“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

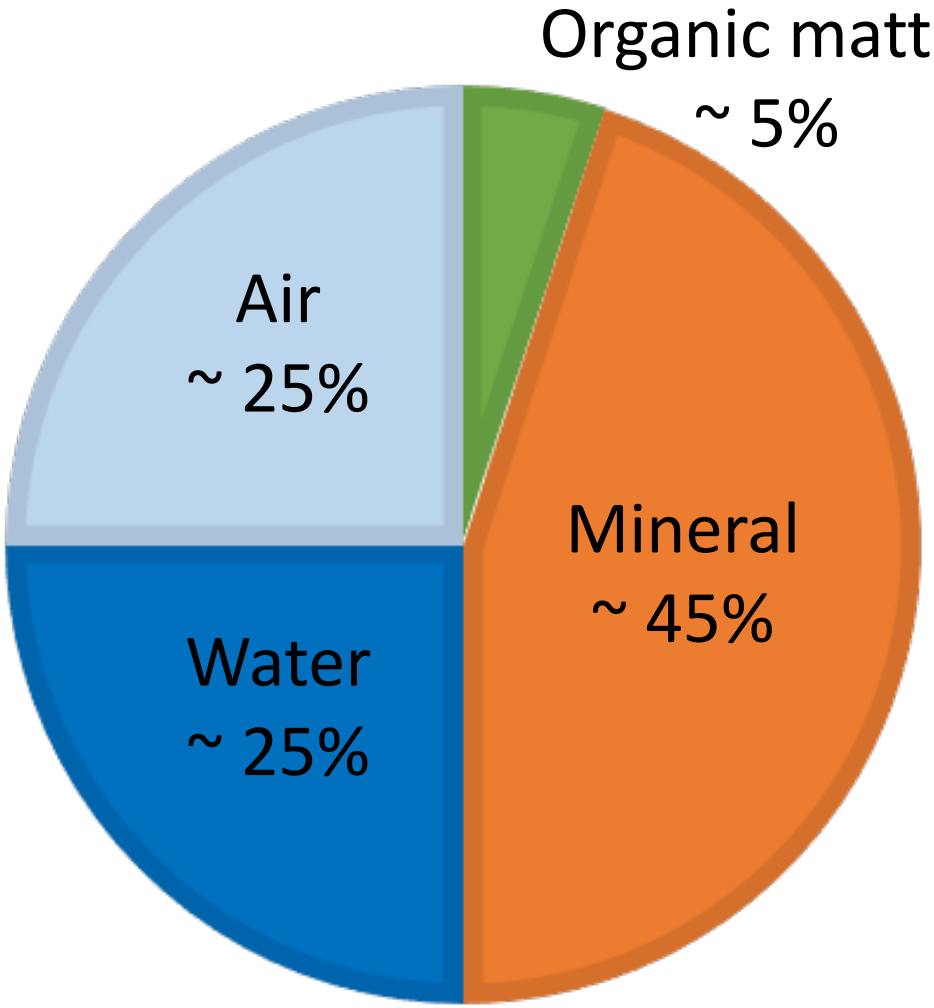
- Soil properties
  - What nutrients might be lacking
  - Water needs
  - What you can grow, and how much
- Understand limitations, to know which properties you can influence
- Management for soil health

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

1. I just had my nails done 33%
2. Clicker training isn't just for dogs 33%
3. There isn't enough "dirt" on the floor to get a good soil sample 33%

Response Counter

Average Soil Composition



Soil Properties

Organic matter (SOM)

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

pH

Texture

Cation Exchange Capacity (CEC)

Which soil properties influence *nutrient* availability? Multiple responses possible.

