Soil Basics

Peyton Ginakes
University of Minnesota

North Central SARE
Sustainable Agriculture Research & Education

What you'll learn:

- What is soil made of?
- What does each part do?
- How does each part help plants?

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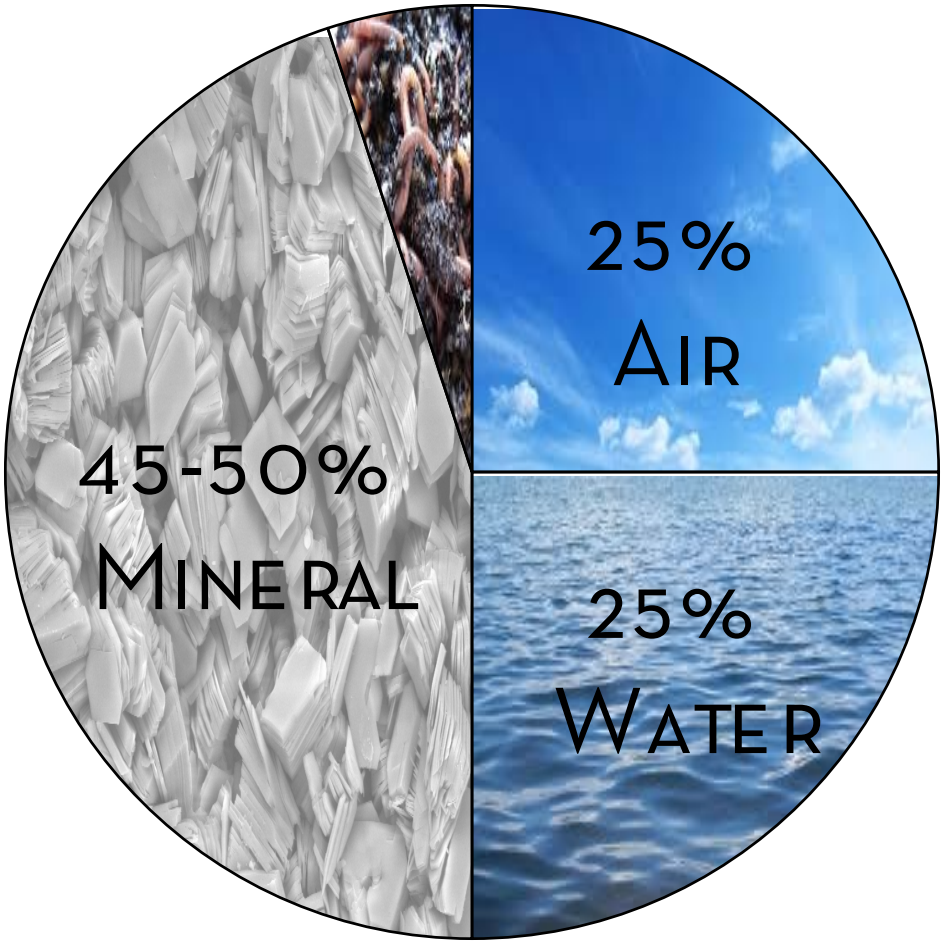
What is soil?

A resource!

What have you done to help soil?

What's in soil?

SOLID MATTER

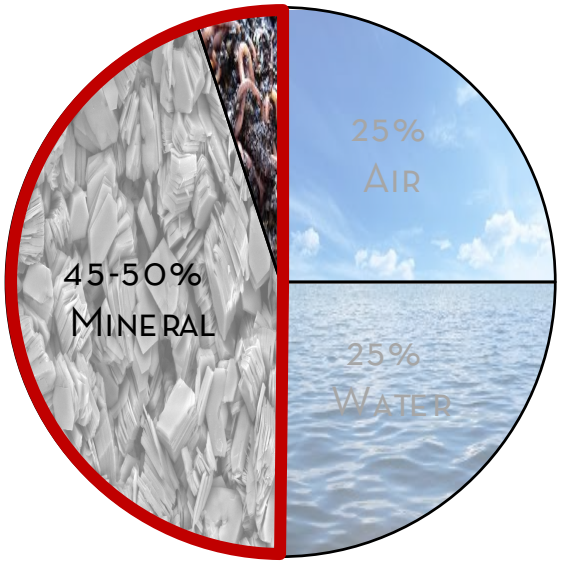


PORE SPACE

Soil is only 1/2 solid

Mineral particles are divided into 3 size classes:

