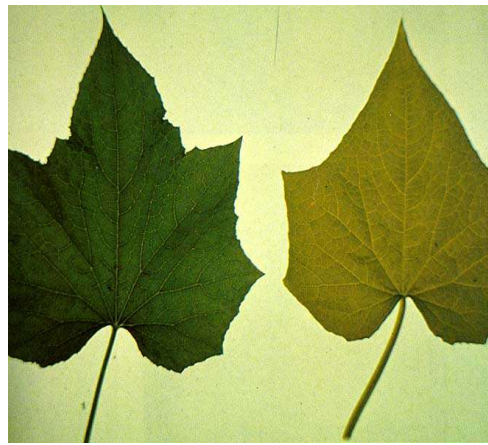




Master Gardener Determining Nutrient Needs and Selecting Soil Amendments



Gold Country Master Gardeners
by Clain Jones, clainj@montana.edu, 406-994-6076
Helena, Feb 22, 2025



Who are you?

- Raise hand if you've been gardening:
 - < 3 years
 - 3-10 years
 - > 10 years
- Raise hand if grow vegetables
- Raise hand if grow flowers
- Raise hand if you want a good stretch
- YOU know your garden goals, plants, issues, etc.
 - make sure to question me if my suggestions don't apply to your situation or make sense.



What do I add to my soil???

Five questions to ask yourself
before you add anything

Today we'll cover:

1. Which elements do I need (N, P, K, S, etc.)?
2. What type of material (e.g. compost) do I use?
3. How much do I apply?
4. Which application method is best?
5. When is the best time to apply it?

Soil tests help to

- Identify nutrient deficiency or imbalance. e.g., too much K interferes with Ca uptake = blossom end-rot in tomatoes
- Calculate fertilizer rates
- Increase yield and/or save on fertilizer costs, and decrease environmental risks

Soil tests are

- Best done in the early spring, but not when soil is wet
- Perhaps best done in the late fall in our climate

<https://landresources.montana.edu/soilfertility/soil-sampling-methods.html> for instructions



Soil laboratory vs home test kits

	Test	Kit cost	Cost/sample
Test kit	N, P, K, pH	\$15 - \$750	\$1.50 - \$7.50
Lab	N, P, K, pH, salts	\$20 per sample + shipping	



- Soil sample treatment: reagents in test kits can get old/go bad
- Test method used: e.g. Olsen vs Bray P
- Format of results: Values vs rating
- 4 home kits tested, 1 provided results $\approx$ lab analysis, others' results moderately to far off (Sharma and Chatterjee, Crops & Soils Mar. 2019). Accurate one most expensive.
- Before trusting a soil test, calibrate results against standard soil test methods.

Visual assessment

With early detections can likely correct in time in garden environments



Pea image by C. Jones



Tomato image from Wikipedia



Image by K. Olson-Rutz



Image by IPNI

Sulfur (S) deficiency is best detected by visual symptoms, soil tests are not reliable

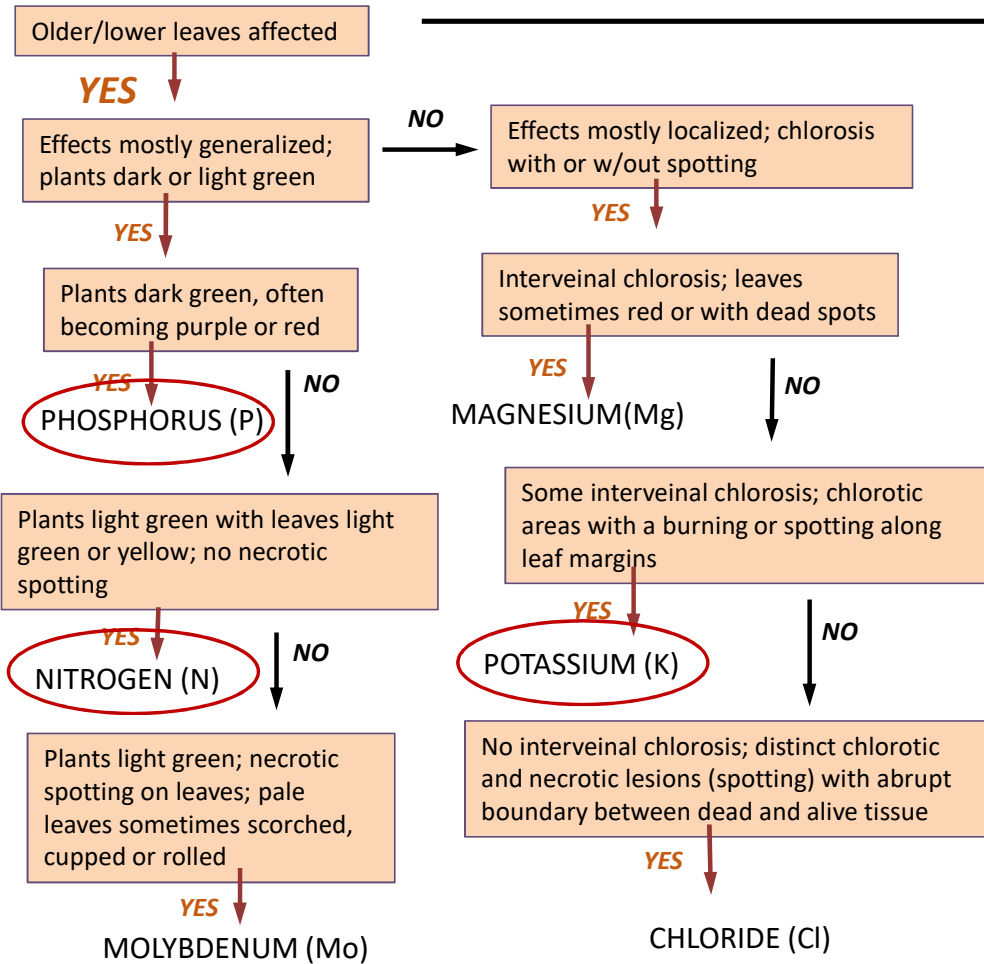
Follow the flow charts and see example images at