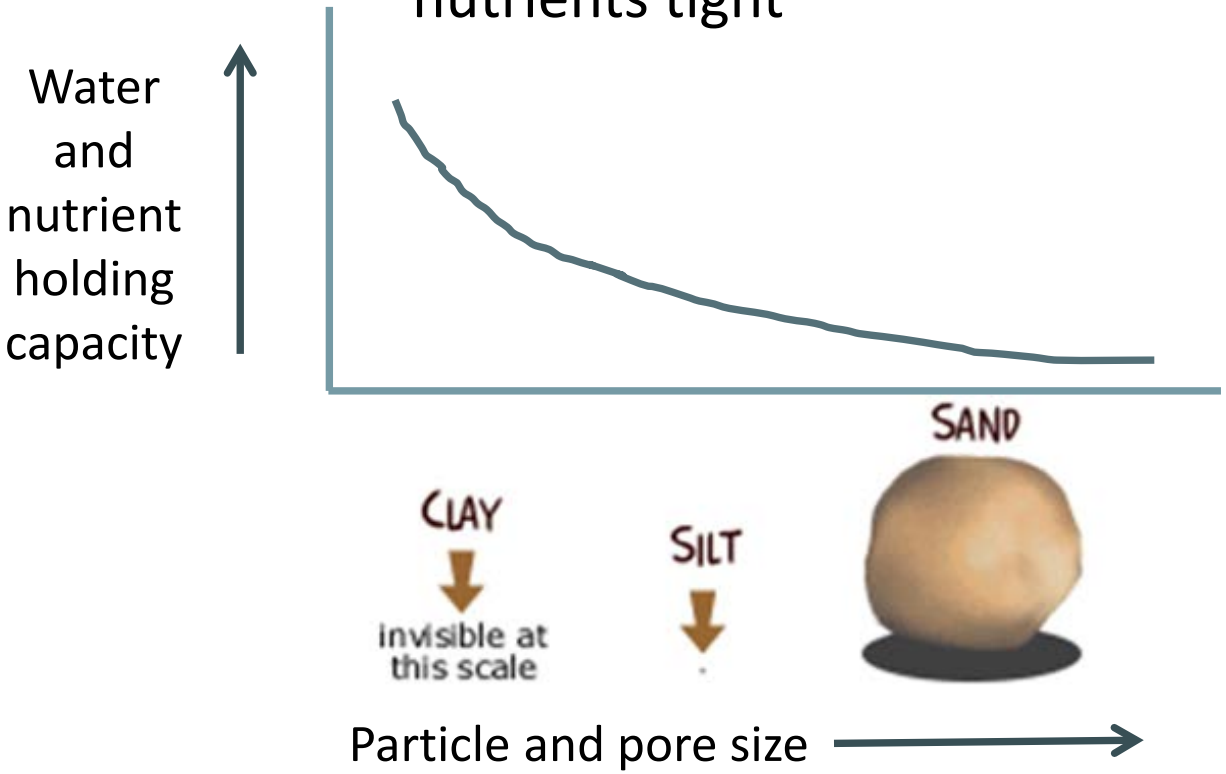
20%	A.	Texture/surface area
20%	B.	pH
20%	C.	CEC (cation exchange capacity = the parking spaces in soil for nutrients)
20%	D.	SOM (soil organic matter)
20%	E.	Color

Response Counter

Soil texture

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

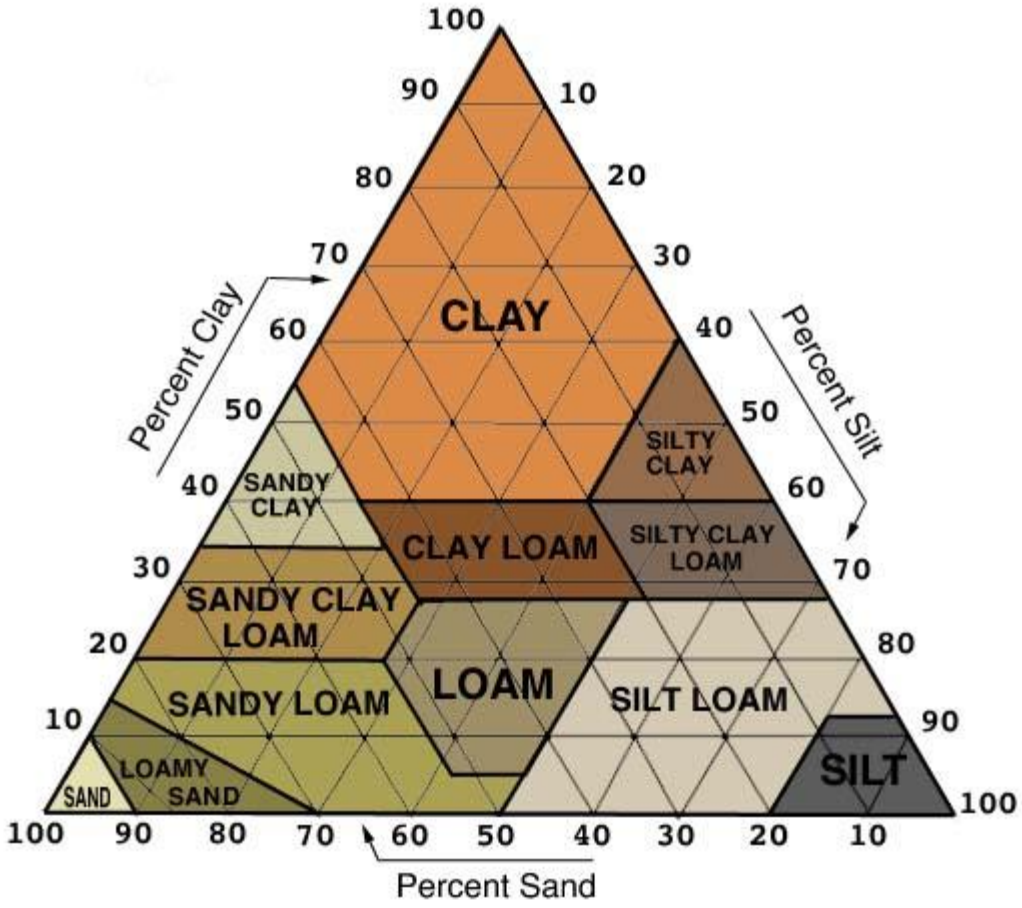
Clay: small pore space, large surface area, often negative charge on surface = holds water and nutrients tight

