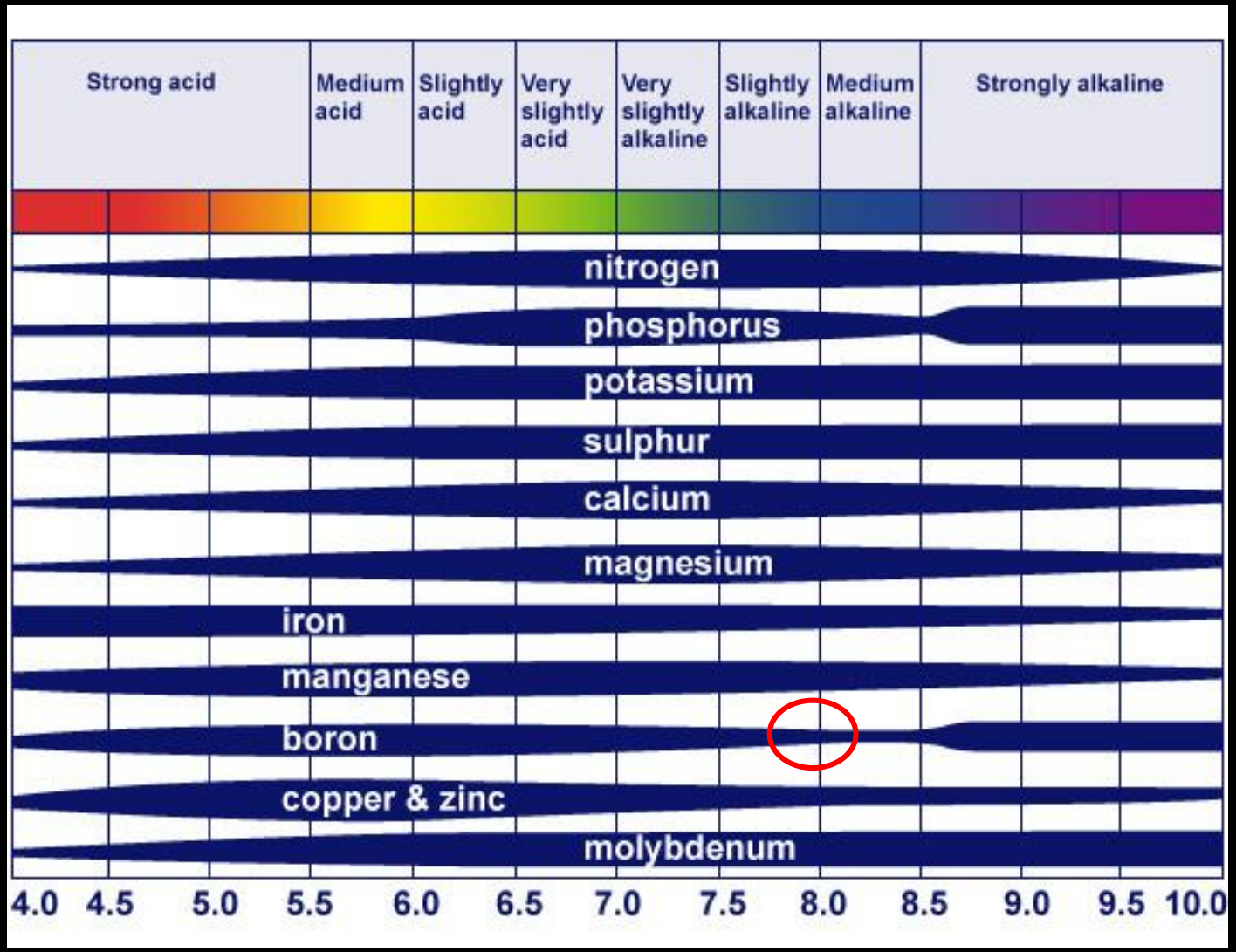


http://www.growing-life.com/shop/gl_soil_ph_table.jpg

How many nutrients do you need?

- Deficiencies
  - Too little
- Toxicities
  - Too much
- Where soil sampling comes into play
- What do you have now?

Fertilization Philosophies

- **Recipe or "cookbook"**

  Apply a fixed amount of fertilizer that seems to have worked in the past. Eventually results in over- or under-fertilization

- **Soil Test Level Maintenance**

  Apply nutrients removed by crop harvest even when the soil test level sufficient. commonly used in Midwest

- **Critical Value**

  Nutrients should only be applied when an economic yield increase is likely

*Slide courtesy of UCCE Advisor: Steve Orloff

So why soil sample?

- Understand your soil
- How to manage
  - Soil texture
  - Soil nutrients
- Track nutrient levels (over time)
  - Avoid deficiencies/toxicities
- Make proper decisions
  - Fertilizer (or no fertilizer)
  - Herbicides
  - Economics

Four Steps to take

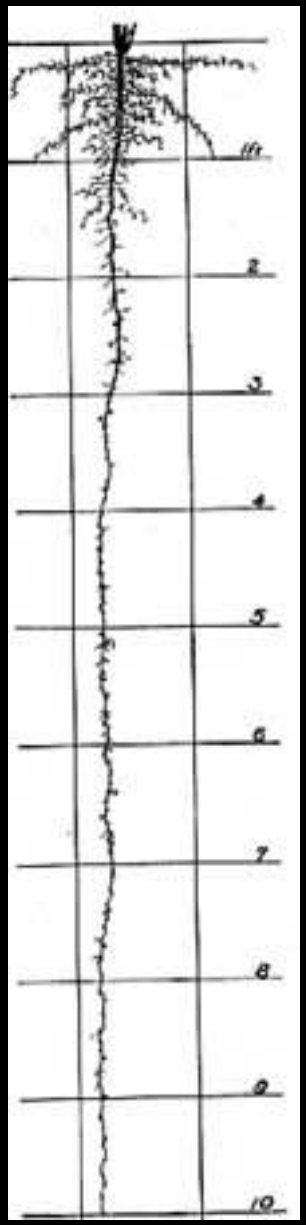
- 1-Sample
  - Representative of the area you are interested in
  - Address variability
- 2-Analysis (extraction in lab)
  - Can vary
- 3-Interpretation of Analysis
- 4-Take action!

http://www.cropservicesintl.com/wp-content/uploads/2014/06/soil-sample.jpg

Acre Furrow Slice

- Variability
- Top 6.7 inches
  - Plow depth
- Alot!! approximately 2,000,000* pounds.
- So “a lot” of material there for plants
- Less than 1 oz. analyzed

- (*Weight - depends on soil density percentage sand, slit, clay, air)



http://plantscience.psu.edu/research/centers/turf/extension/factsheets/acre-furrow-slice