<http://landresources.montana.edu/soilfertility/nutrientdeficiencies.html>

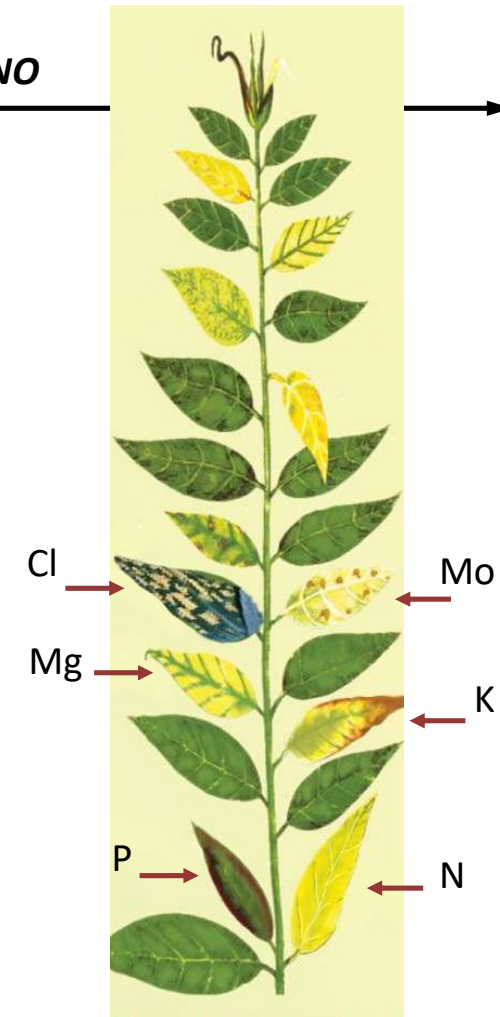
Visual tissue assessment

In Nutrient Management Module 9
<http://landresources.montana.edu/nm>

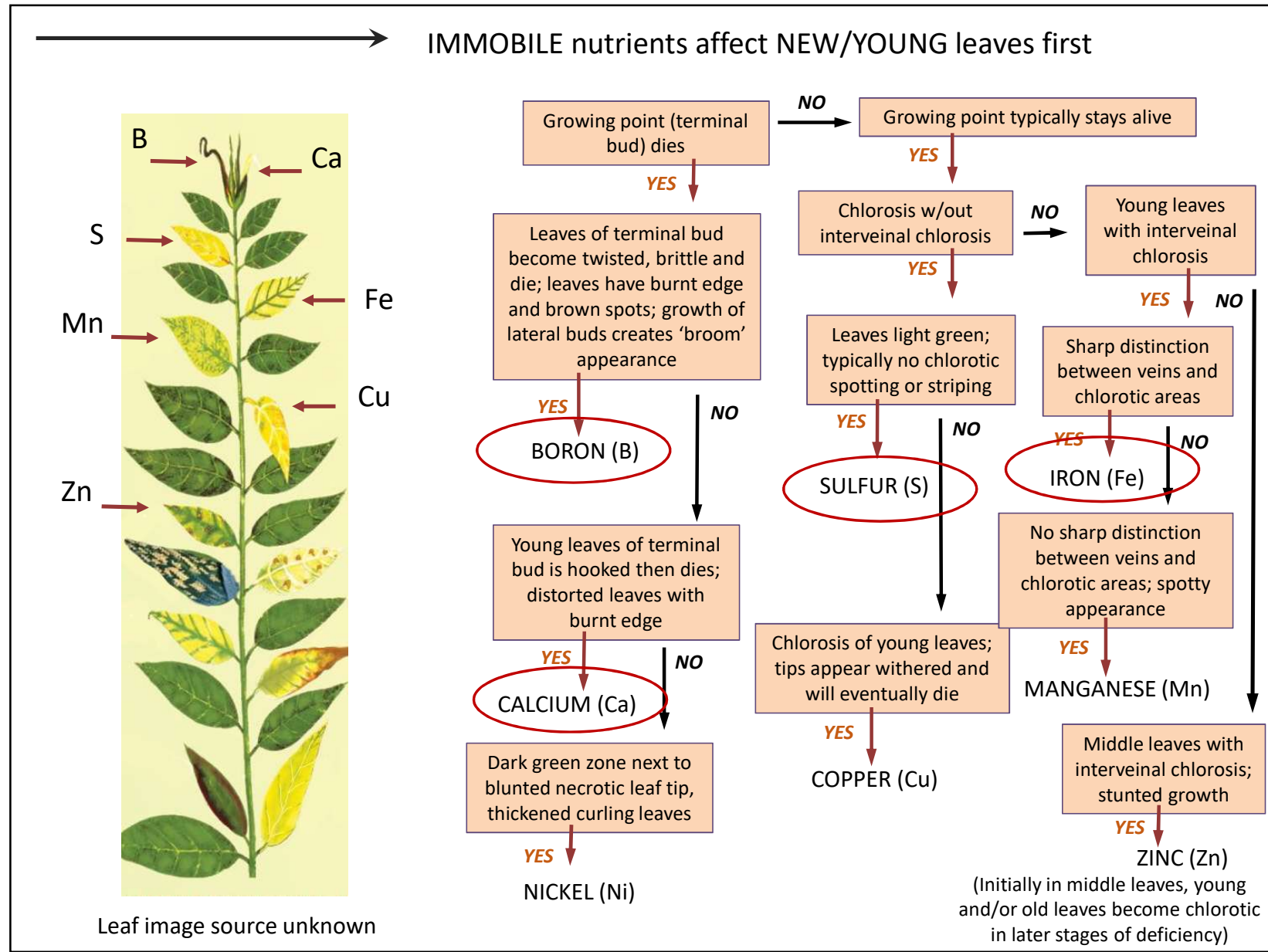
Nutrients **MOBILE** in PLANT affect **LOWER** leaves first



NO



Leaf image source unknown



What nutrient is lacking?

1. N
2. P
3. K
4. Sunshine
5. Fe



- Lower leaves are more yellow than upper leaves
- Deficient leaves may be smaller

Why would an N fixing plant (bean) be N deficient?

What nutrient is lacking?

1. N
2. P
3. S
4. The trellis
5. Fe



Image by C. Jones

Upper leaves are yellow
with S deficiency.

What nutrient is lacking?

1. N
2. P
3. TLC
4. S
5. Iron



Image by K. Olson-Rutz



- Chlorosis between veins especially on younger or upper leaves
- Highly susceptible plants: raspberry, Amur maple, crabapple, mountain ash, and roses
- When soils are cold

What nutrient is lacking?

1. N
2. P
3. K
4. S
5. vinegar and oil



- Dark green foliage with purple stems or leaves, especially on the underside
- Healthy vigorous plants that don't flower to produce fruit