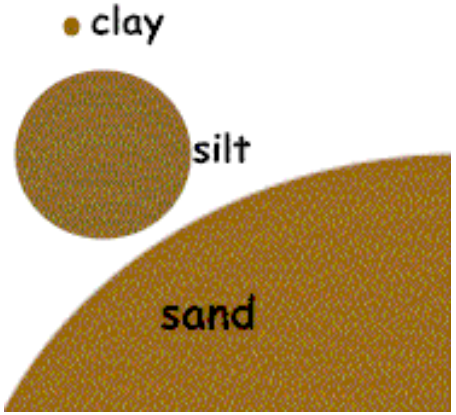


Mason jar texture test

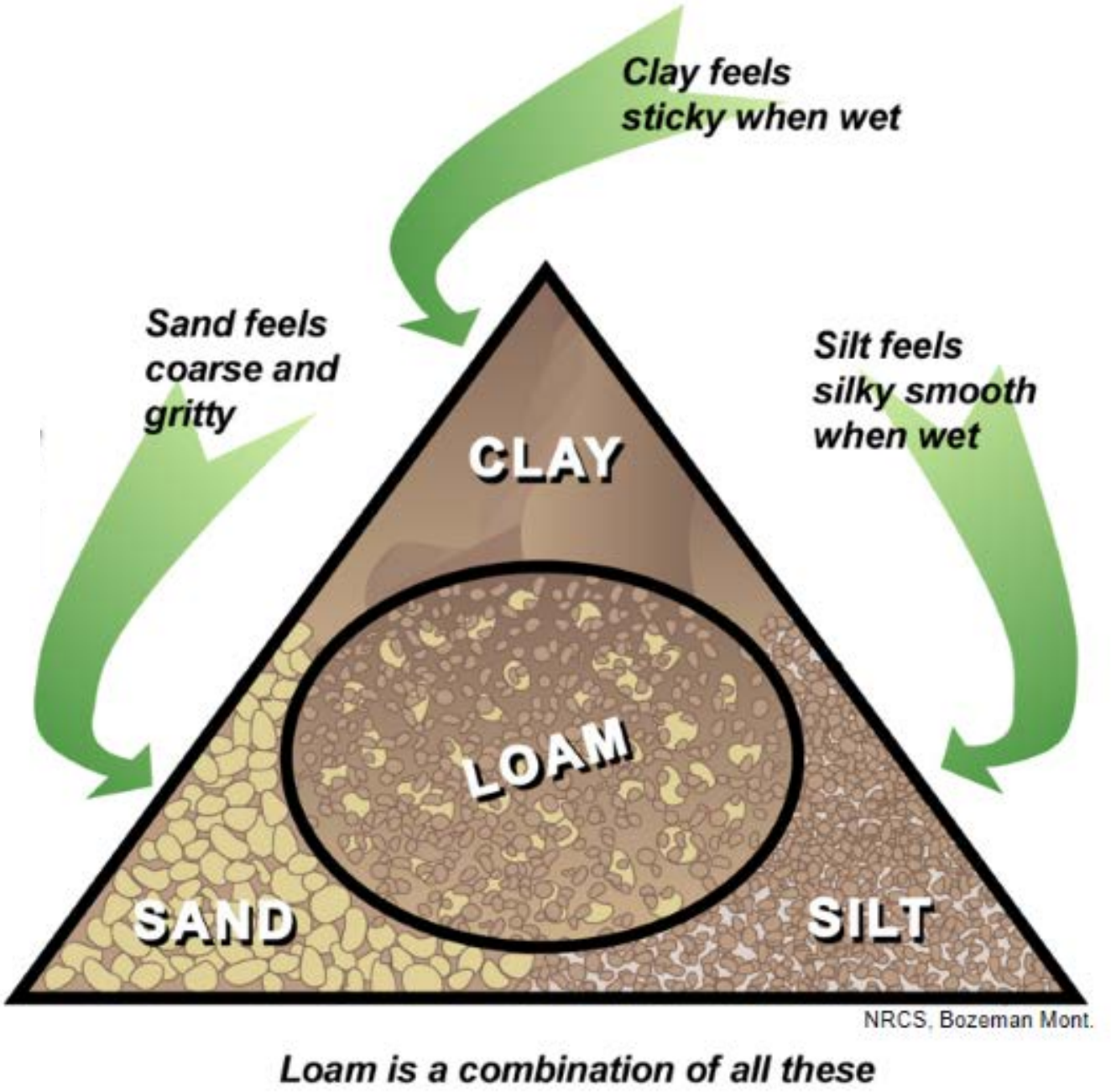
- Fill a straight sided jar 1/3 with soil
- Add water until almost full
- Add 1 tsp dishwasher soap or water softener
- Shake and let settle for 24 hours
- Estimate or measure % of layers

Using the soil texture triangle





Textural triangle for the tactile



Loam is a combination of all these

Texture Effects on Soil Properties

	Drainage	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

Infiltration	Excellent	Moderate	Poor
Drainage	Excellent	Moderate	Poor

If clay holds lots of water, why is it not ideal?