Sampling Design

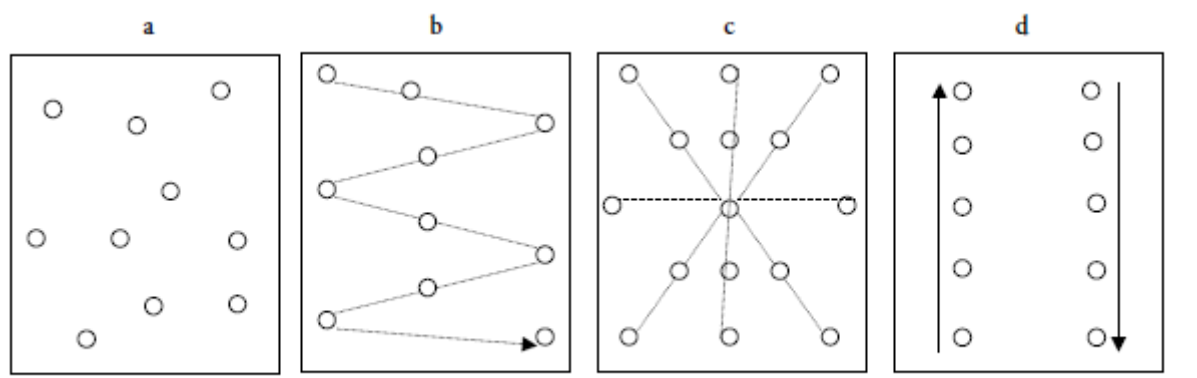
- Whole Field
- “Zone” Sampling
- Grid Sampling

Whole Field

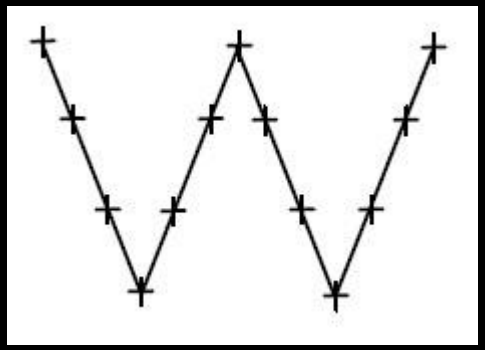
- Uniform management
  - Fertilizer
  - Plant species
  - Cheap (one sample)
- Avoid odd spots
  - Low areas
  - Eroded areas
  - Field edges
  - Fertilizer banded areas

Whole Field Sampling Design

- Take 10-20 soil samples
- Random or systematic
- Good coverage
  - W pattern
  - Grid pattern
  - V pattern



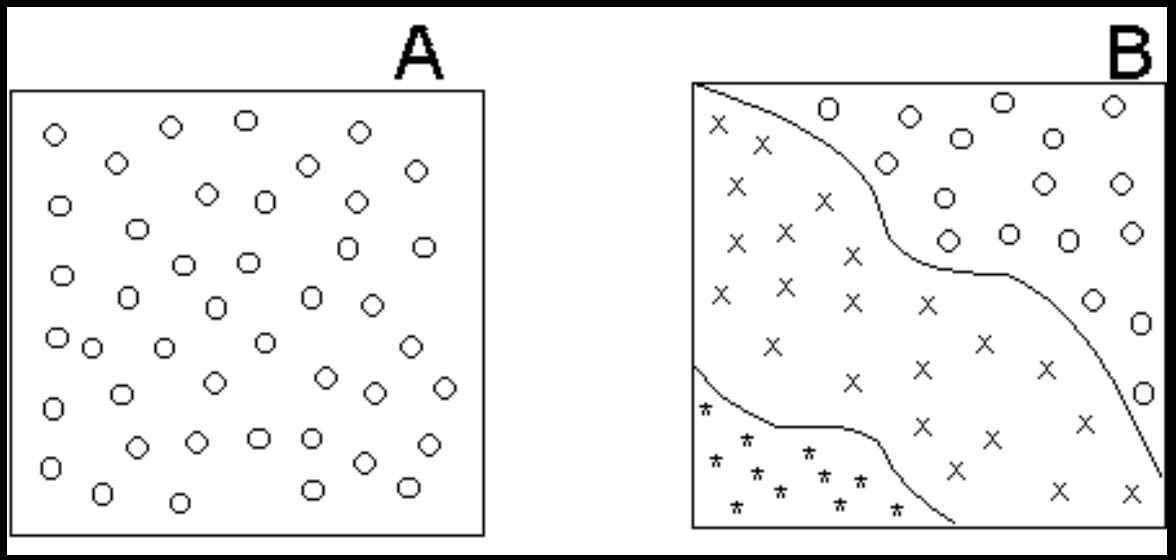
Sampling patterns for nematodes. (a) Random sampling; (b–d) systematic sampling.

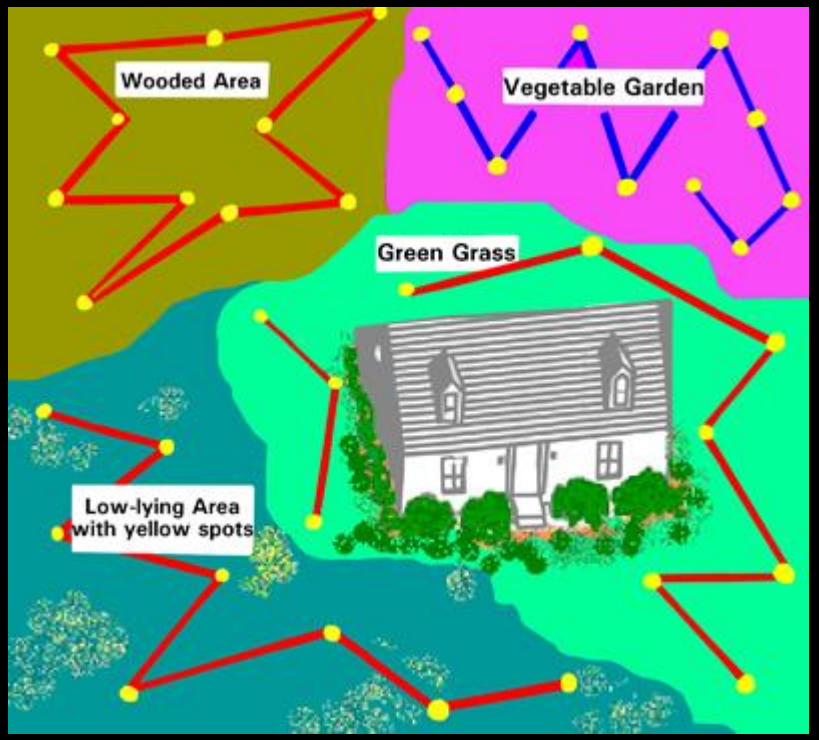


https://cals.arizona.edu/crop/cotton/soilmgt/images/img2.gif

Zone Sampling Design

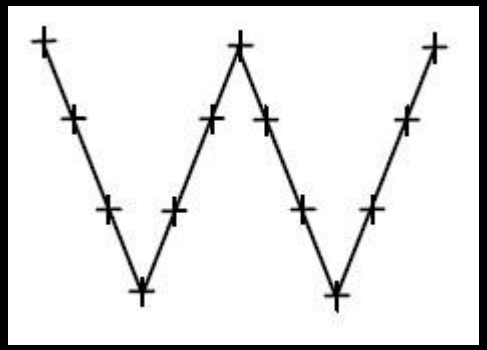
- Field broken down into “zones”
- Works well with prior knowledge
  - Topography
  - Past history
  - Nutrient maps
  - What you are growing
- Enables non-uniform management!
- Typically cost effective