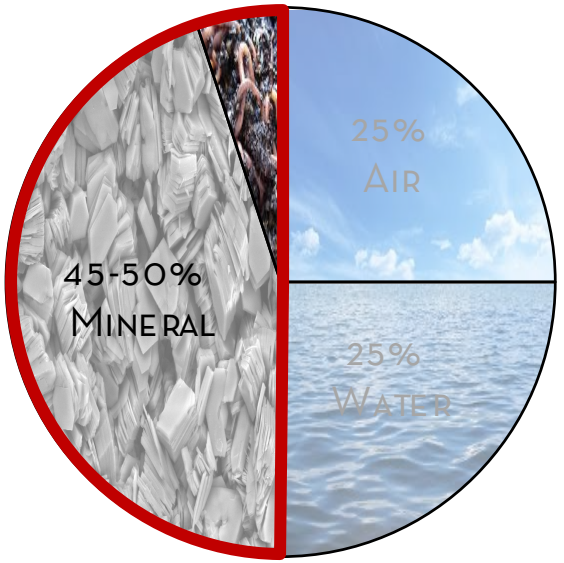
- sand
- silt
- clay



The amount of each particle size determines soil "texture"

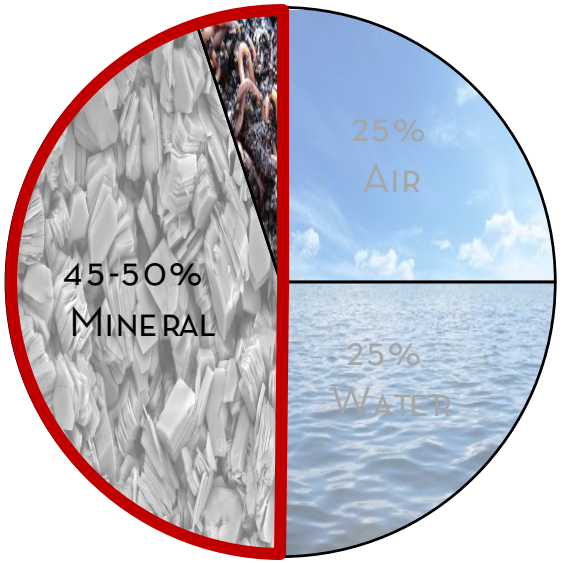
Soil Texture: Sand

- 0.05 – 2.0 mm in size
- Sometimes visible to the eye
- Gritty when wet and dry
- Drains quickly
- Irrigation is especially important due to drainage



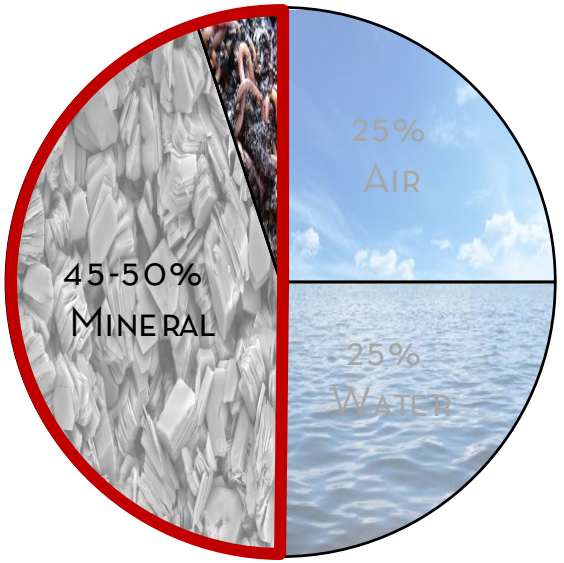
Soil Texture: Silt

- 0.002 – 0.05 mm
- About as thick as a strand of hair!
- Feels like flour
- Don't till more than necessary, or this good soil will get washed away!