Multiple responses possible.

A.	Poor aeration	25%
B.	Surface pooling	25%
C.	Compaction	25%
D.	Low nutrient content	25%

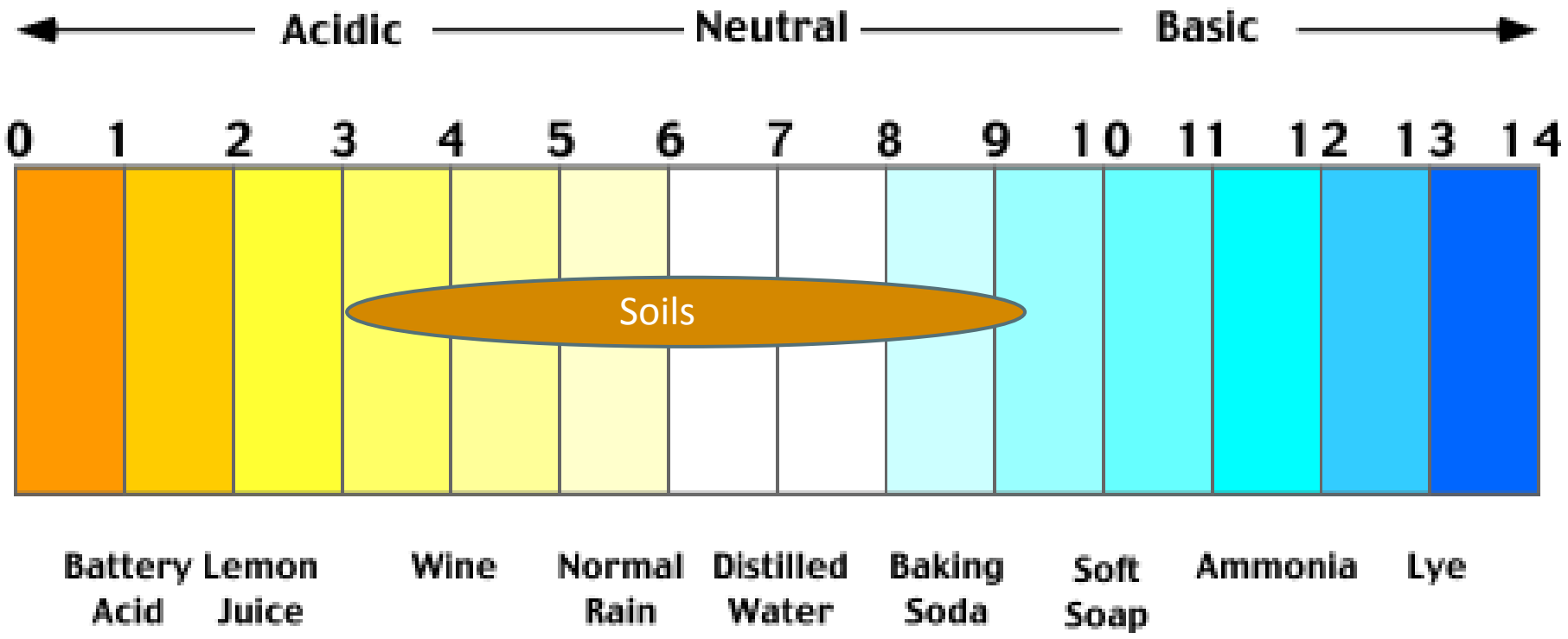
Response Counter

Questions?

Soil pH – which is true?