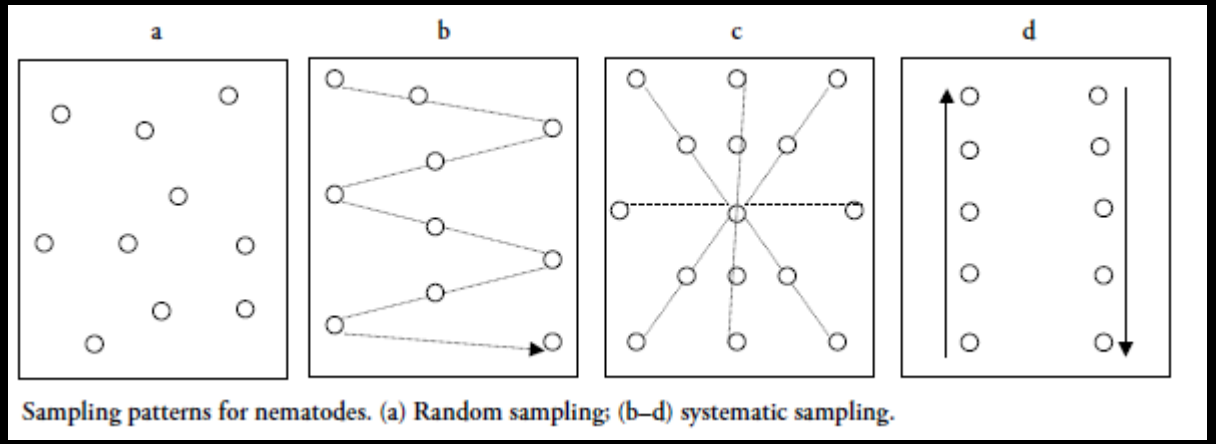




https://cals.arizona.edu/crop/cotton/soilmgt/images/img2.gif

Sampling Pattern





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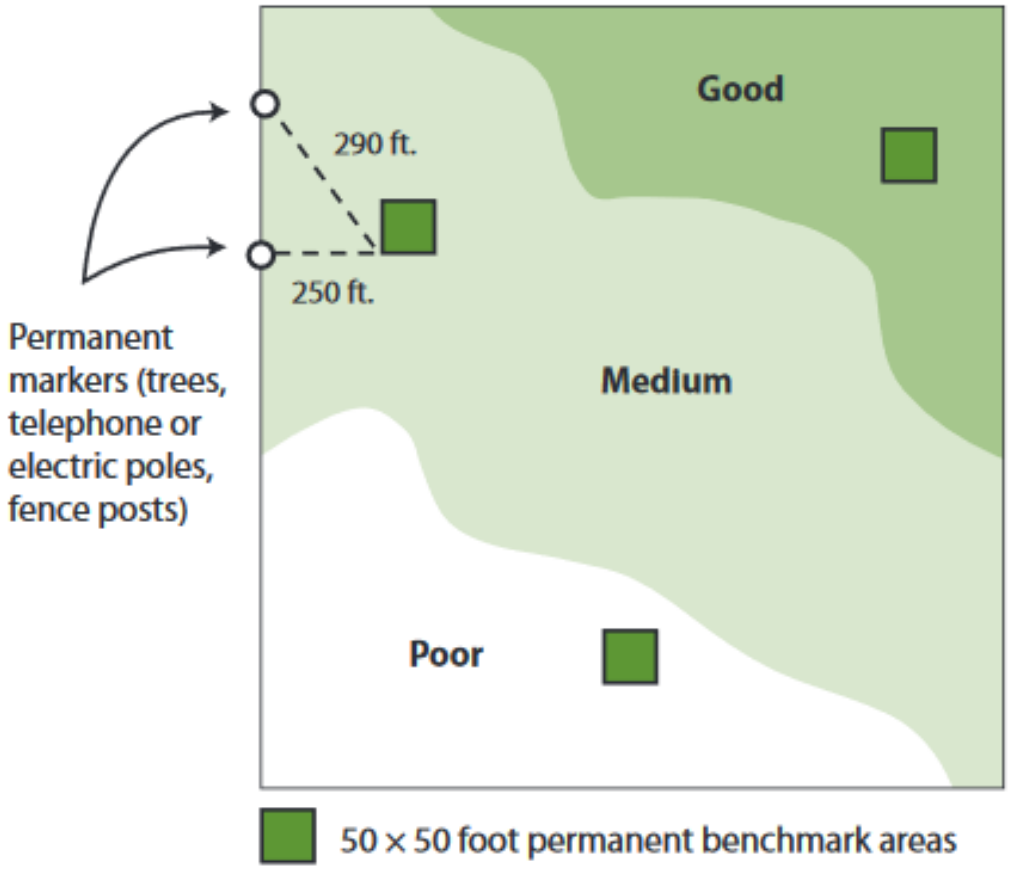
https://cals.arizona.edu/crop/cotton/soilmgt/images/img2.gif

http://agnema.com/wp-content/uploads/2015/07/patterns.png

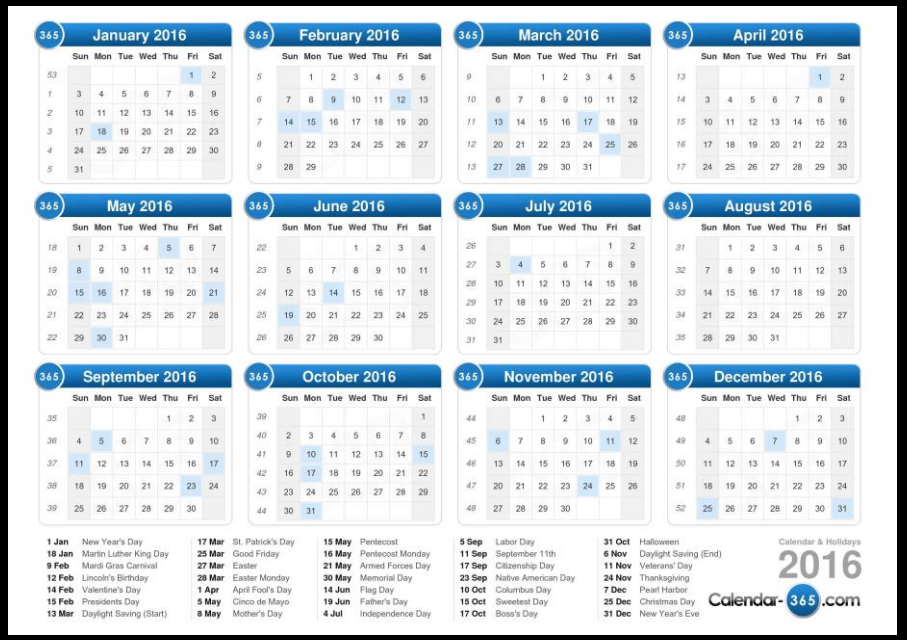
Recommended soil and plant tissue sampling procedures involve establishing permanent benchmark sampling locations (50 × 50 feet or 5 × 5 m) within areas of the field that support good, medium, and poor alfalfa growth. Define these benchmark areas in relation to measured distances to specific landmarks on the edge of the field or use global positioning systems.