Pseudo-deficiencies

Other issues can cause symptoms that look like nutrient deficiency symptoms

1. Insects
2. Salinity
3. Moisture stress
4. Disease
5. Herbicides

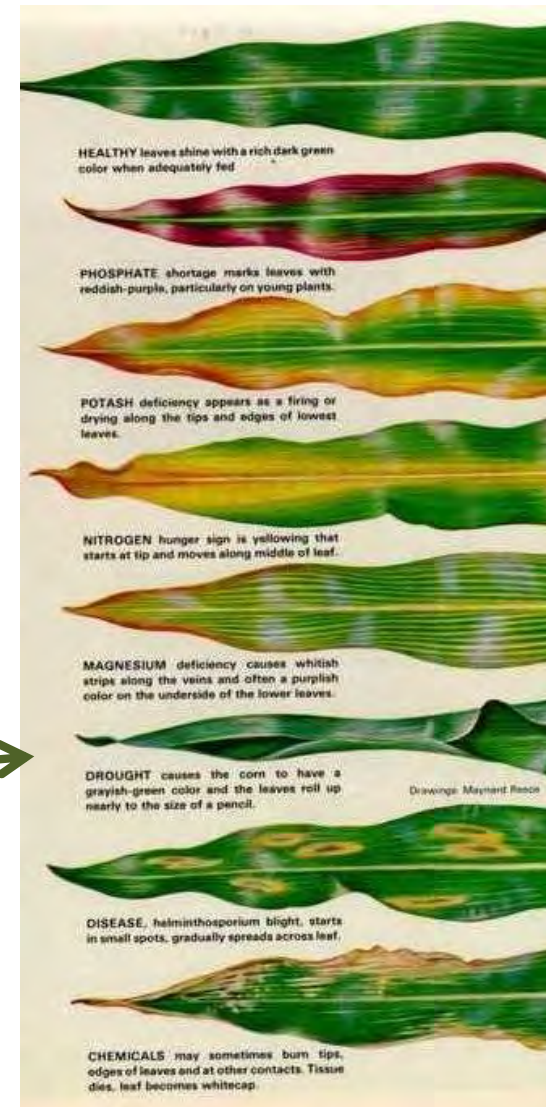


Photo: Ontario Ministry of Ag., Food & Rural Affairs

Questions?

How to read a soil test

Sample report

Location: West high tunnel		Sample date: March 30, 2021	
Crop to be grown: Vegetables		Sampling depth: 0-6 inches	
Property	Test value	Interpretation	Recommendation
Nitrate-N	12 lb/acre 6 ppm	Low	3 lb N/1000 ft ²
Olsen Phos	15 ppm	Medium	2 lb P ₂ O ₅ /1000 ft ²
Potassium	192 ppm	Medium	1 lb K ₂ O/1000 ft ²
Sulfate-S	15 ppm	High	0
Boron	0.5 ppm	Medium	0.02 lb B/1000 ft ²
Iron	47 ppm	Very high	• Low or Medium = below critical level • High = nutrient is sufficient
Zinc	1.3 ppm	High	
Soluble salts	0.3	Low	
Organic matter	3.4%	Medium	Recommended fertilizer rates not always provided
Soil pH	7.7	Medium	
CEC	17.8	Medium	
Texture	Sandy loam		

Questions?

Fertilizer rates

How much fertilizer do I need to apply?

Fertilizer need = (Crop demand) – (what's plant-available in soil)

- Calculate based on soil test results and crop
- Often provided on soil test results. Make sure based on DESIRED CROP (e.g., fruit trees, vegetables) and MT GUIDELINES
- In pounds per 1,000 square feet (lb/1000 ft²) or pounds per acre (lb/acre)
- If lab doesn't provide recommendation or is from another state, MSU publications provide guidelines and example calculations

<https://landresources.montana.edu/soilfertility/publications-presentations.html>

What if lab doesn't provide an N recommendation?

Location: Garden A Sample date: 3/5/2019

Crop	Nitrate-N			OM %
	ppm	lb/ac	Depth (in)	
Garden	30	60	0-6	4.3

1. Soil test = 60 lb N/ac
2. Adjust for N supplied by organic matter (%OM)
3. Compare to MSU Guidelines
4. Amendment amount depends on source

See tables in *The Soil Scoop*, MT200705AG, EB0240

Soil Test	Organic Matter (%)		
Nitrate - N	< 1.5	1.5 – 3.0	> 3.0
lbs /acre	lbs/1000 sq.ft.		
<20	4	3	3
20-40	2	2	2
40-80	1	1	0.5
>80	0	0	0

Your turn

	OM %	Nitrate –N ppm	P ppm	K ppm	pH
Test	3.6	14	77	788	7.5

Using this data from a soil report and Table 3 from Montguide (or the previous slide), **how much N required?**
 $N \text{ ppm} \times 2 = N \text{ lb/acre}$

1. 3 lb/1000 sq. ft.
2. 2 lb/1000 sq. ft.
3. 1 lb/1000 sq. ft.

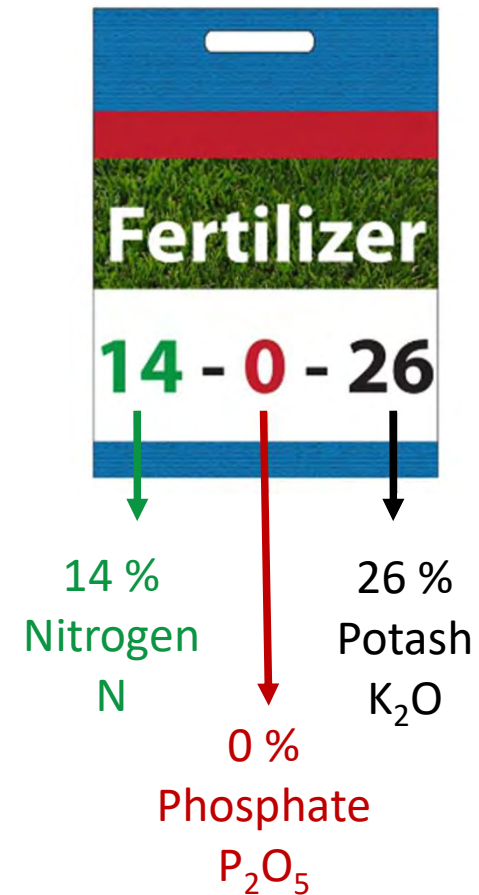
How much amendment?