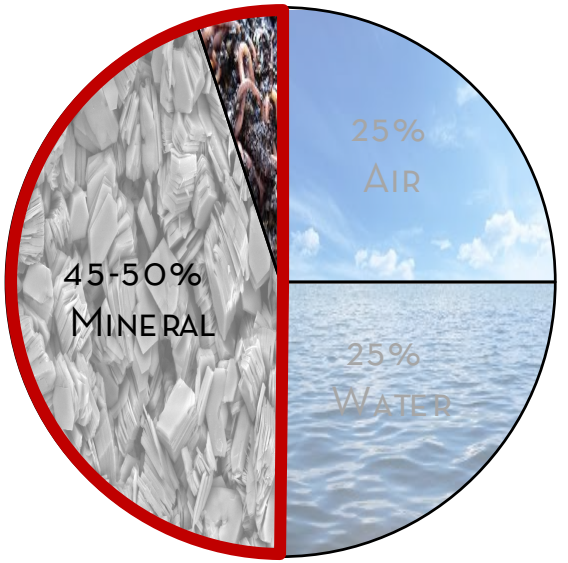


Soil Texture: Clay

- The smallest particle size
- Less than 0.002 mm
- Invisible to the eye
- Feels sticky when wet
- Dries slowly in the spring; plan accordingly!



Soil Texture

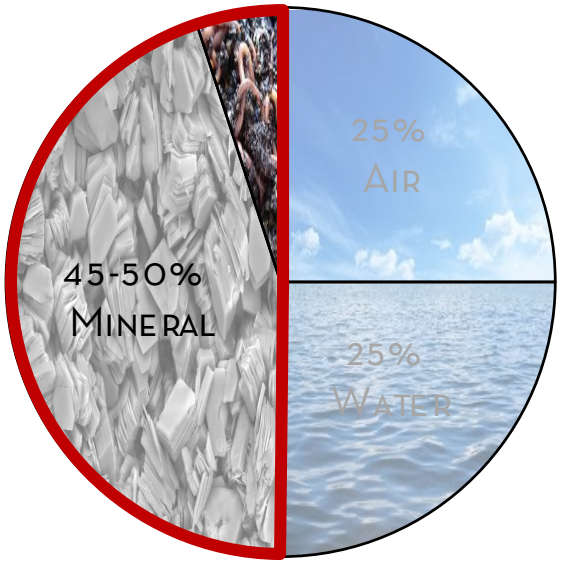


Soil is only 1/2 solid

Organic Matter can make up anywhere from 1 to 5% of soil

It's VERY important!

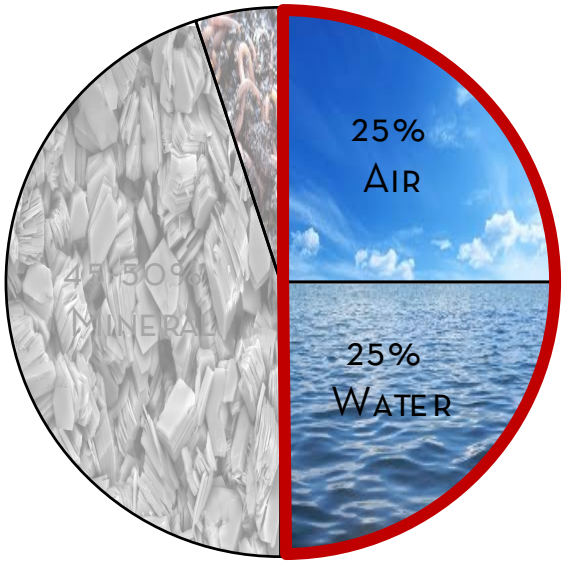
We can change how much is in soil with how we manage soil



Soil is half pore space

Soil pore space is made up of air and water:

- When it rains, it's more water than air
- When it's been dry, it's mostly air



Soil is half pore space

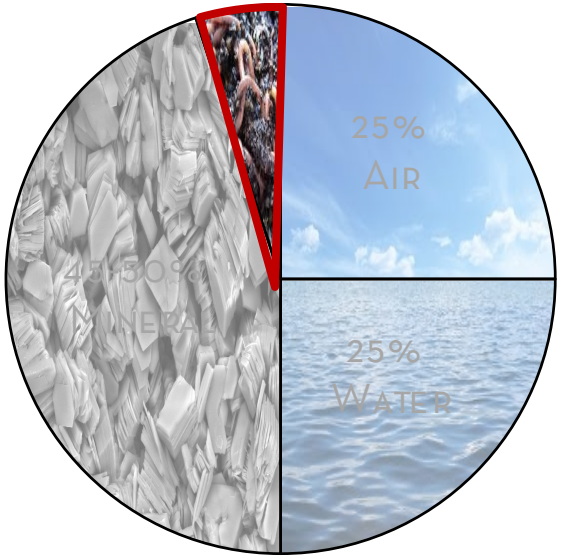
Why do plants need both air and water?