http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/pdfs/UCAlfalfa8292Fertilization_free.pdf

Track changes over time

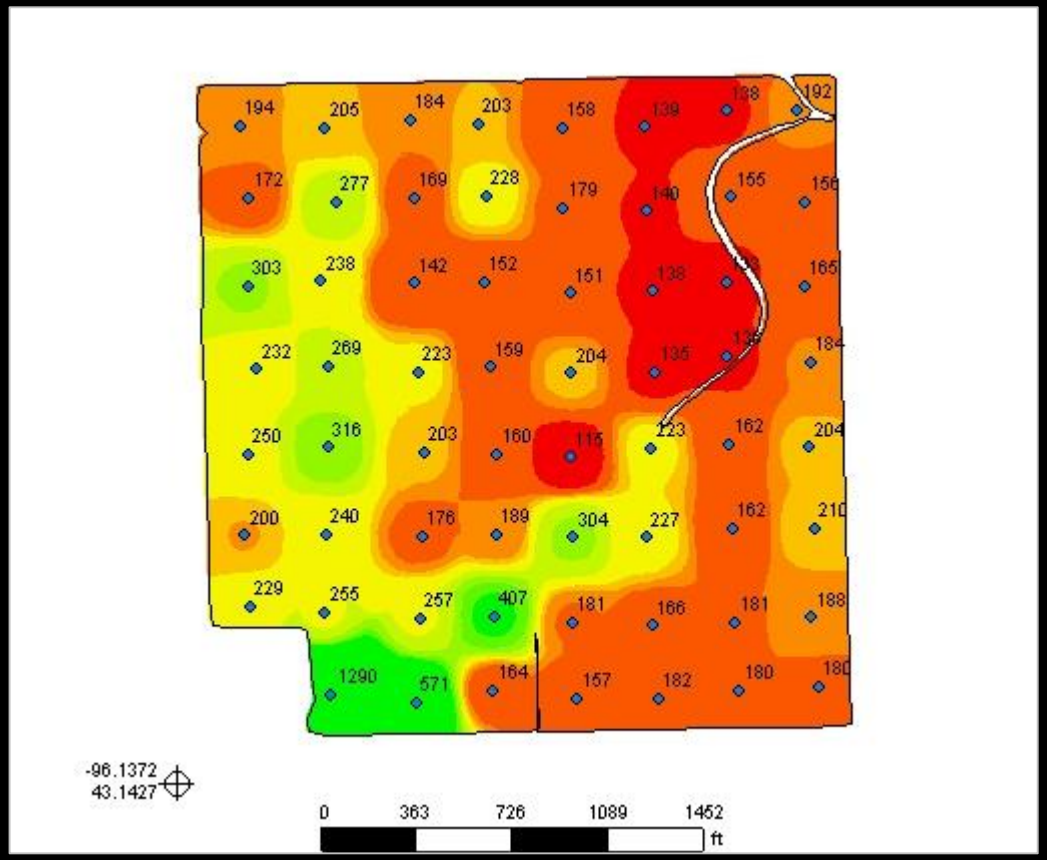
- Sample at the same time of year
- Sample to the same depth
- Run the same tests
- Keep track of fertilizer applications and plants grown.



http://www.calendar-365.com/jpg/2016-calendar-v1.1.jpg

Grid Sampling

- Comprehensive sampling!
  - New area or field
  - Limited prior knowledge (good/bad)
- Site specific management feasible
- Assess variability
- Expensive…

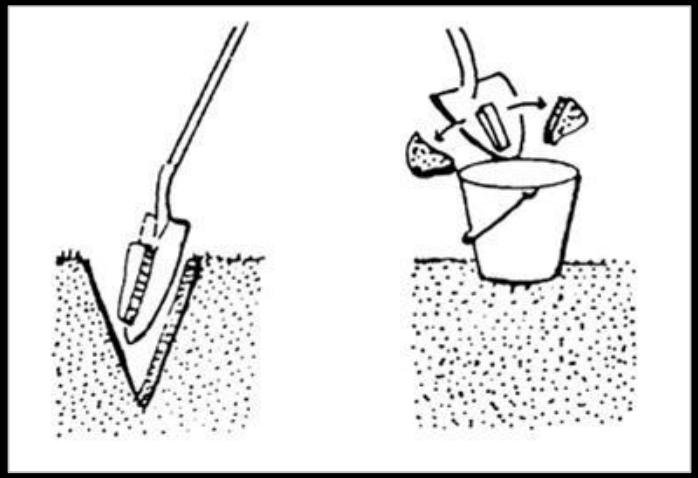


http://www.hullcoop.com/agronomy/fertilizer

Taking the Samples

- Need equipment
  - Probe
  - Agar
  - Shovel
- Bucket
- Bags

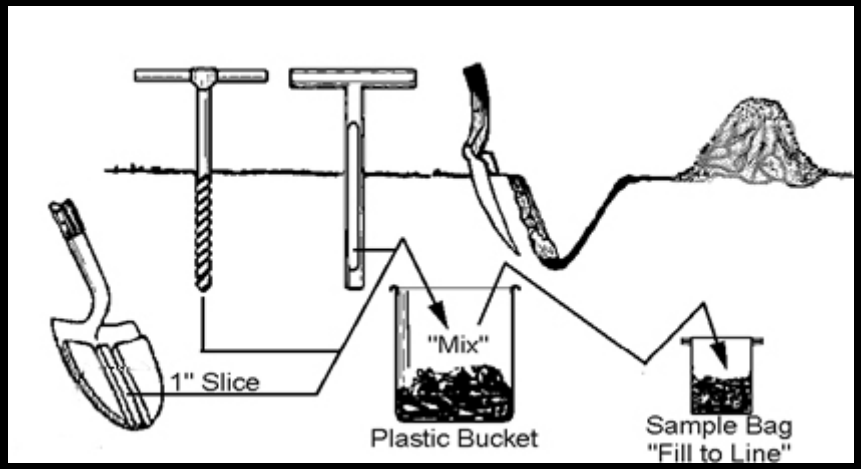
http://cse.ksu.edu/REU/S14/elias940/soil_probe.jpg



http://beyondorganicresearch.com/wp-content/uploads/2011/06/sampling-soil-with-shovel1.jpg

Soil labs provide specific instructions

- Type of bag
  - Paper
  - Plastic
- Pattern
- Number of samples
- Depth
- Etc.



http://outagamie.uwex.edu/files/2012/04/soil-sampling.jpg

What determines sampling depth?

