“Soil” not “Dirt”

on Small Acreages

Gallatin County Extension

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Why should land owners know something about soils?

- For healthy plants, tasty vegetables, good forage yields, and cover for livestock and wildlife
- To protect the environment
- For efficient use of resources (water, fertilizer, $)

Today's topics

- Soil properties' effect on
  - Water needs
  - Nutrients
- Understand limitations, to know which properties you can influence
- Management for soil health

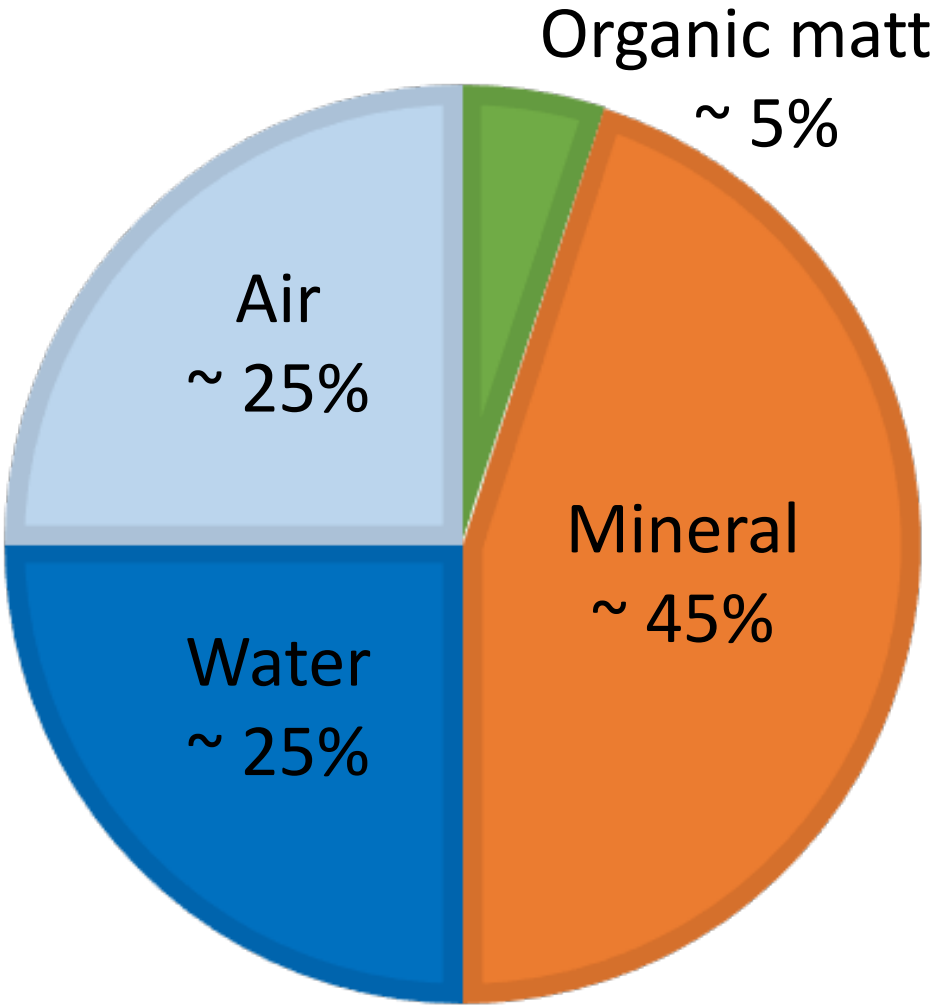
Hands-on is the best way to learn, but we'll use clickers because….

35% A. I just had my nails done

36% B. Clicker training isn't just for dogs

29% C. There isn't enough "dirt" on the floor to get a good soil sample

Average Soil Composition



Soil Properties

Organic matter (SOM)

- small in % volume
- controls >90% of function

pH

Texture

Cation Exchange Capacity (CEC)

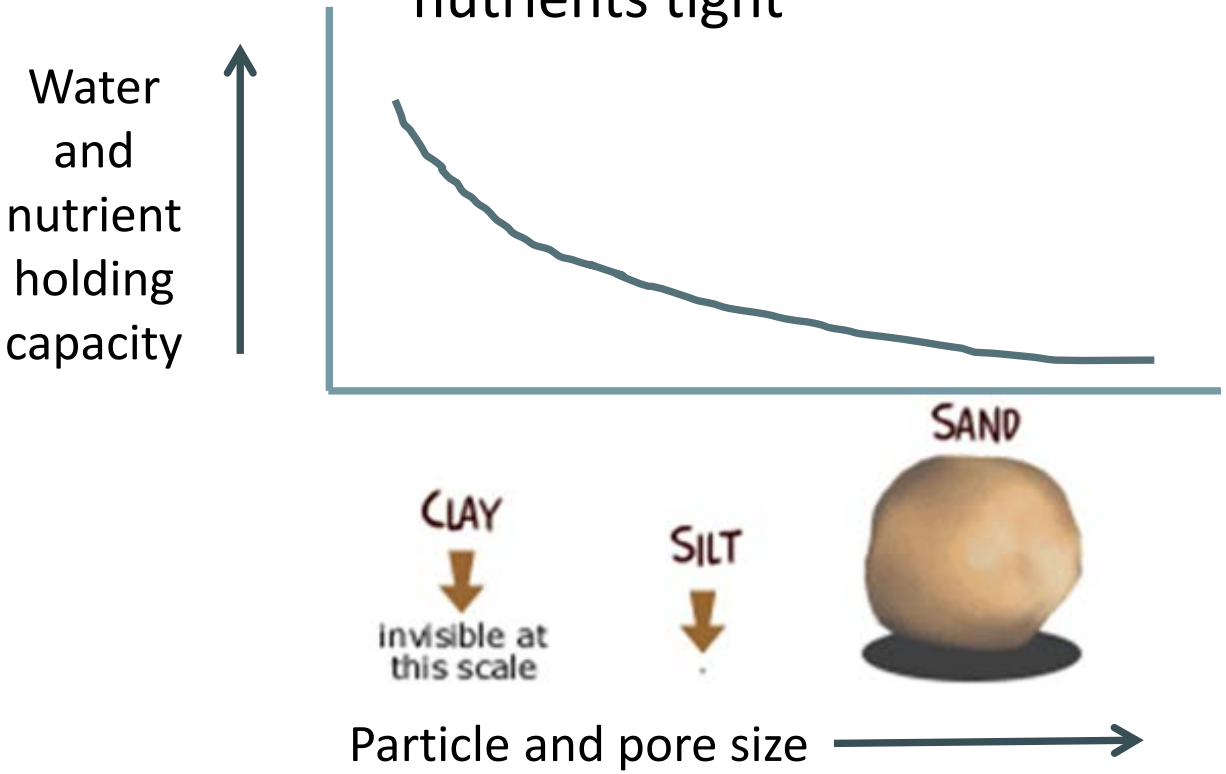
What to look for on a soil test report? Factors affecting plant health and production