Does 2 lb N mean 2 lb of bloodmeal?

Nutrient amount supplied by an amendment depends on:

- Nutrient concentration = Grade
- Amount and rate of conversion to plant available form
 - *High and fast*: nitrate, ammonium, phosphates, sulfates, fresh green material, manure slurry/teas
 - *Low and slow*: rock phosphate, bone meal, elemental sulfur, greensand, compost, manure solids

See tables in *Market Vegetable Farms* bulletins



Fertilizer amount =

(Required lb nutrient) ÷ (nutrient fraction in fertilizer)

- To add 2 lb N/1000 ft²
- Using 14-0-26 = 14% N, 0% P₂O₅, 26% K₂O
 - 2 lb N/0.14 = 7.14 lb of 14-0-26 to supply 2 lb N
- Using ammonium sulfate (21-0-0-24) **What's the math?**
 - 2 lb/0.21 = 9.5 lb of 21-0-0-24 for 2 lb N
- Using manure compost (approx 0.6-0.5-0.6)
 - 2 lb/0.006 = 340 lb manure compost

Will 340 lb manure compost supply 2 lb N that growing season?

 - **NO** - **only 5-15%** of that is plant available in first growing season.
- Pick the amendment with NPK content that matches needs

Table 7 in *Market Vegetable Farms: Soil Phosphorus, Potassium & Micronutrients* has NPK of common amendments

What if lab doesn't provide a **P** recommendation?

Location: Garden A Sample date:03/05/2019

Crop	P ppm		K ppm	pH
	Bray	Olsen		
Garden	10	4	400	8.0

P rate: MSU guidelines are based on Olsen P.

Bray works in pH < 7.3

Olsen works pH > 6

Mehlich/2.05 – 14 $\approx$ Olsen P

Which P test should be used in this soil?

Tables in *The Soil Scoop*, MT200705AG, EB0241 No additional K needed

	Olsen P (ppm)				
	< 4	4 – 8	8 – 12	12 – 16	> 16
lb P ₂ O ₅ /1000 sq. ft.	5	4	3	2	0
	K (ppm)				
	< 75	75 – 150	150 – 250	>250	
lb K ₂ O/1000 sq. ft.	3	2	1	0	

Addition of micronutrients

- Micronutrients are rarely lacking in soils with high organic matter; Iron (Fe) may be deficient especially when soils are cold
- Read the label
- The challenge is ability to evenly apply tiny amounts



Correction of iron deficiency

- **Lower pH.** Can you do that with elemental S?
 - Difficult in highly buffered soils
 - Acidifying liquid fertilizers likely will not help
- **Applications of iron**

Ferrous sulfate: can become unavailable quickly,
combine with elemental S

Iron Oxide (ferric oxide; e.g. ironite): Is NOT soluble in water, rust stains on concrete

Chelated Iron

- Foliar: expensive, must be applied often
 - Marginal success
 - Not all are suited for high pH soil (FeEDDHA appears to be best)
- *Bone and blood meal* are also sources of iron



7 days post 2nd
foliar application
by C. Jones

Questions?

Fertilizer and amendments



Feed the plant or
feed the soil that
feeds the plant?



Conventional/chemical

- No carbon
- Easy to store
- Higher nutrient concentration
- Custom formulated
- Easy to use
- Usually provide quickly available nutrients
- Liquid or solid concentrate

Compost/manure

- Bulkier
- Nutrient content low but diverse (micronutrients)
- Nutrient content highly variable and difficult to quantify
- Takes time to 'release' nutrients
- Reuses nutrients
- Increases **organic matter**: improves soil structure, water absorption and holding, etc.

Organic matter is KEY to healthy soils

- Feeds soil micro- and macro-life (about as much as an elephant/acre)
 - reduces diseases
 - releases several nutrients
 - detoxes harmful substances
- Stores nutrients
- Increases water holding capacity
- Increases ability to resist erosion
- Turns into humus for soil quality and nutrients
- Improves tilth
- 5 - 8% OM is optimal – OM is not the cure-all for all soil ailments