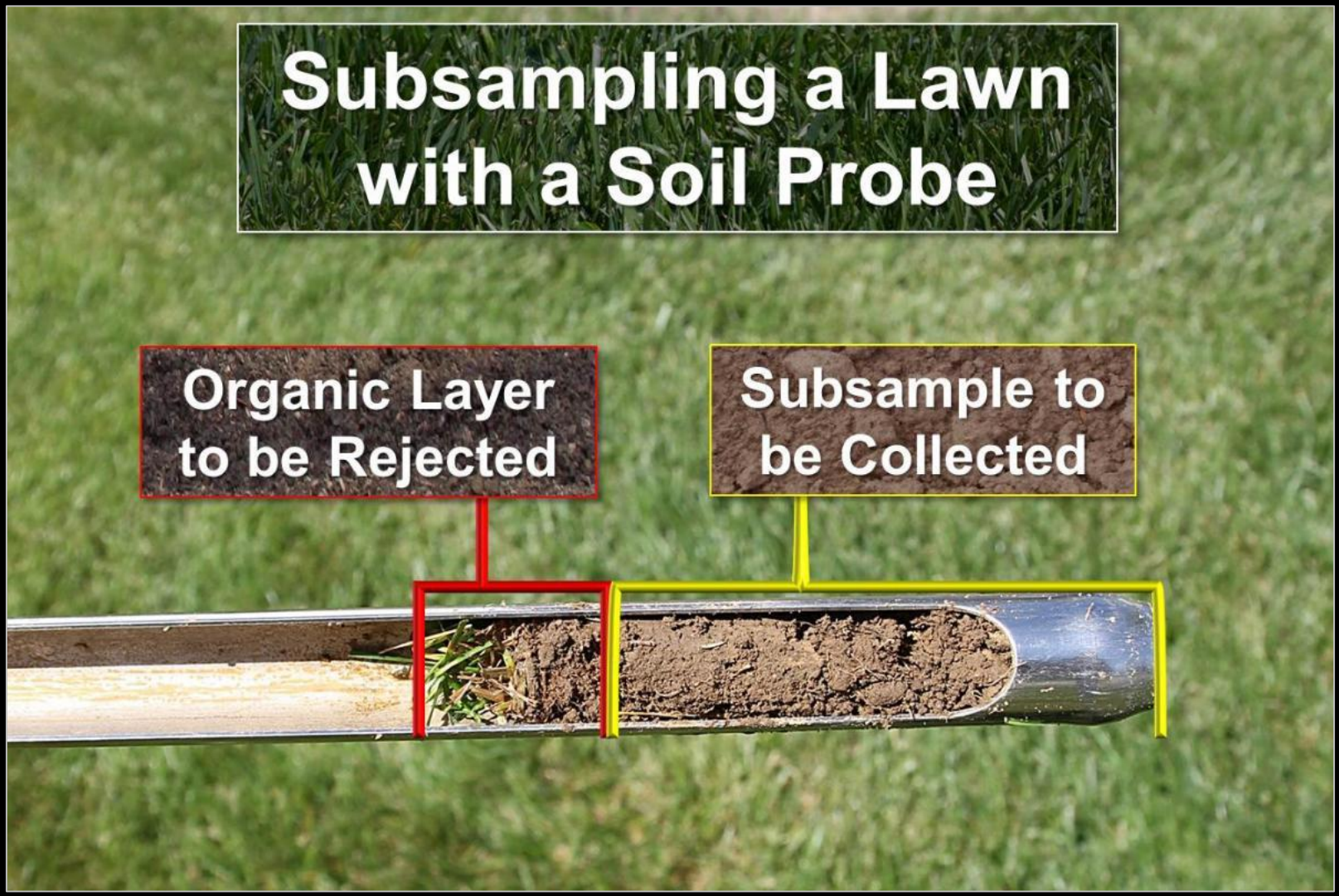
- Why are you sampling in the first place?
  - Elements most interested in
  - Rooting zone of desired plant species
  - Nematode sampling - sample shallow - include feeder roots

https://www.ndsu.edu/fileadmin/_migrated/pics/giddings.jpg

Sampling Depth

- It depends…
- Generally (nutrients/ph)
  - 6-8 inches
  - Plow depth
  - *Critical values
- Nitrate leaching
  - Sample various depths
  - Top eight inches
  - 8-20 inches
  - 20-36 inches

http://www.paulgassfamily.com/prologue/prologue7.html



http://ohioline.osu.edu/sites/ohioline/files/imce/Agriculture_and_Natural_Resources/HYG-1132-Figure-10-Subsampling-Lawn-with-Soil-Probe.jpg

Combining Samples

- Place in bucket
- Mix thoroughly
  - Needs to be uniform!!
  - Acre furrow slice…
- Approx. 2 cups of soil sent to lab
- Some labs - air dry
- Some labs - send wet immediately! (reduce nitrogen loss)

http://www.omafra.gov.on.ca/IPM/images/soil/soil_testing/soil-sampling_2005_044_zoom.jpg

Drying the Sample?

- Check with the lab
  - Some dry
  - Some don’t
- If drying
  - Air dry 24 hours
  - Spread out on paper (1 inch)
  - Fan
  - Stir occasionally

Send Quickly

https://cdn4.iconfinder.com/data/icons/email-2/128/Email_express_mail-512.png

When to Sample

- Typically fall
- Fertilization
  - P and K need time to be available to the plants
  - N does not need time
    - Also can be lost - denitrification/leaching
    - Fertilize with N in the spring.
- Avoid winter
  - Wet/frozen soils difficult
  - Nitrate values off
- Sometimes spring
- Keep it consistent