Factor	Value	Impact/consider
Nutrient content	Nutrient dependent	Too little = hungry plants, too much = contaminate water, burn plants
Soil organic matter	≤ 1 (%)	Minimize bare soil, increase N, add legumes
	> 3 (%)	Little need for extra N on pasture
Soil pH	< 6	Poor seedling establishment and legume nodulation
	> 8.3	Nutrients tied up
Soluble salts (EC)	> 4 (mmhos/cm)	Too saline, water stress, nutrient imbalance
Soil texture and CEC		Water and nutrient holding capacity

Soil texture

Sand: large pore space, low surface area = low water or nutrient holding capacity

Clay: small pore space, large surface area, often negative charge on surface = holds water and nutrients tight

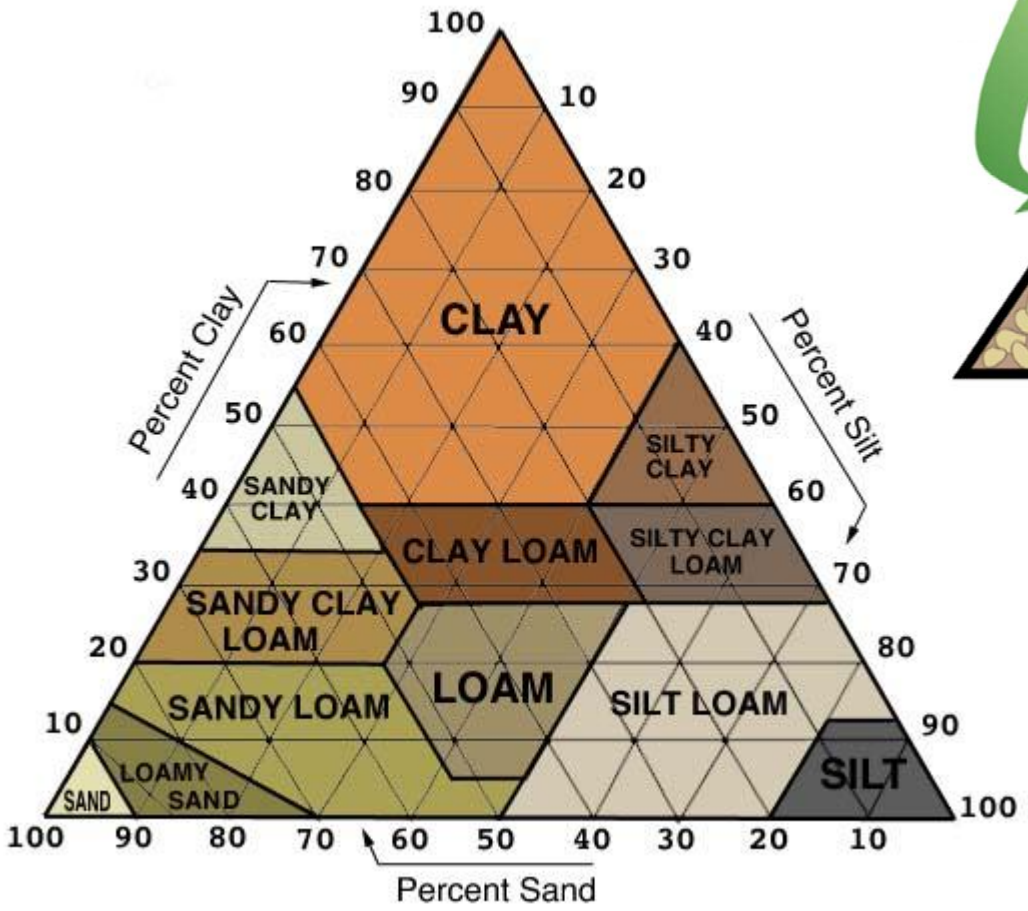


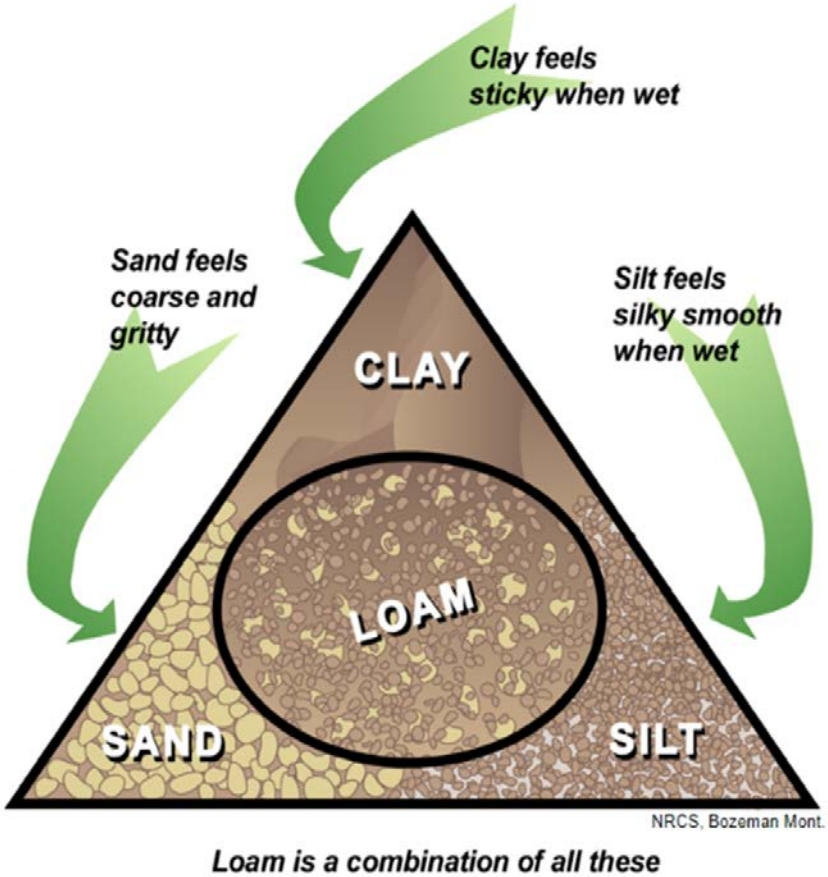
Ideal is **loam** to **clay loam** approx. equal parts of sand, silt, clay

Mason jar texture test

- Fill a straight sided jar 1/3 with soil
- Add water until almost full
- Add 1 tsp dishwasher soap or water softener
- Shake and let settle
- Mark sand depth at 1 min.
- Mark silt depth after 6 hours (or by color/texture change with clay at 24 hr)
- Calculate clay by difference (or measure at 24 hours)

Using the soil texture triangle





Loam is a combination of all these

Texture Effects on Soil Properties

	Drainage Infiltration	Water holding capacity	Aeration	CEC
Sand	excellent	poor	excellent	low
Silt	good	good	good	medium
Clay	poor	excellent	poor	high

Soils with large surface areas, such as clay and organic matter, have more cation exchange capacity and surface area and therefore are generally more fertile.