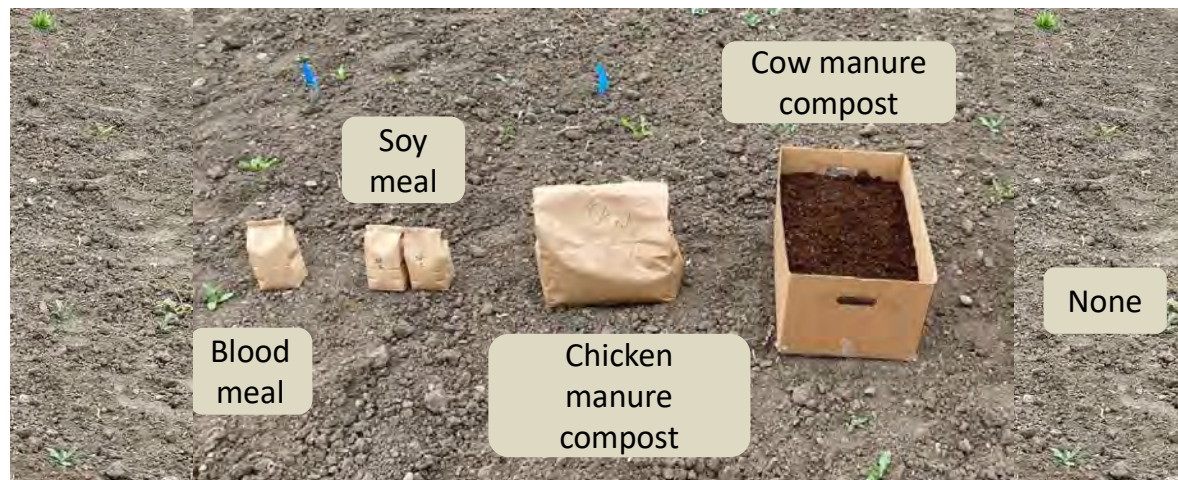
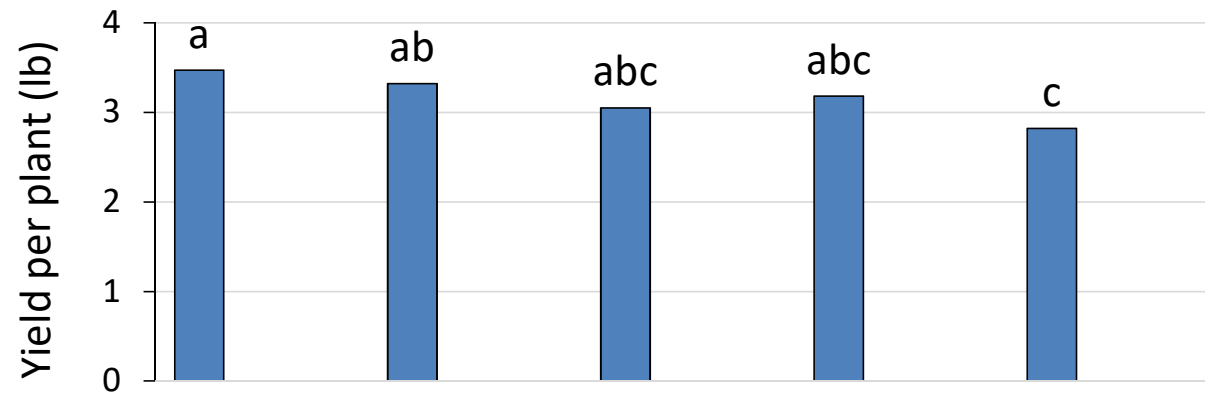


Image by Marit Olson

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

- A. Provide nutrients as it decomposes
- B. Hold water which helps nutrients move from soil to plant roots
- C. Consistently reduce soil pH
- D. Reduce soil compaction
- E. Increase water infiltration
- F. Supply high amounts of nutrients

Compost is not the most efficient source of N



Amount of material to add 3 lb N/1000 ft² on a 50 ft² bed

Image and data by Charlie Watt

Using manure compost to supply 2.4 lb N in growing season using averages of several manure compost types

➤ Compost only releases 5-15% of it's N in first growing season	N	P ₂ O ₅	K ₂ O
	lbs/1000 sq. ft.		
Added by 1" manure compost in 1 st growing season	2.4	8.4	9.6
2,000 lbs depending on manure type = a lot of work			
Removed annually by harvest ^{1.}	2.3	0.6	2.5
How many years' worth?			