Soil Organic Matter (SOM)

Organic = materials that were once alive, either recently or *thousands* of years ago

Mostly a source of carbon (C) and nitrogen (N), but can also provide other nutrients – very nutritious!

More on this in the next unit...



Soil Health

Peyton Ginakes
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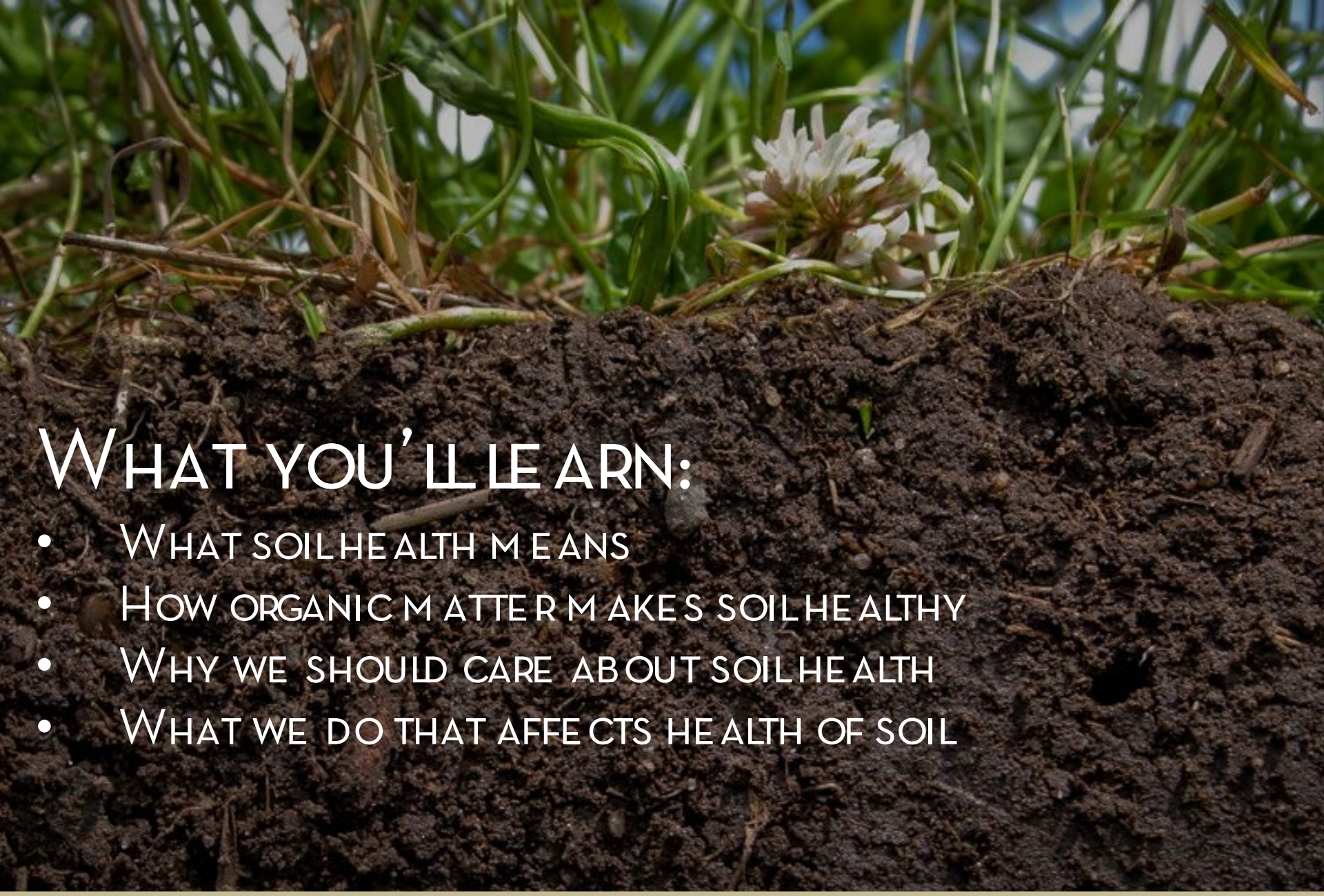