Texture effect on soil properties

Water holding capacity would seem a benefit.
But, what are problems in clay soils?

- Surface pooling and runoff
- Compaction
- Drowned roots

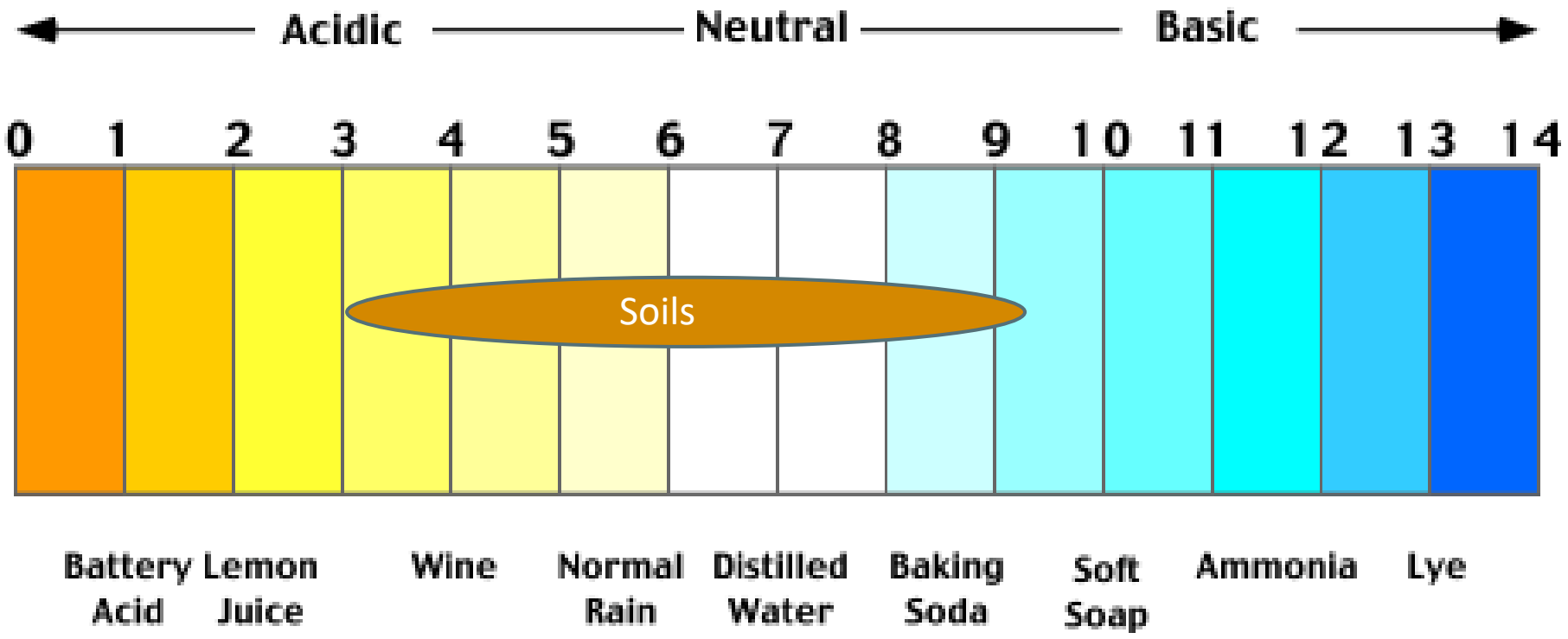
Questions?

On to pH, Cation Exchange Capacity (CEC) and Soil Organic Matter (SOM)

Soil pH – which is true?

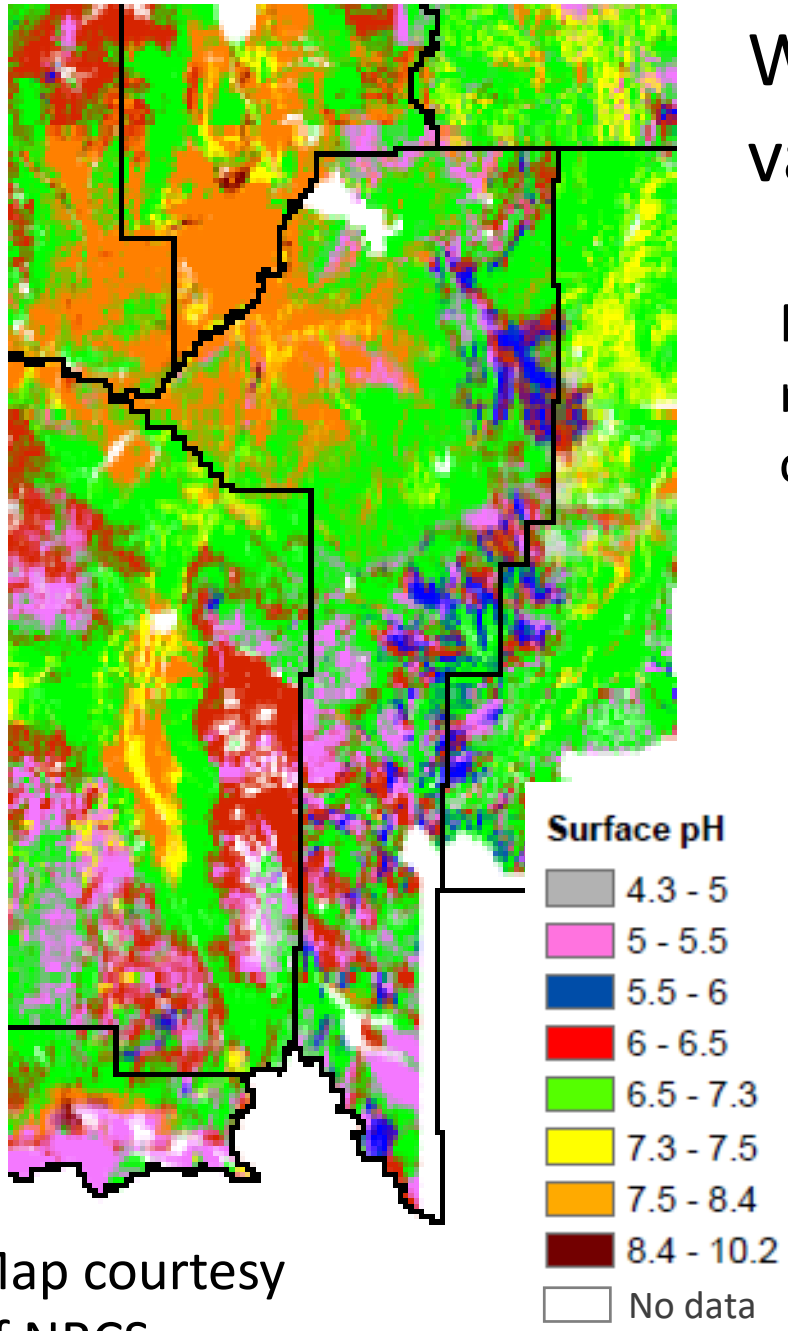
0 of 30

1. Has no influence on nutrient availability — 20%
2. Is difficult to alter — 20%
3. Most vegetables prefer pH > 7.5 — 33%
4. Legumes prefer pH < 6 to fix N — 27%