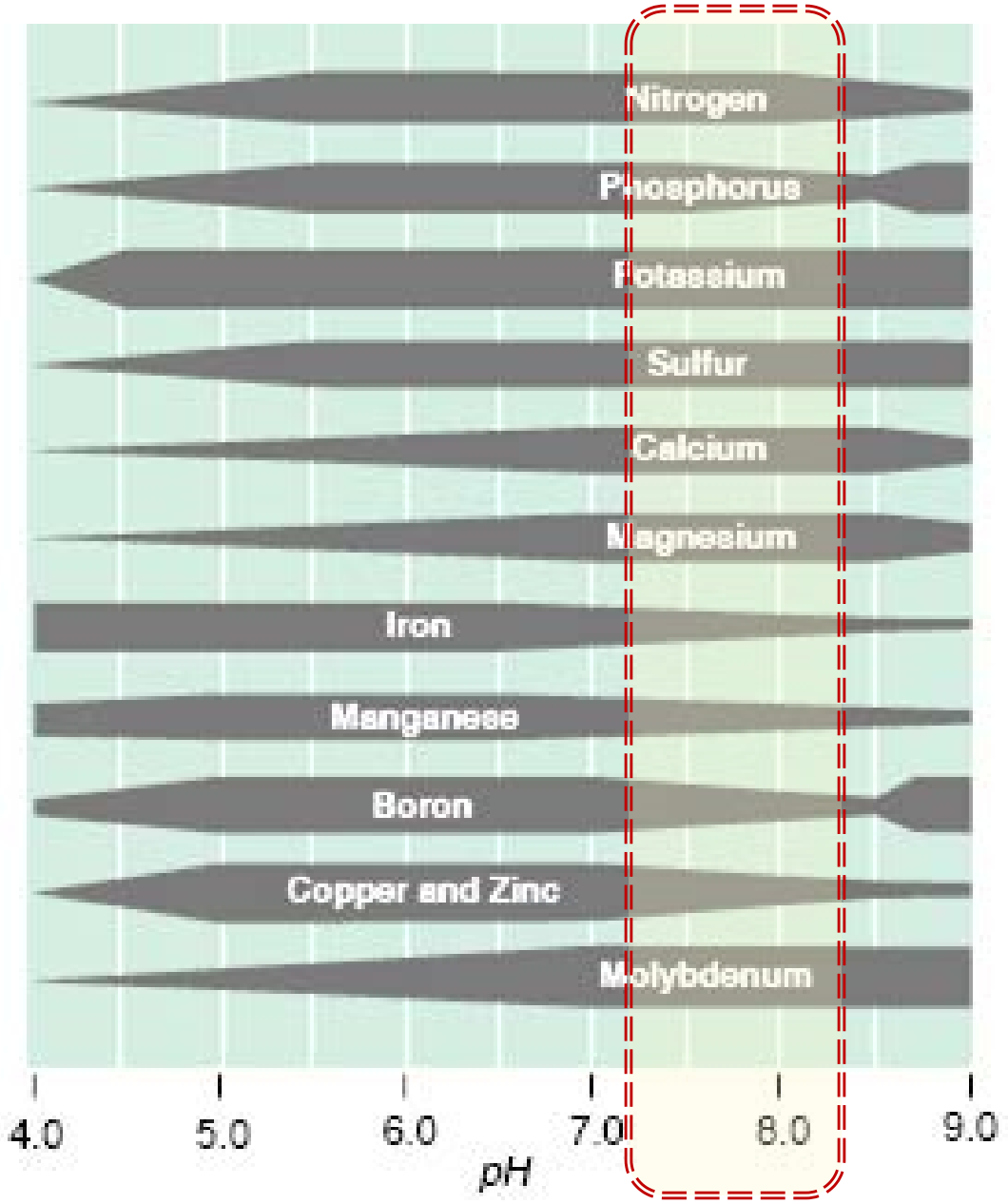
Response Counter

1. Has no influence on nutrient availability — 33%
2. Is difficult to alter — 33%
3. Most vegetables prefer pH > 7.5 — 33%



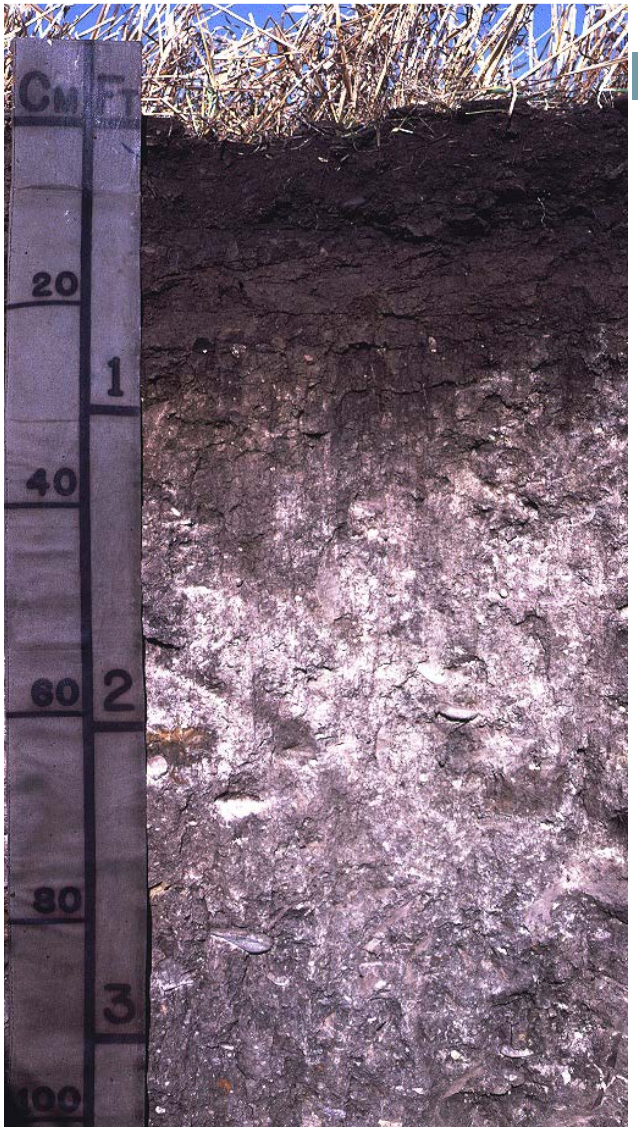
pH affects soil nutrient availability

Most MT soils are high pH, alkaline calcareous soils may limit P, Fe, Mn, B, Cu, Zn because they stick tight to the soil, plants can't get them



Why are most MT soils high pH?