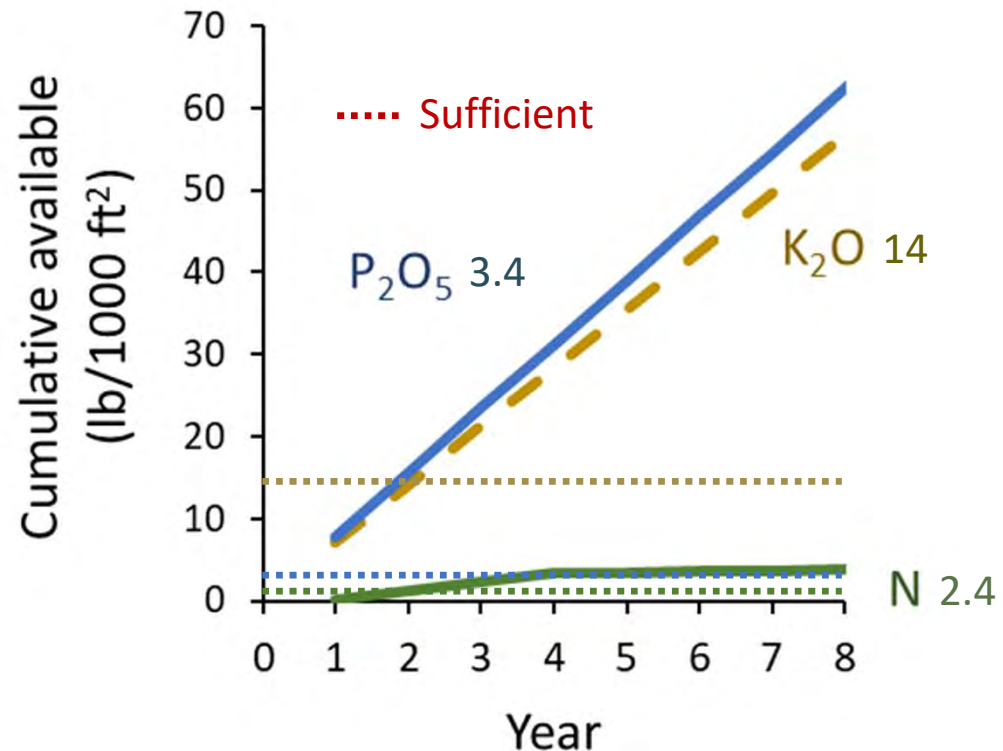
Why are small annual doses better in irrigated systems?

Table 7 in *Market Gardens: Soil Phosphorus, Potassium & Micronutrients* has NPK of common amendments

^{1.} Univ. Mass, Michigan State, Oregon State, Morris et al. 2007

What happens if
you meet N needs
with manure?

Rapid excess
buildup of P and
K by adding 1"
manure compost
annually



Adapted from Hartz 2009 UC Davis Symposium, and EB0241

- 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 unpublished data, Ohio State University)

Considerations when fertilizing with manure

- Good source of micronutrients
- Make sure it is composted if used in growing season
- Be aware of:
 - Residual herbicide risk, bioassay (use pea or tomato seed/seedling) if not SURE
 - Salt
 - Weeds and pathogens
- Easy to over-apply N, P and K
 - Nutrient imbalance
 - Water contamination by leaching and runoff



WA State Univ.
Extension



Questions?

Soil pH and Texture

Why test for soil pH?

- Plants vary in soil pH preference – pick appropriate species
- Affects soil nutrient availability - indicates which soil nutrients to watch

pH value	Impact
< 5	Poor seedling establishment
< 6	Poor legume nodulation
< 5.5	Nutrients leached or tied up (N, P, K, S, Ca, Mg, Mo)
> 8.0	Nutrients tied up (P, Fe, Mn, B, Cu, Zn) possibly high Na