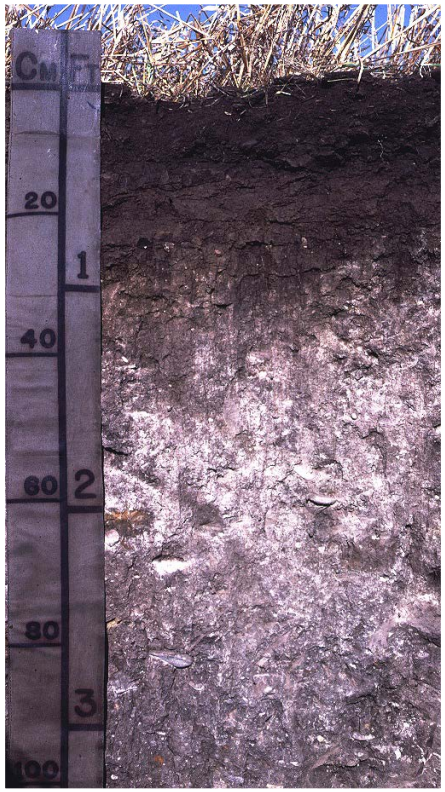


What are surface horizon pH values in this region?

Many arable soils in our region are high pH because of a calcium layer



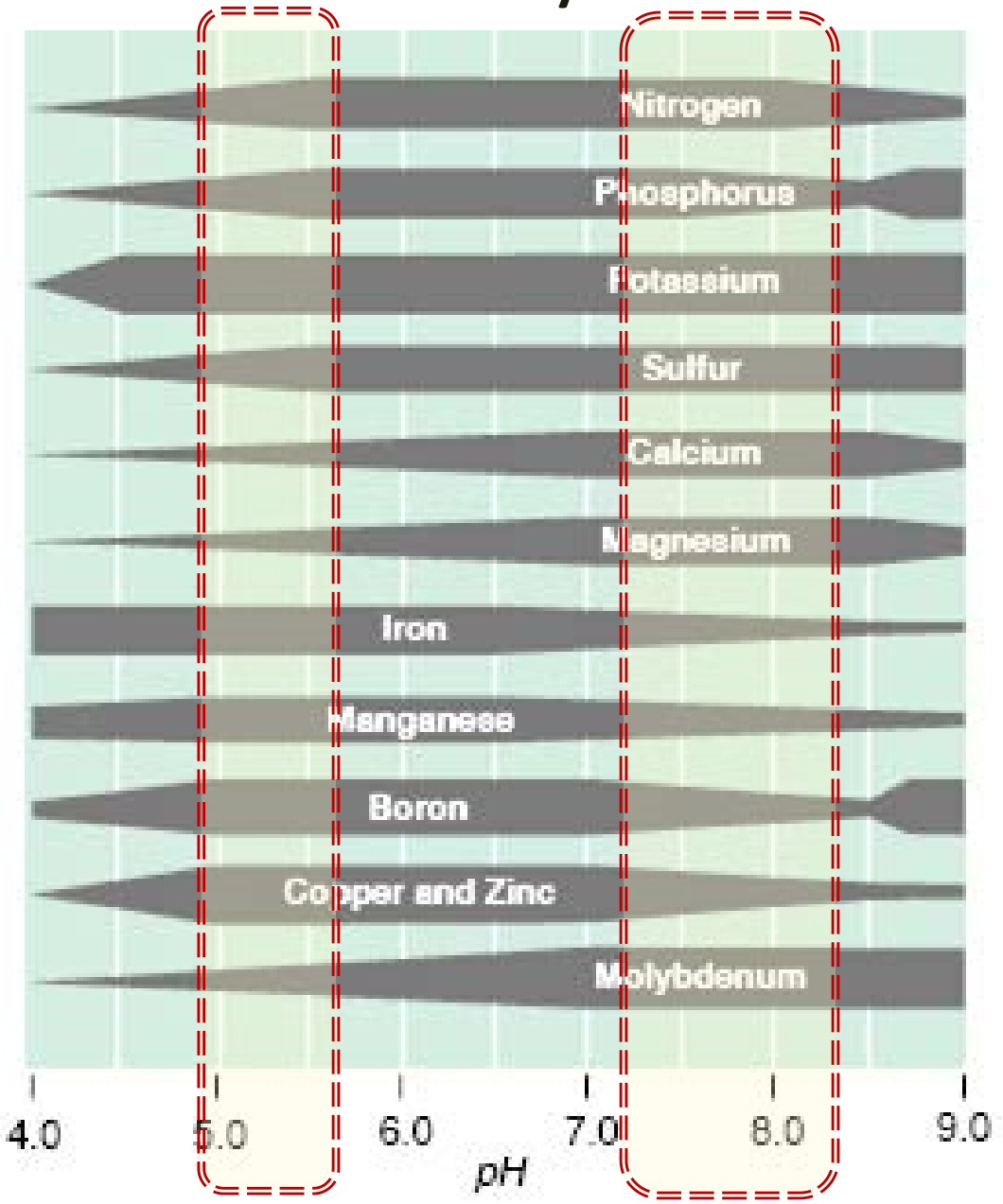
Map courtesy of NRCS



pH affects soil nutrient availability

Low pH, acidic soils – may limit N, Ca, Mg, Mo because they don't stick tight and can leach away (Fe) or form minerals (P)

High pH, alkaline calcareous soils – may limit P, Fe, Mn, B, Cu, Zn because they stick tight to the soil, plant can't get them



What is the best option to lower pH in highly calcareous soils?

17% A. Add elemental sulfur (S)

23% B. Add gypsum ($CaSO_4$)