- Most MT soils are highly calcareous = alkaline
- Even if surface soil isn't alkaline, the subsoil usually is



Mollisol – common in Montana and or semi-arid regions

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

17% A. Add elemental sulfur (S)

17% B. Add gypsum ($CaSO_4$)

17% C. Add pine needles

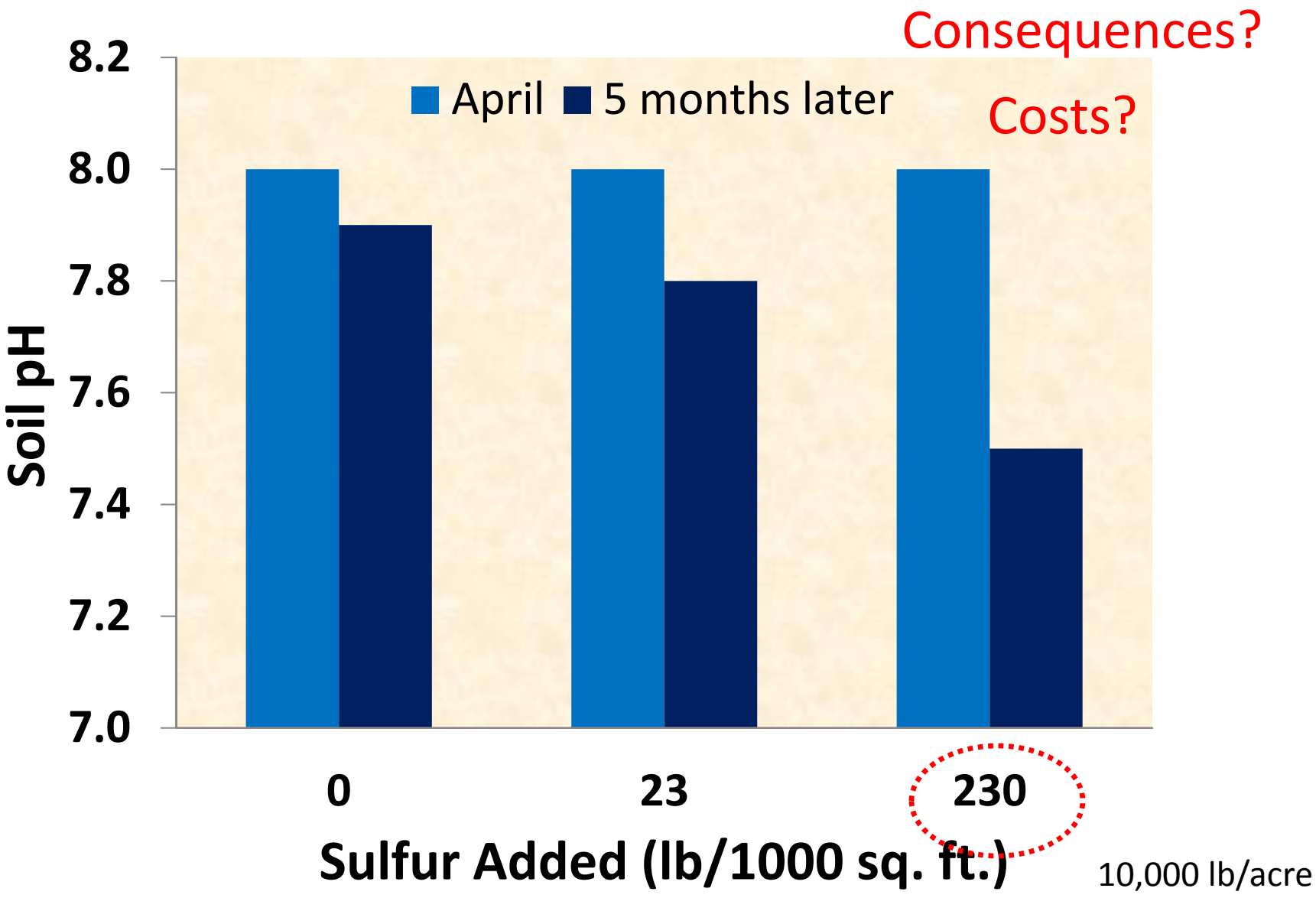
17% D. No reasonable option to lower significantly and QUICKLY on LARGE scale

17% E. Use ammonia based N fertilizers (e.g., urea)

17% F. Plant legumes

Response Counter

Adding elemental sulfur



AgVise Laboratories

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

A.	You spend $366/1000 sq ft	25%
B.	Your soil pH will drop by at least 1.5 units	25%
C.	Soil S levels will remain well below toxic	25%
D.	Soil salt levels will improve	25%

Response Counter

Same study site – added 115 lbs gypsum /1000 sq. ft. with no change in soil pH

Plants have different ‘preferred’ pH

Crop	Preferred pH
Sweet pea	7 - 8
Blueberry	4.5 – 6.0
Raspberry	5.0 – 7.5
Burr clover	> 7
Alfalfa	> 5.7
Blue grama grass	> 7
White clover	< 7

Blueberries don’t grow well in Gallatin Valley, sweet peas do!