What you'll learn:

- What soil health means
- How organic matter makes soil healthy
- Why we should care about soil health
- What we do that affects health of soil

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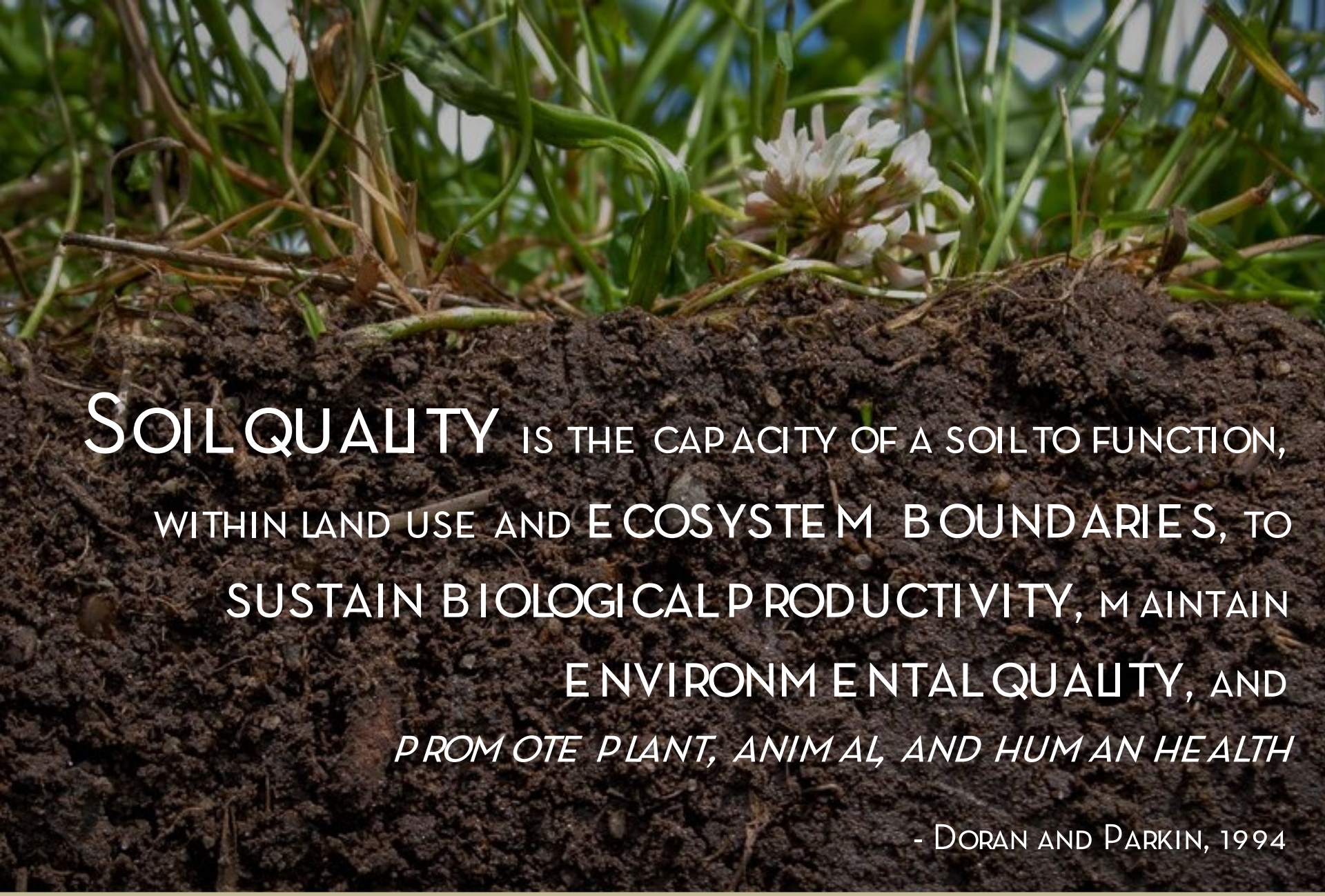

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Why Should I Care about Soil Health?