7% C. Add pine needles

17% D. No reasonable option to lower significantly and QUICKLY on LARGE scale

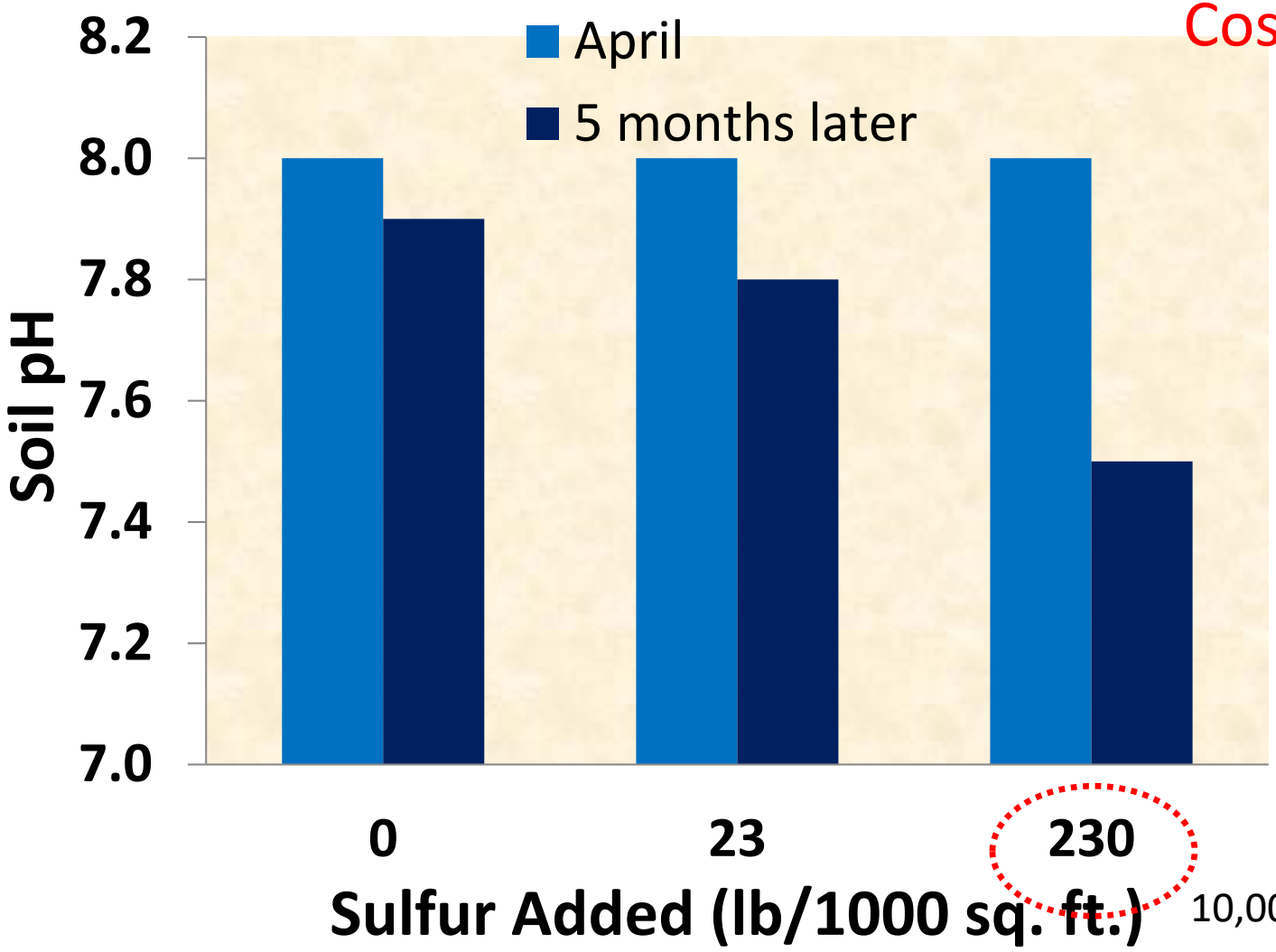
20% E. Use ammonia based N fertilizers (e.g., urea)

17% F. Plant legumes

Adding elemental sulfur

Consequences?

Costs?



10,000 lb/acre

AgVise Laboratories

What might happen if you add 230 lbs S/1000 sq. ft.?

- Soil S levels may become toxic
- Soil salt levels may become toxic
- You spend $366/1000 sq ft

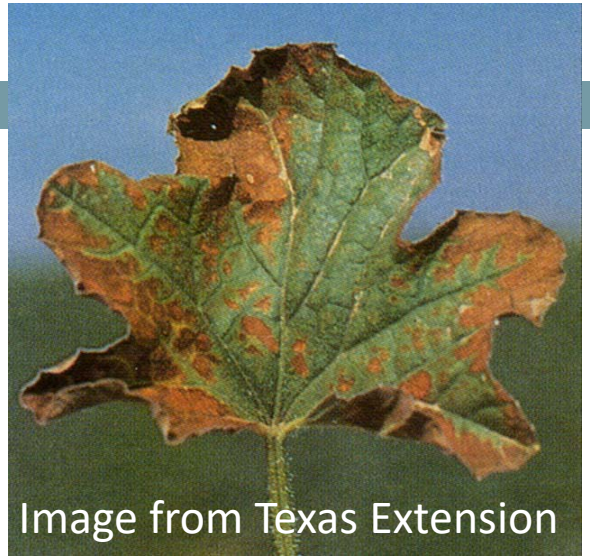


Image from Texas Extension

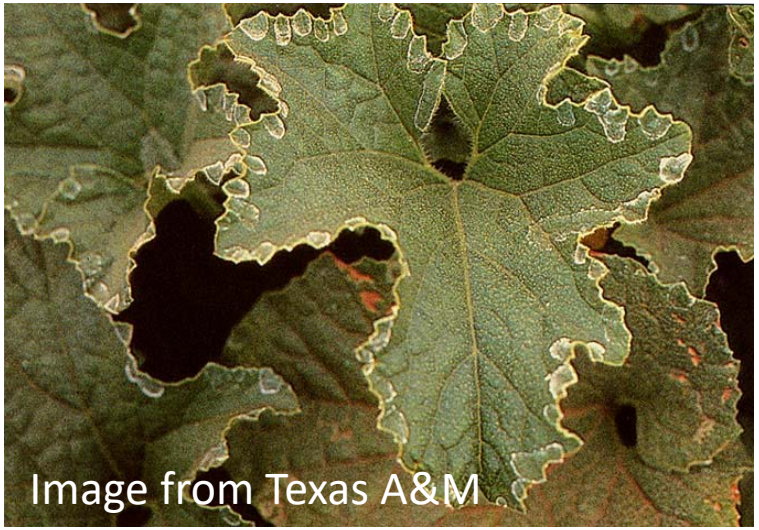
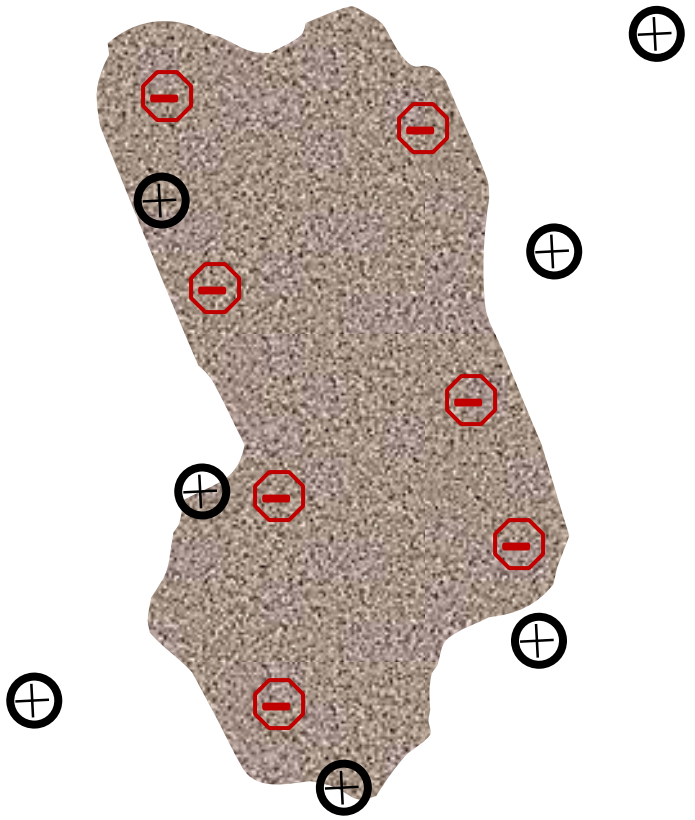


Image from Texas A&M

Cation Exchange Capacity CEC – the parking spaces for nutrients in the soil

- CEC is the total neg. charge on a soil
- A high CEC soil (> 15) has the capacity to attract and hold nutrients with positive charges, e.g., K^+, Zn^{+2}, NH_4^+
- Soils with large surface areas, such as clay (58 meq/100g) and SOM (215 meq/100g), have more CEC and therefore are generally more fertile.
- What else might high CEC soils hold onto?