Select species suitable for pH and soil type, see: *Dryland Pastures in MT and WY*

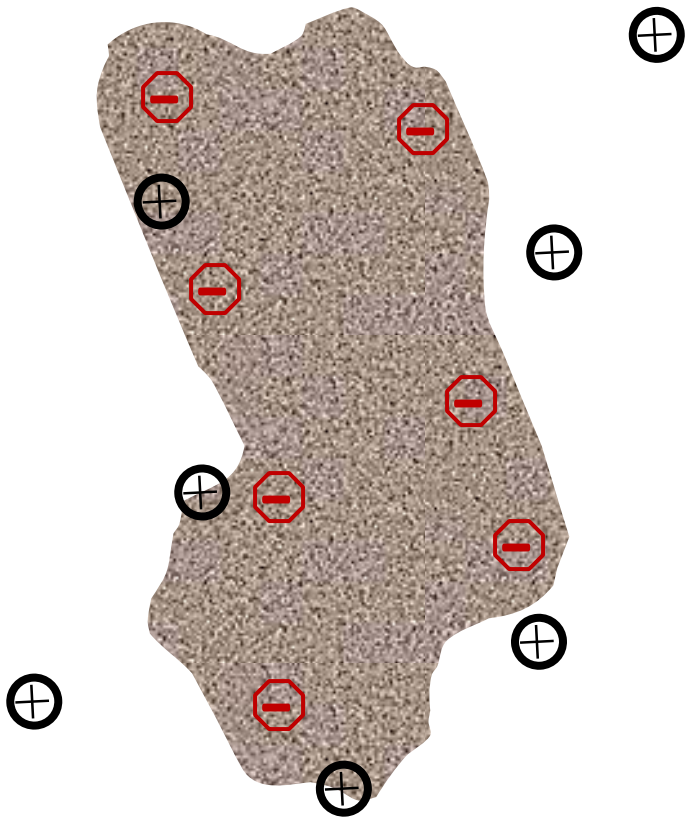
Questions?

CEC and AEC – the parking spaces for nutrients in the soil

- Cation Exchange Capacity (CEC)
  - Total negative charge on a soil
  - A measure of the soil's ability to hold onto and supply positive ions, e.g. Potassium (K^{+}) and Zinc (Zn^{+2}), to a crop
- Anion Exchange Capacity (AEC)
  - Total positive charge to hold onto nutrient anions such as sulfate (SO_4^{-2})
  - Generally weak bonds that release as concentration of nutrient in solution drops