*photo courtesy of Steve Orloff

Types of Analysis

- Nutrients
  - N, P, K, pH, Ca, CEC, Na, Organic matter, Zn, Fe, Mn, Mg, Na, Cu, Cl, Bo, Su
- Salts (Saturated Paste)
  - SAR, electrical conductivity, Ca, Mg, Na, Ph Cl

http://soiltest.in/images/soiltest.gif

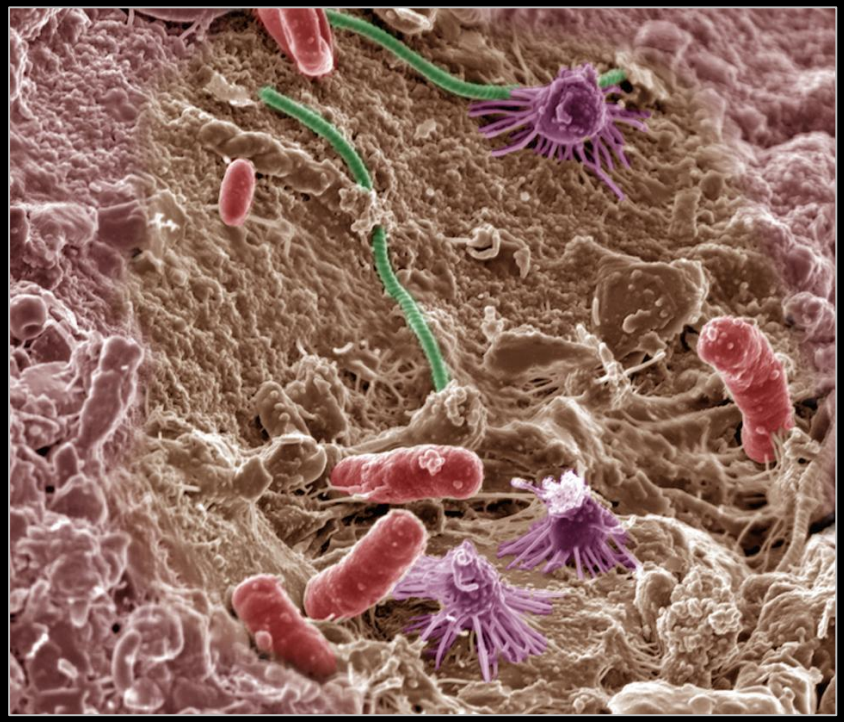
Soil Health

- Soil - not just a medium with nutrients, but alive!
- “A single teaspoon (1 gram) of rich garden soil can hold up to one billion bacteria, several yards of fungal filaments, several thousand protozoa, and scores of nematodes, according to Kathy Merrifield, a retired nematologist at Oregon State University.”

http://extension.oregonstate.edu/gardening/secret-life-soil-0

Biologic Tests

- Biological Test Examples
  - Solvita
  - Hanley
  - Microbe community

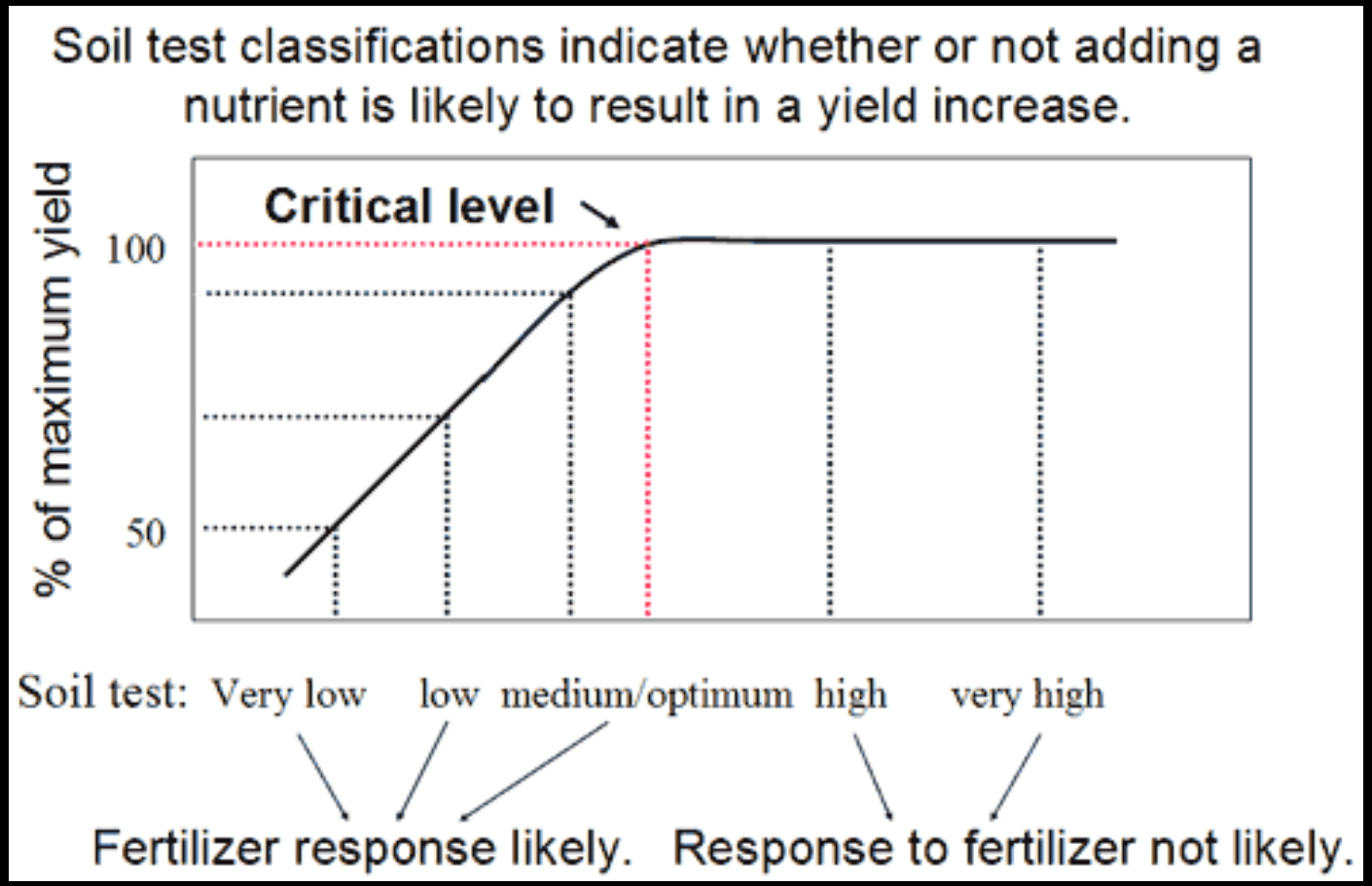


https://www.forbes.com/sites/jamesconca/2016/03/03/microbes-can-handle-global-warming-right/#6b2afedb7fb4

What do the test values mean?