Herbicides



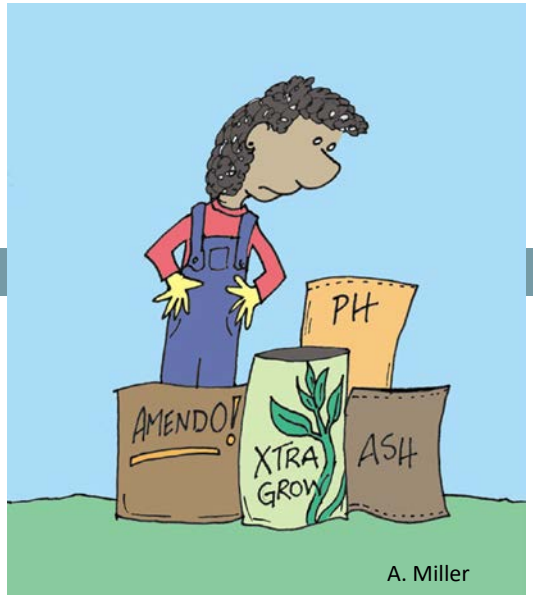
Changing SOM

- We can't change CEC of mineral soil or soil pH very well, but can increase SOM to influence soil CEC
- Guesses on how long to increase SOM from 2.0 to 2.2% (meaning by 10%)?
- SOM can change:
  - relatively rapidly in a garden – gardeners love to add organic matter (discussed later)
  - takes a long time on cropland/pasture – MSU study, CRP (ungrazed, unharvested alfalfa) increased from 1.4% SOM to 1.48% SOM in 10 years in top foot.
  - If you harvest hay, or graze pasture you are maybe maintaining, most likely losing SOM

Questions?

On to soil nutrients

How do I know what to add to my soil???



Six questions to ask yourself before you add fertilizer

1. Which elements do I need? (N, P, K, S, Ca)
2. How much do I apply?
3. What type of material do I use?
4. Which application method is best?
5. When is the best time to apply it?
6. Will I get a return ($ or environmental) on my investment?

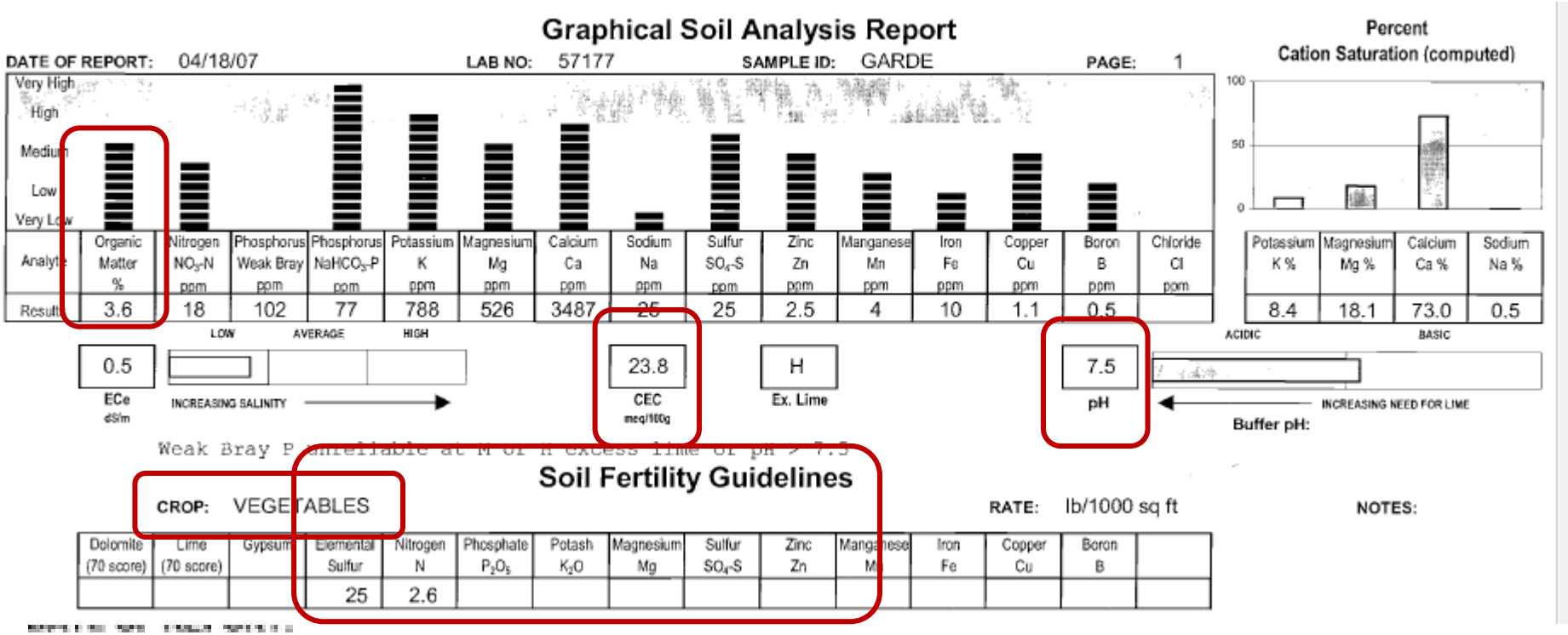
Soil test

- To identify nutrient deficiency or imbalance
- To help calculate fertilizer rates
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks
- Best done in early spring, but not when soil is wet, therefore in our climate perhaps best done in late fall
- See publications listed at end for details on ‘how-to’

How much fertilizer do I need to apply?