- What conditions let crops do well? What is soil like when crops are healthy?
- How did you manage soil where you farmed previously? How do you manage it here? Are the practices you use different?
- What did you do when you farmed before to re-energize the soil? Have you discovered alternative methods that are more or less suitable for re-energizing soil here?

Why Should I Care about Soil Health?

Having a more diverse soil food web can mean that inputs are broken down more efficiently for plants to use

Why Should I Care about Soil Health?

Having better aggregation decreases erosion and runoff

Why Should I Care about Soil Health?

Why Should I Care about Soil Health?

Having healthier soil can improve crop resistance against pests and environmental stresses

MORE PRODUCTIVE CROPS

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How Can I Help Soil Health?

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Cover Crops

Peyton Ginakes
University of Minnesota

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What you'll learn:

- What a cover crop is
- Benefits and challenges of using cover crops
- How to select a cover crop
- Estimating how much N a cover crop is providing

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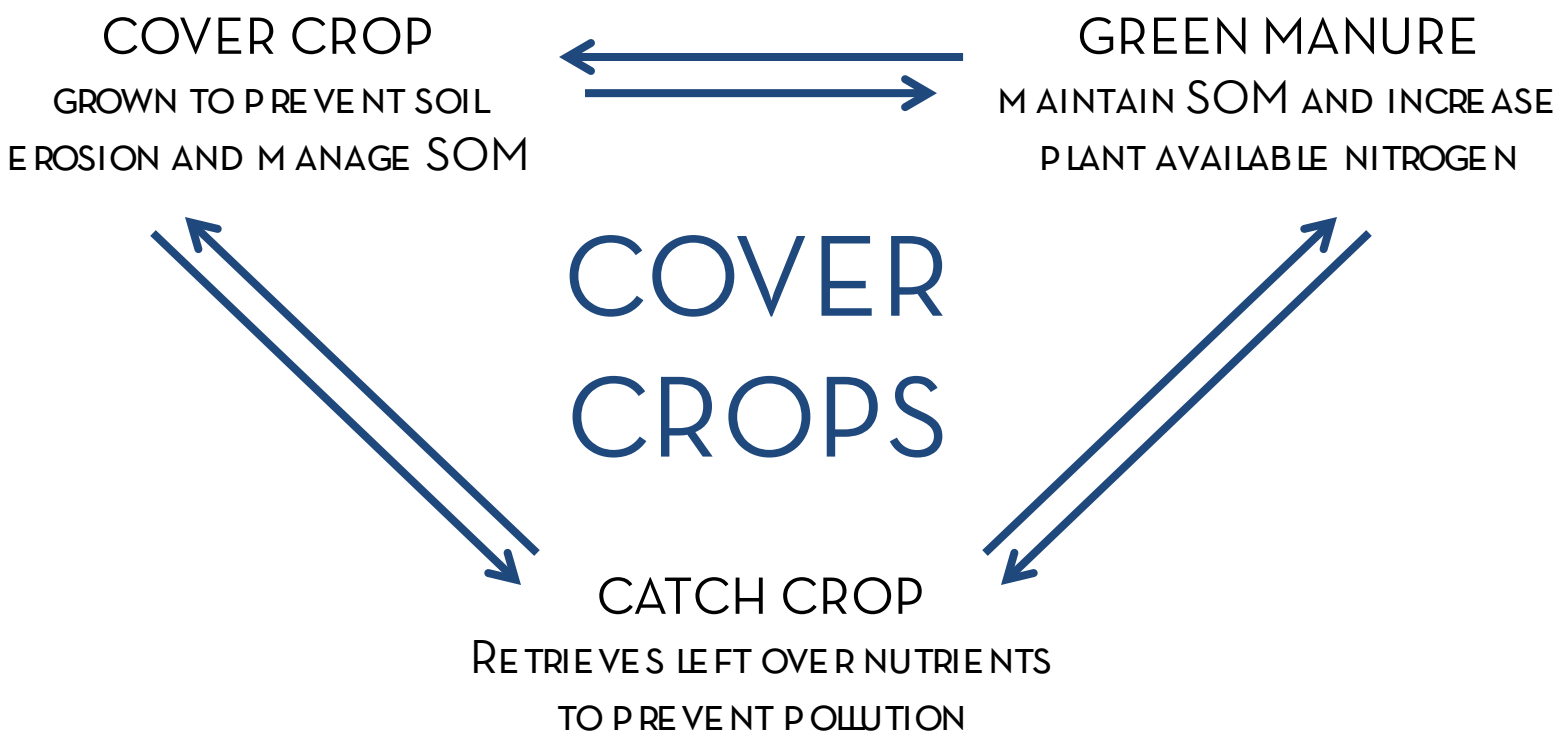
What is a cover crop?