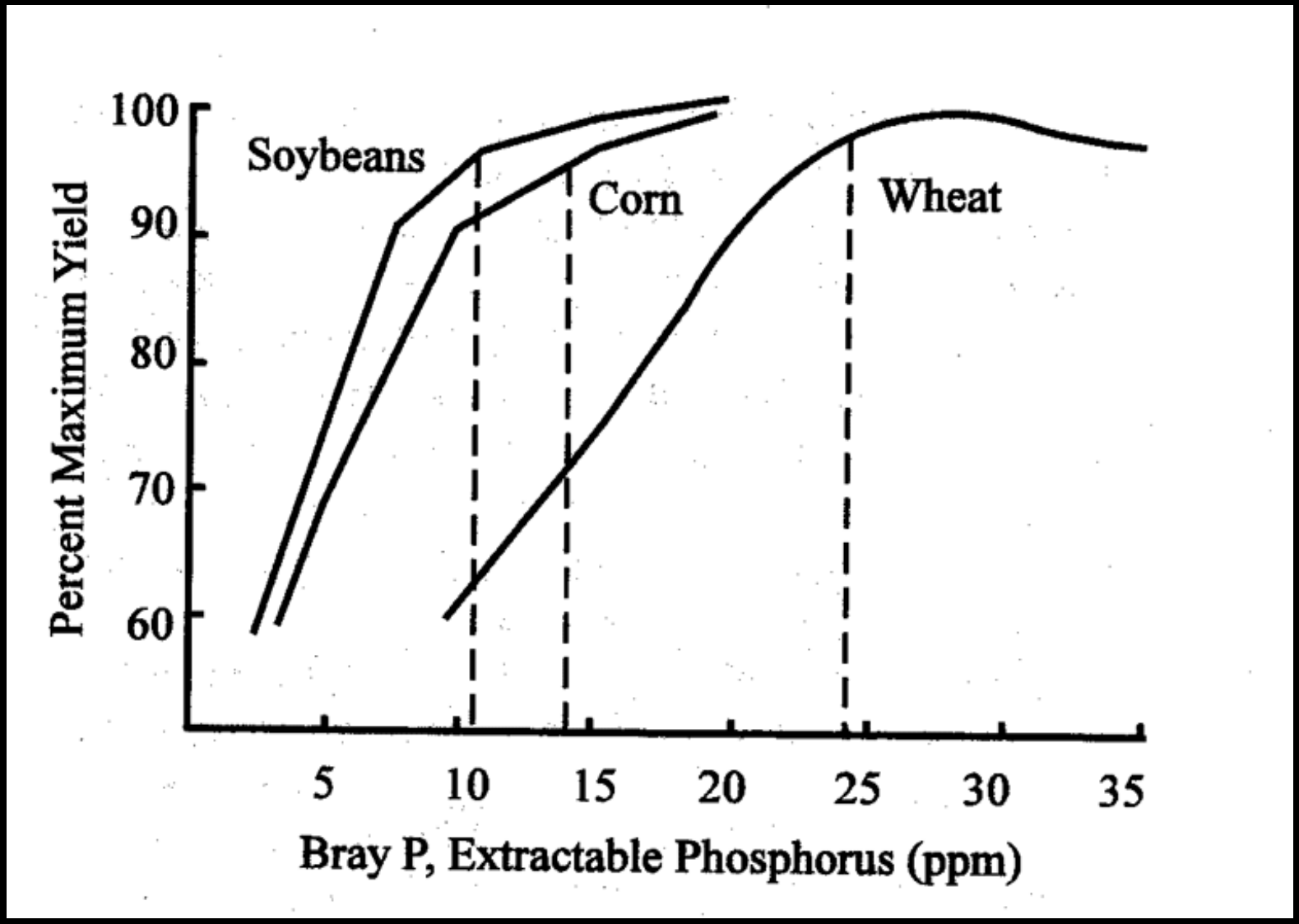
- Critical Soil Test Values
- Lots of research!
  - Crops
  - Conditions
  - Multiple years
  - Specific depth
  - Specific analysis
- Apply fertilizer or not (and how much)

Fertilizer Response Curves



https://courses.cit.cornell.edu/css412/mod3/img/Critical-Level.gif

Example



https://courses.cit.cornell.edu/css412/mod3/img/Critical-Level.gif

Alfalfa Table Example

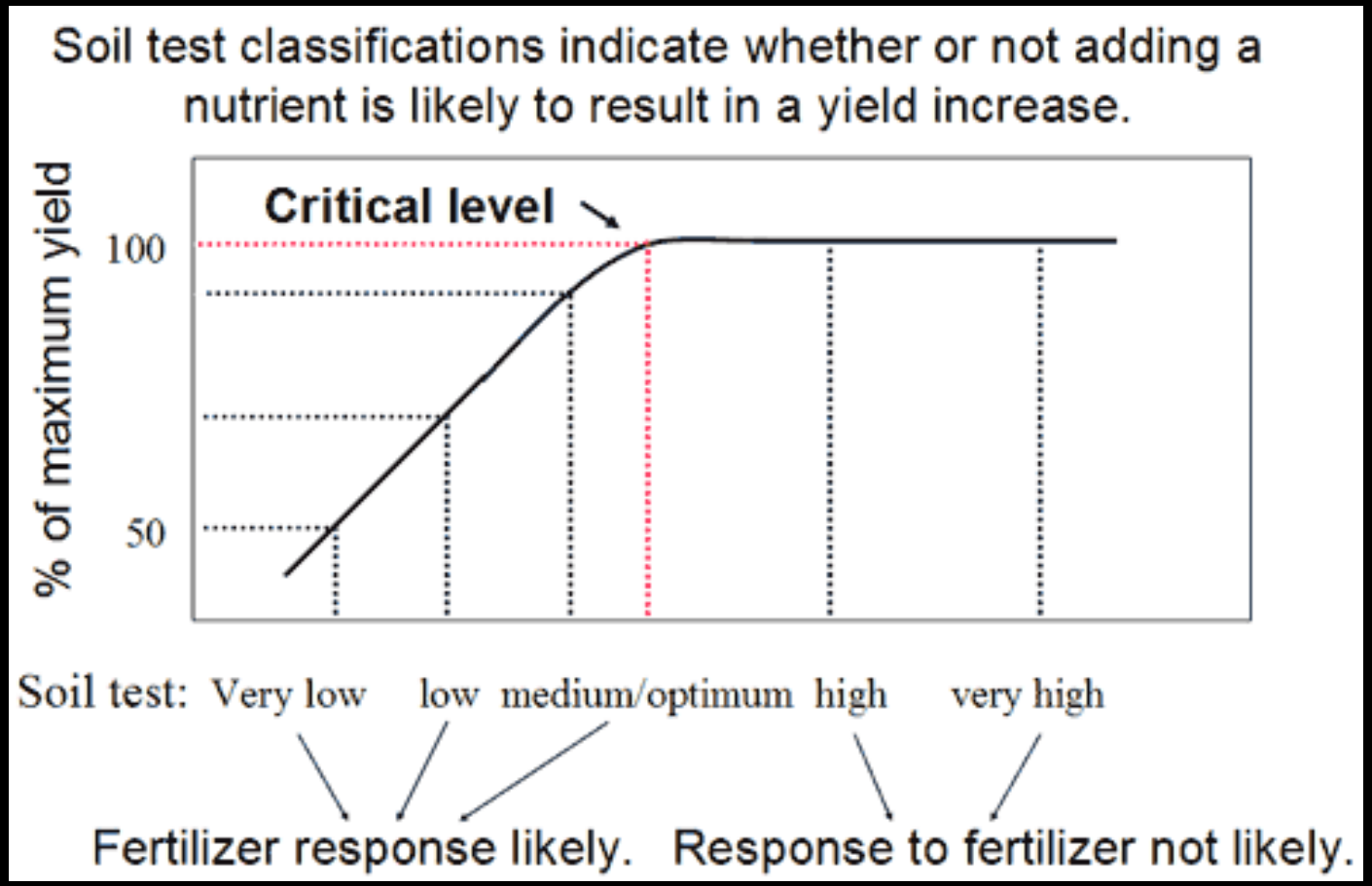
Table 5.5. Interpretation of soil test results for alfalfa production.