- Estimate the amount of fertilizer needed based on soil test results, crop needs and area to receive fertilizer
- Most fertilizer recommendations are in pounds per 1,000 square feet, or pounds per acre
- MSU bulletins MT200702AG, 03AG,and 05AG, and EB0216 and 0217 provide guidelines and example calculations

Gallatin Valley garden soil test report – info provided



Graphical Soil Analysis Report

DATE OF REPORT: 04/18/07 LAB NO: 57177 SAMPLE ID: GARDE PAGE: 1

Very High / High / Medium / Low / Very Low

Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Result	3.6	18	102	77	788	526	3487	25	25	2.5	4	10	1.1	0.5	

LOW AVERAGE HIGH

Percent Cation Saturation (computed)

Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
8.4	18.1	73.0	0.5

ACIDIC BASIC

0.5 ECe dS/m — INCREASING SALINITY

23.8 CEC meq/100g

H Ex. Lime

7.5 pH — INCREASING NEED FOR LIME

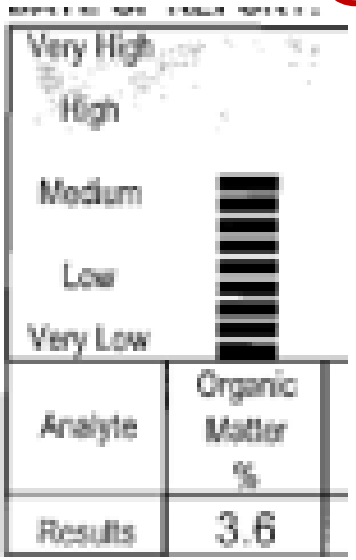
Buffer pH:

Weak Bray P unreliable at M or H excess lime or pH > 7.5

Soil Fertility Guidelines

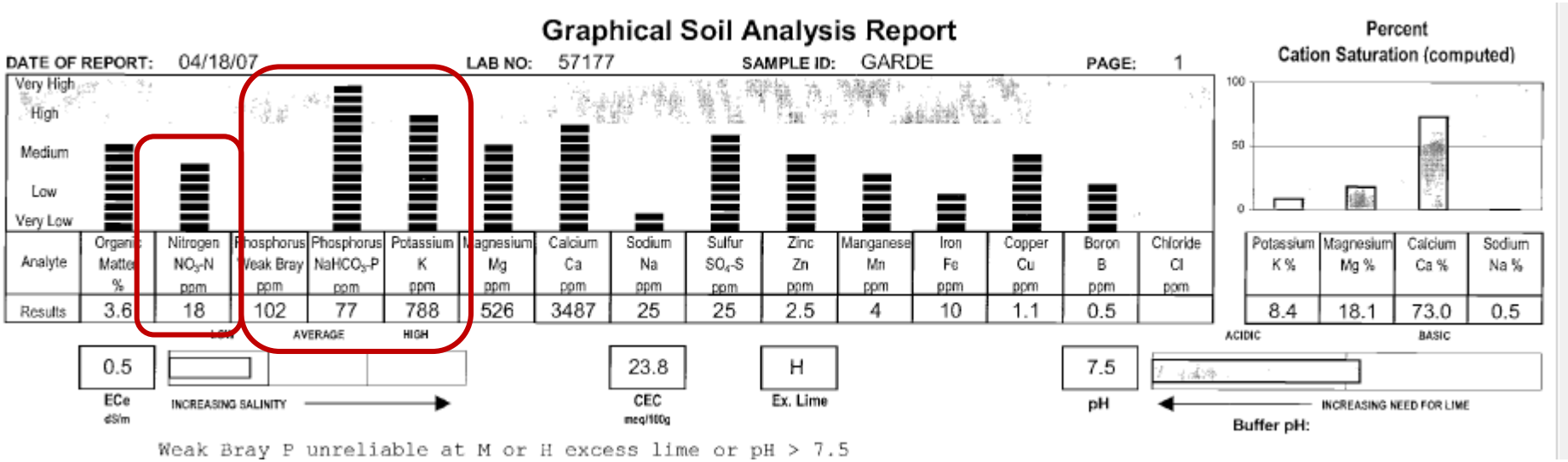
CROP: VEGETABLES RATE: lb/1000 sq ft NOTES:

Dolomite (70 score)	Lime (70 score)	Gypsum	Elemental Sulfur	Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B	
			25	2.6										



- Desired crop
- SOM
- CEC
- pH
- Texture is missing
- Fertilizer rates provided

Garden soil test report – some items to calculate

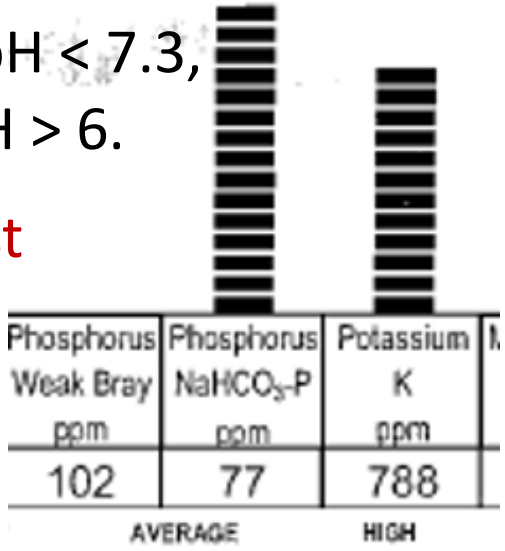


To determine N rate you need:

1. Crop/yield goal
2. Soil sample depth to convert ppm to lb N/acre (ppm x 2 x actual depth in inches / 6)

P rate: MSU guidelines are based on Olsen P.
Bray works in pH < 7.3,
Olsen works pH > 6.

Which P test use in this soil?



Compost can never be applied in excess

54% A. True

46% B. False

- Compost can create excess N, P and K.
- N can contaminate ground water, P can contaminate surface water and excess P and K can limit uptake of other nutrients

Nutrients removed at harvest vs. nutrients in 1” of manure compost

	N	P_2O_5	K_2O
	lbs/1000 sq. ft.		
Removed by annual veg harvest	2.3	0.5	2.7
Added by 1” manure	40	15	40