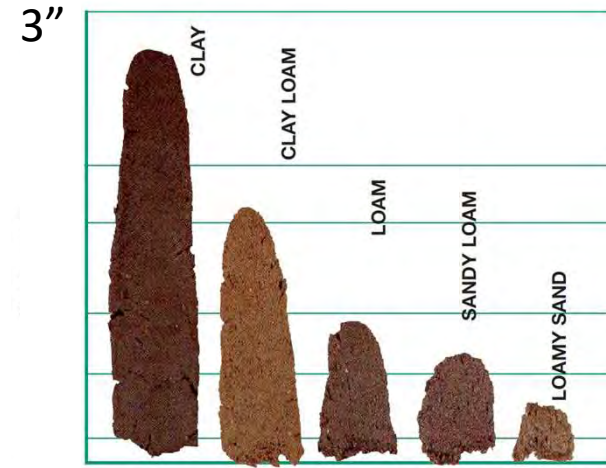
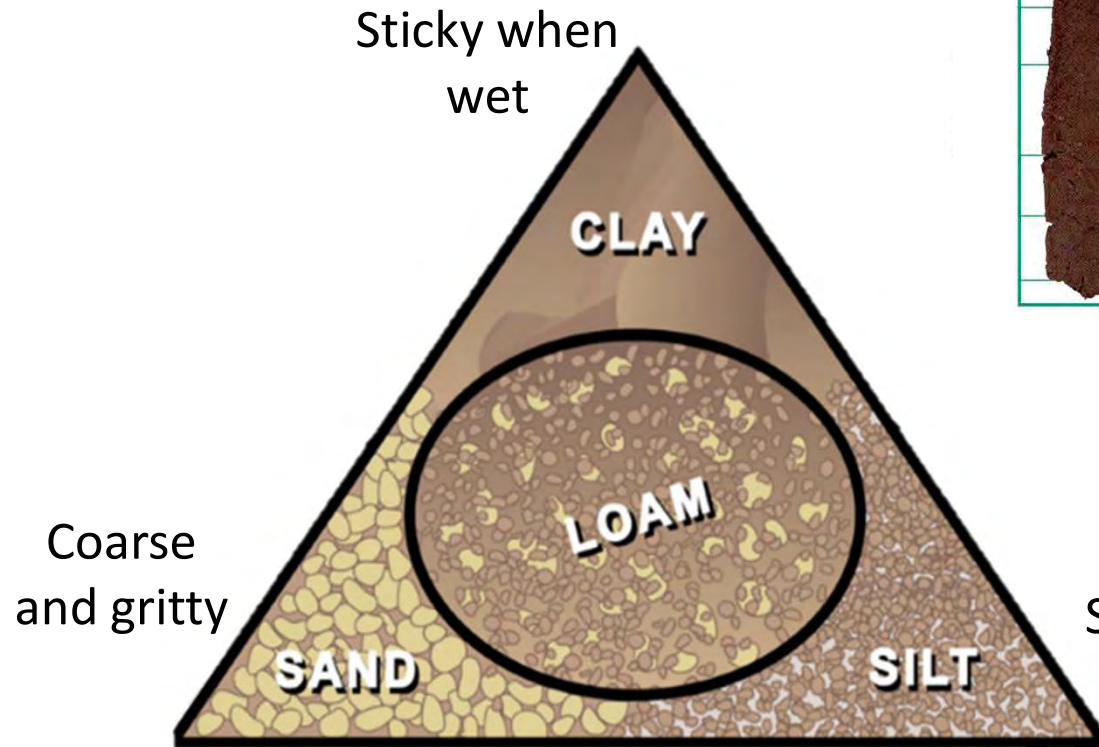
What is the best option to lower pH in highly calcareous soils?

1. Add elemental sulfur (S)
2. Add gypsum (CaSO_4)
3. Add pine needles
4. No reasonable option to lower significantly and quickly on a large scale
5. Use ammonium-based fertilizer
6. Plant legumes

Common Soil Amendments for pH

Amendment	Purpose	Notes
Sulfur	Reduces soil pH	Expensive, beware of salts and excess S
Lime – Ca + CO ₃ , OH, or O, not liquid calcium	Increases soil pH	If pH < 6, in top few inches to help germination, select low pH tolerant species

Soil texture based on feel



Ability to hand-form ribbon

<https://landresources.montana.edu/soilfertility/soil-sampling-methods.html>
for "Mason- jar" method instructions

Image from NRCS Bozeman, MT

Ribbon image from Gov. W. Australia

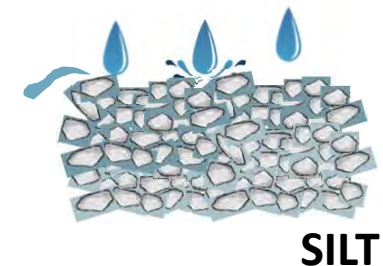
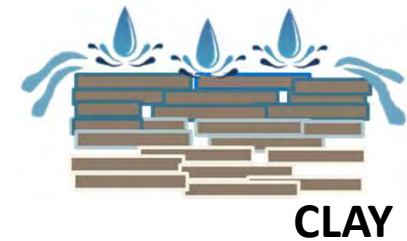
Common Soil Amendments – for clay soil

Amendment	Purpose	Notes
Coarse Sand	Improves aeration/drainage	1" sand worked into top 6" soil creates ~clay loam where needed
Compost	Improves soil health, water and nutrient-holding capacity, tilth, micronutrients	Versatile amendment

- Add small amounts of organic matter annually
- Mix into top 3 to 6 inches – lightly with garden fork
- Minimize tillage – rototilling breaks up soil aggregates
- Live plant roots and worms increase aggregation important for drainage

Management influenced by texture

- Clay/high OM soil – store water and nutrients
 - slow irrigation less often (e.g., low flow emitters, every 3-4 days)
 - incorporate nutrients to avoid runoff and get to plant roots
- Sandy/low OM soil – don't hold water and nutrients
 - short frequent irrigation (daily) to avoid leaching nutrients
 - a little nutrients at a time to avoid leaching loss



Summary

- N, P and sometimes Fe most commonly missing
- Soil test to determine what is missing or in excess, to calculate fertilization rates, protect environment, save \$\$
- Organic materials harder to use but supply multiple benefits
- With manure watch for excess P and K, N leaching, herbicide residuals, salts
- Encourage soil cover with crops or plant-material mulch
- Changing soil pH is not easy – select species for pH present

Thank you!
Questions?



For additional information on garden soil nutrients:

<https://landresources.montana.edu/soilfertility/home-gardening.html>