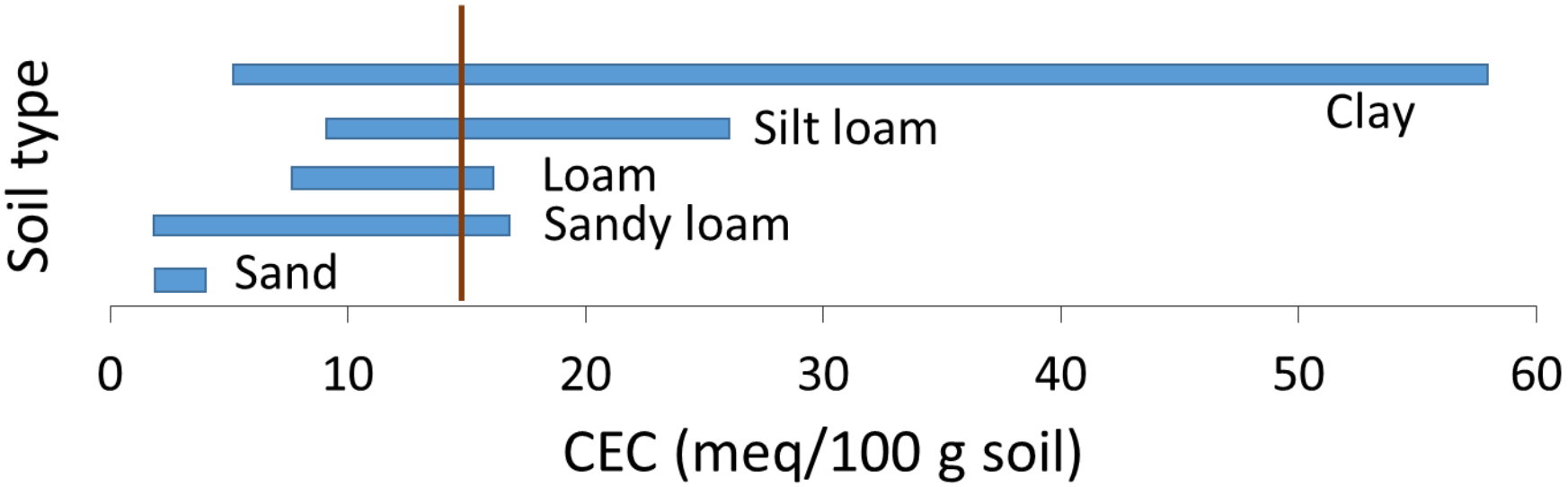
Cation Exchange Capacity

- Many essential plant nutrients carry positive charges. Example: K^{+}, Zn^{+2}
- A fertile soil has the capacity to attract and hold these nutrients.
- Soils with large surface areas, such as clay and SOM, have more CEC and surface area and therefore are generally more fertile.



CEC is generally > AEC

CEC ranges for different soil types



CEC > 15 has high capacity to hold cations such as K^+, NH_4^+

What else might high CEC soils hold onto? Herbicides

Management influenced by CEC and texture

- Water
  - low CEC soils – short frequent irrigation (daily) – to avoid leaching nutrients
  - high CEC soils – slow irrigation less often (e.g., low flow emitters, every 3-4 days)
- Nutrients
  - low CEC soil, a little at a time to avoid leaching loss
  - High CEC, incorporate them – to avoid runoff and get to plant roots

SOM = Soil organic matter

What does SOM **NOT** do for soil?

Response Counter

17%	A.	Increase CEC
17%	B.	Provide nutrients as it decomposes
17%	C.	Hold water which helps nutrients move from soil to plant roots
17%	D.	Consistently reduce soil pH
17%	E.	Reduce soil compaction
17%	F.	Increase water infiltration

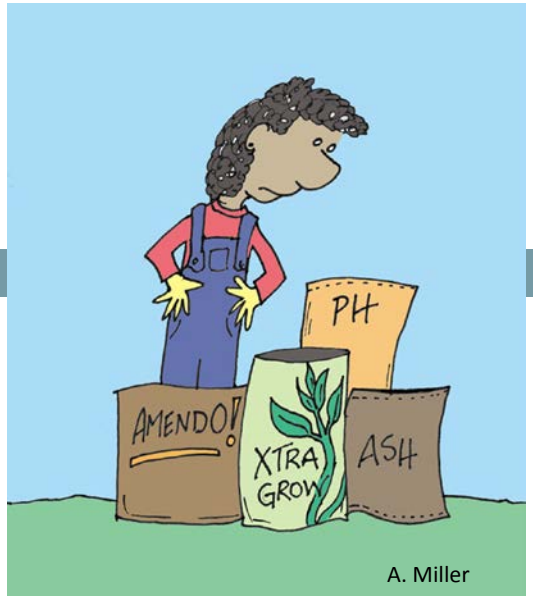
High surface area and CEC (215 meq/100 g for SOM vs. 58 for clay)

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?

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’

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

Figure 3. Sample Soil Test Report and Fertilizer Recommendations

Name: Producer		**Sample Date:** April 1, 2007		
Lab Number: 12345		**Your Sample Number:** 1		
Crop to be Grown: Spring Wheat		**Previous Crop:** Fallow		
Sampling Depth: 0 to 24 inches		**Yield Goal:** 50 bu/acre		
Soil Test Results			**Interpretation**	**Recommendation**
Nitrate-N	0-6 in	37 lb/acre		
	6-24 in	36 lb/acre		
	0-24 in	73 lb/acre	Medium	90 lb N/acre
Olsen Phosphorus	0-6 in	15 ppm	Medium	20 lb P_2O_5/acre
Potassium	0-6 in	192 ppm	Medium	40 lb K_2O/acre
Sulfate-S	0-6 in	6 lb/acre		
	6-24 in	54 lb/acre		
	0-24 in	60 lb/acre	High	———
Boron	0-6 in	0.5 ppm	Medium	1 lb B/acre
Copper	0-6 in	1.7 ppm	Very High	———
Iron	0-6 in	47 ppm	Very High	———
Manganese	0-6 in	10 ppm	Very High	———
Zinc	0-6 in	1.3 ppm	High	———
Soluble Salts	0-6 in	0.3	Low	———
Organic Matter	0-6 in	3.4%	Medium	———
Soil pH	0-6 in	7.7	Medium/High	———
CEC	0-6 in	17.8	Medium	
Soil Texture	0-6 in	Sandy Loam		

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 provide guidelines and example calculations

Approximately how much total N, P, and K does 1” of manure compost supply?

	N	P_2O_5	K_2O
	lbs/1000 sq. ft.		
Removed annually	3.4	0.3	3.2
Added by 1” manure	40	15	40
Added by 1” manure	6	1	6

1. 50%
2. 50%

Response Counter

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Considerations when fertilizing 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
- 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

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

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

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/

Resources

- *Soil Acidification: Management*
  http://landresources.montana.edu/soilfertility/soilscoop.html

USDA-NRCS Web Soil Survey
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

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?