Very easy to add too much

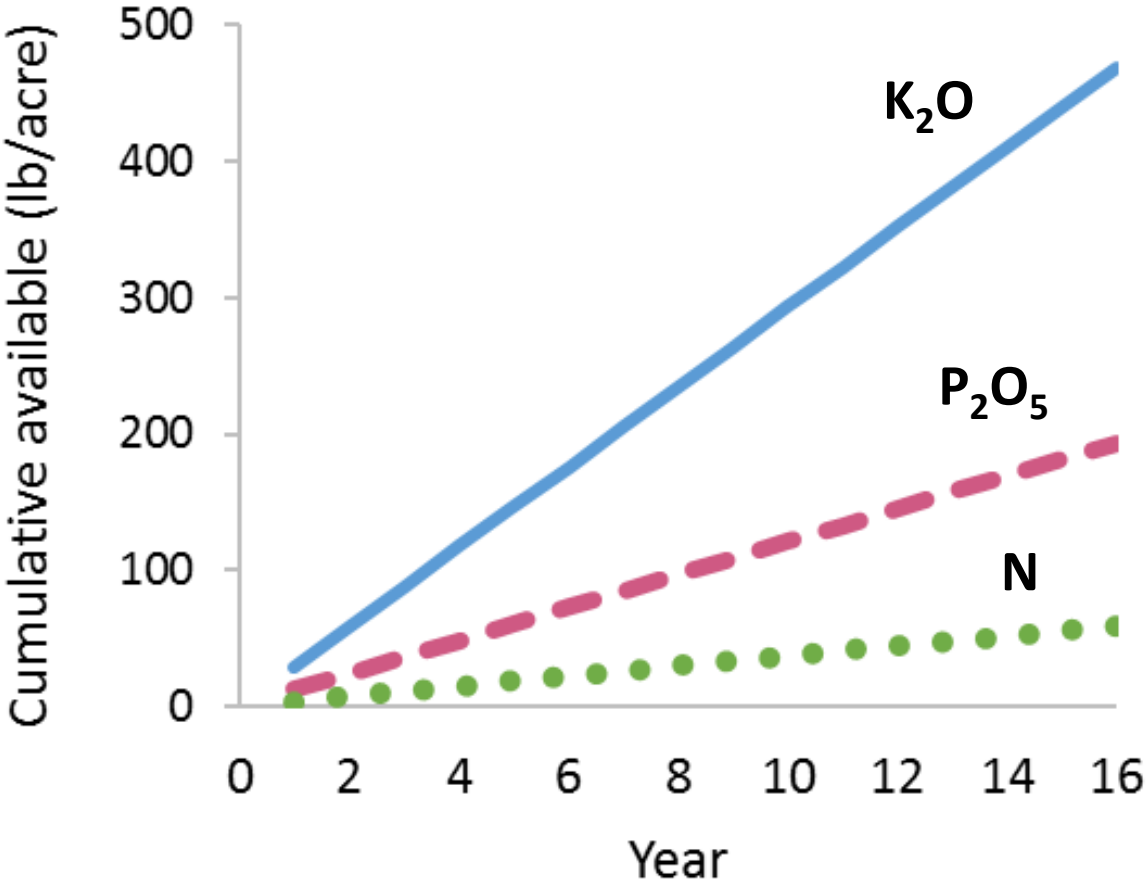
N, P, K added by 4000 lbs ≈ 1” material/1000 sq. ft.

	N	P_2O_5	K_2O	N:P_2O_5
	lbs/1000 sq. ft.			
Annual veg harvest[1]	2.3	0.5	2.7	5:1
Manure compost[2]	40	15	40	3:1
Yard compost[3]	58	8	12	7:1
Green pine needles[4]	57	12	25	5:1
Dry leaves[5]	40	9	18	5:1

1 Univ. Mass, Michigan State, Oregon State, Morris et al., 2007
2 MSU
3 Maryland Urban compost LeafGro and SmartLeaf
4 Pietrzykowski et al., 2018
5 Heckman and Kluchinski 1996

What happens if you supply N with manure?

Rapid excess buildup of P and K if fertilizing to meet N needs



- Of 67 Midwest gardens 92% had excess P and 88% excess K after just 1 to 6 years of 'uninformed' fertilization with composted dairy manure (Hansen unpub data, Ohio State Univ)
- Feed to P and K demands and use legumes or source such as blood meal to supply N

Additional considerations when fertilizing with manure

- Consider the salt content
- Herbicide residual; SOM has huge CEC, CEC holds onto herbicides - know your source!
- Can be full of weed seeds & pathogens
- Prevent water contamination from runoff and leaching


Oregon State Univ.


Chesapeake Bay Prog.

Fertilizing grasses in Montana

- Introduced grasses respond better to N fertilizer than native grasses
- N fertilizer does not need to be applied each year; when conditions are good, plants use the available N stored in the soil
- During dry seasons, much of the N remains for the following year
- At least 2-3 years (up to 5-6 years) of positive response to fertilizer N are likely to occur after application
- Fertilizing grasses at 50 lbs N/acre is more economical over time than fertilizing grasses at 100 lbs N/acre

See resources listed at end for more details

Fertilizer application timing

- Conventional
  - Apply and incorporate (nitrogen) shortly before plants ‘take off’ in the spring
  - Broadcast N fertilizer needs to be incorporated by tillage or ½” water ‘event’
  - Provide additional N mid-season if needed
- Organic material
  - Takes time to decompose and become available
  - Incorporate in the fall or spread composted in the spring, once ground thaws, but before growth starts
  - Do not apply on snow or frozen ground

Questions?

On to healthy soils

What describes a good soil?

- Good aeration, drainage and tilth
- Organic matter and organisms!
- Doesn’t crust after planting
- Soaks up heavy rains with little runoff
- Stores moisture for drought periods
- Has few clods and no hardpan
- Resists erosion and nutrient loss
- Produces healthy, high quality vegetables and crops

How can I manage for healthy soils?

- Know your soil's properties and only add amendments as needed
- Avoid compaction by:
  - Reducing tillage and traffic when wet
- Increase the organic matter content by:
  - Adding compost and manure
  - Moderate grazing
- Maintain cover with vegetation or garden residue

Evaluate soil nutrient status in addition to soil test

- Visual assessment of tissue: may identify what has been lacking to this point, once symptoms appear, yield may already be compromised.
  - Flow chart in Nutrient Management Module 9 http://landresources.montana.edu/nm
  - Flowchart and examples posted at http://landresources.montana.edu/soilfertility/nutrientdeficiencies.html
- Tissue concentrations, not an exact science either

What is/was deficient here?

57% A. Ability to spell

23% B. Time to read the bag label

20% C. Shouldn't have let the fairies handle the spreader

ID of 'problem' is not always clear cut

Evaluate and adjust

- Indicators of soil nutrients: yield, quality (taste, appearance, forage nitrate), nutrient deficiencies or toxicities
- Use this year's observations to fine tune rates next year
- What else might be unique to your operation to consider that isn't on a soil test? Depth to water table, other?
- What other tools?

Summary

- Understanding soil properties guides proper fertilization
- Soil testing is an important tool to calculate fertilizer rates, maximize plant heath, protect environment
- The right source, rate and timing leads to optimal fertilizer use and plant health.
- Observe and adjust to your specific conditions

Resources

On soil fertility website under *Extension Publications*

http://landresources.montana.edu/soilfertility/

- *Soil Nutrient Management for Forages: N* (EB0217)
- *Soil Nutrient Management for Forages: PKSMicros* (EB0216)
- *Home Garden Soil Testing & Fertilizer Guidelines* (MT200705AG)
- *Soil Sampling Strategies* (MT200803AG)
- *Interpretation of Soil Test Reports for Agriculture* (MT200702AG)
- *Developing Fertilizer Recommendations for Agriculture* (MT200703AG)
- *Soil Sampling and Laboratory Selection* (4449-1) http://landresources.montana.edu/NM/
- *The Soil Scoop* http://landresources.montana.edu/soilfertility/soilscoop.html

Resources

At online MSU Extension catalog
http://www.msuextension.org/category.cfm?Cid=1

- *Using Manure as Fertilizer* (EB0184)
- *Home Composting* (MT199203AG)
- *Manure Composting* (MT201206AG)
- *Dryland Pastures in MT and WY* (EB0019)

QUESTIONS?