NUTRIENT	EXTRACT[2]	SOIL VALUE (PPM)[1]			
		DEFICIENT	MARGINAL	ADEQUATE	HIGH
Phosphorus	Bicarbonate	< 5	5–10	10–20	>20
Potassium	Ammonium acetate	< 40	40–80	80–125[3]	>125
	Sulfuric acid	< 300	300–500	500–800	> 800
Boron	Saturated paste	< 0.1[4]	0.1–0 .2	0.2–0 .4	>0.4[5]

http://ucanr.edu/sites/siskiyou_county_coop_extension/files/117595.pdf


Photo Courtesy of Steve Orloff

Fertilizer Response Curves



https://courses.cit.cornell.edu/css412/mod3/img/Critical-Level.gif

Three Bears and Fertilization

- Not too much
- Not too little
- Just right….

http://clipart-library.com/images/6Ty5nMzRc.png

Other Tests

- Tissue Tests
  - Measure of what is in the plant vs soil
  - More accurate for specific nutrients - Boron/Sulfur
- Irrigation water tests
  - Salts?

Why does it matter?

- Know what plants will grow in your soil
  - PH
  - Soil texture
  - OM
- Gardening
- Crops
  - Yields
  - Deficiencies reduce profit

Why does it matter?

- Fertilizer and soil amendments are expensive!
- Feb 2017 -
  - Nitrogen- 0.38$/lb to 0.42$/lb
  - MAP 11-32-0 $442/ton
  - UAN 32-0-0 $218/ton
  - DAP 18-46-0 $431/ton
  - Potash 0-0-60 $392/ton

https://www.dtnpf.com/agriculture/web/ag/news/crops/article/2017/01/11/retail-fertilizer-prices-start-2017

Herbicides

- PH
- Soil texture
- Soil organic matter
- Plant back restrictions

http://i.ebayimg.com/00/s/MTYwMFgxMjAw/z/0AkAAOSwFTRTrBas/$_35.JPG

http://sustainablepulse.com/wp-content/uploads/2-4-D-Amine-Weed-Killer-Qt.jpg

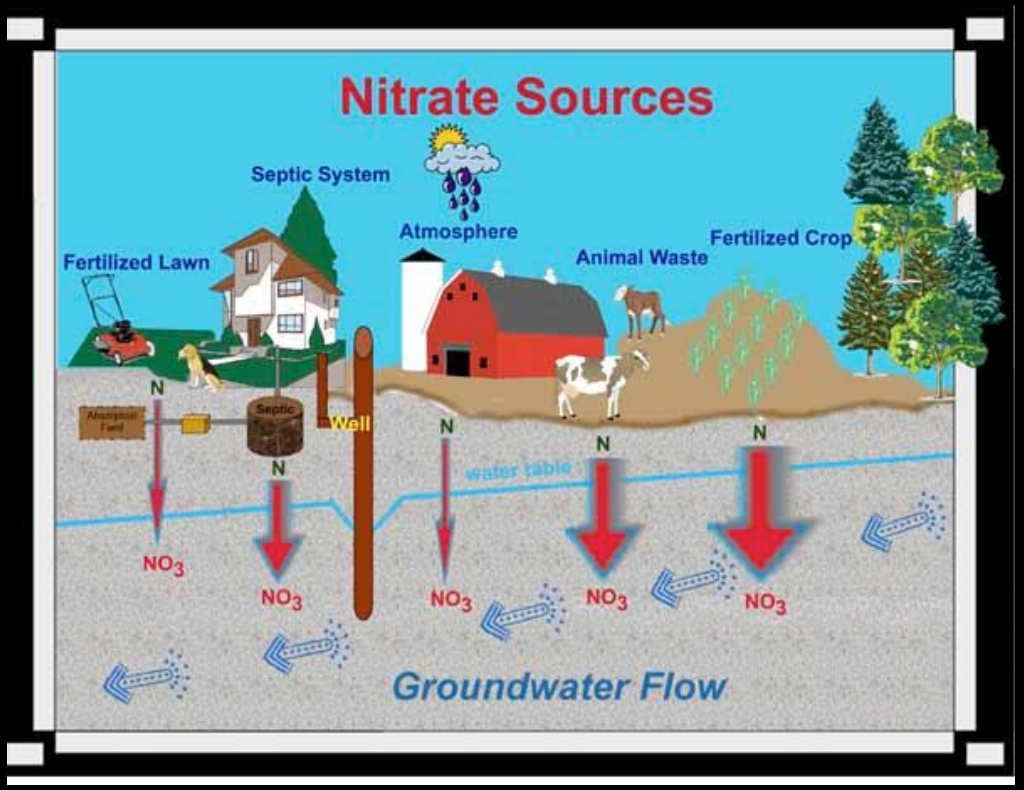
Environmental Harm

- Eutrophication
  - Nitrate and phosphate
  - Leach into water
  - Provide nutrients to aquatic plants and algae
  - Algae blooms
    - Lack of oxygen
    - Toxins
    - Etc.
  - Approx. 60% coastal rivers/bays affected by nutrient pollution

http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar09b_eutro.html

Nitrogen Leaching

- Nitrate -
  - Moves with water through soil into groundwater
  - Balancing act - enough for the crop, not enough to leach
  - Blue baby syndrome
  - Nitrate converted to Nitrite - toxic



http://ww3.co.portage.wi.us/groundwater/undrstnd/Images/NO3Sour600.jpg

Soil Testing Labs

- California
  - http://cesonoma.ucanr.edu/files/27431.pdf
- Other non-California labs of note
  - Stukenholtz Lab, Idaho
    - Lab the Pardner often uses
  - Ward Labs, Nebraska
    - Economical sample prices

http://www.ttlassoc.com/wp-content/uploads/2011/09/Soils-Laboratory-Testing.jpg

Some Soil Testing Resources

- http://sfp.ucdavis.edu/pubs/Family_Farm_Series/Veg/Fertilizing/soil/
- http://cebutte.ucanr.edu/files/152933.pdf

Questions?

Fertilizer Bag

- Three numbers of N-P-K
- 10 pound bag of 16-8-8
- How many pounds of each element?

Fertilizer Bag

- Three numbers of N-P-K
- 10 pound bag of 16-8-8
- How many pounds of each element?
  - 1.6 pound nitrogen
  - .8 pounds phosphorus
  - .8 pounds potassium