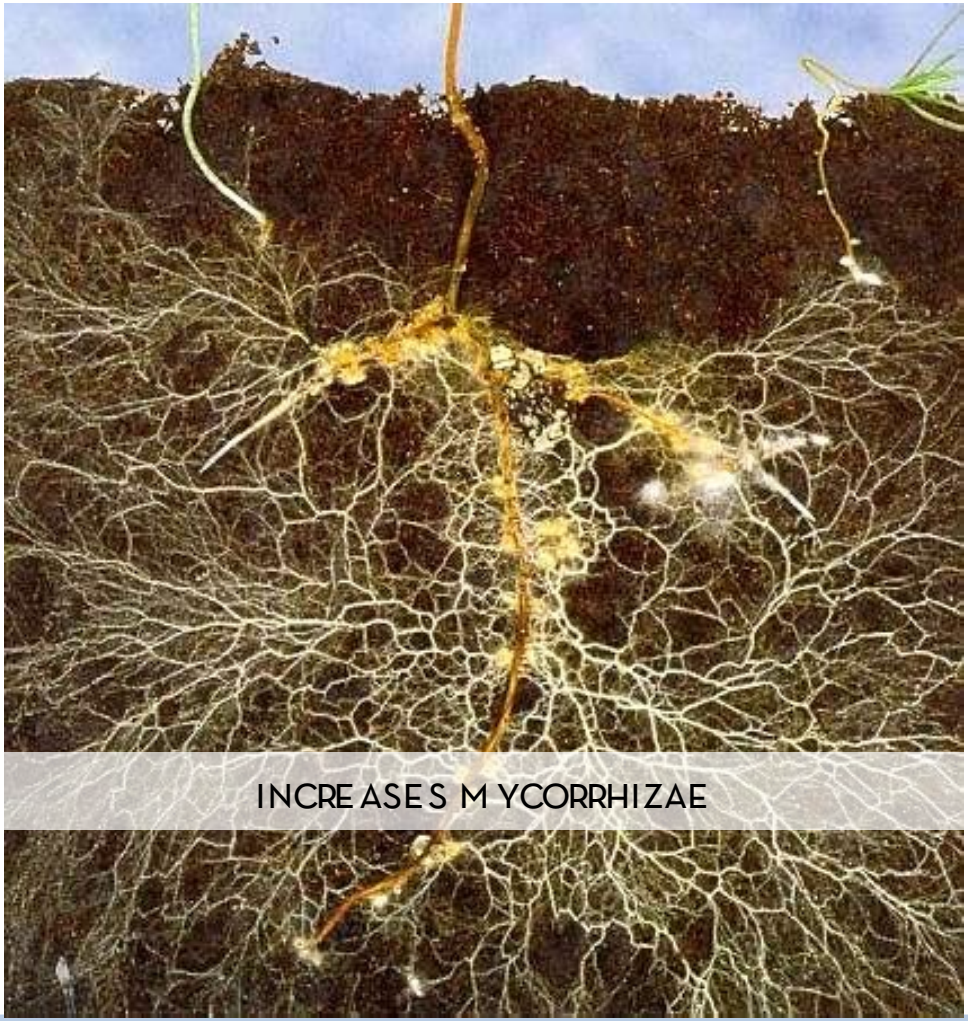


How do cover crops help soil?

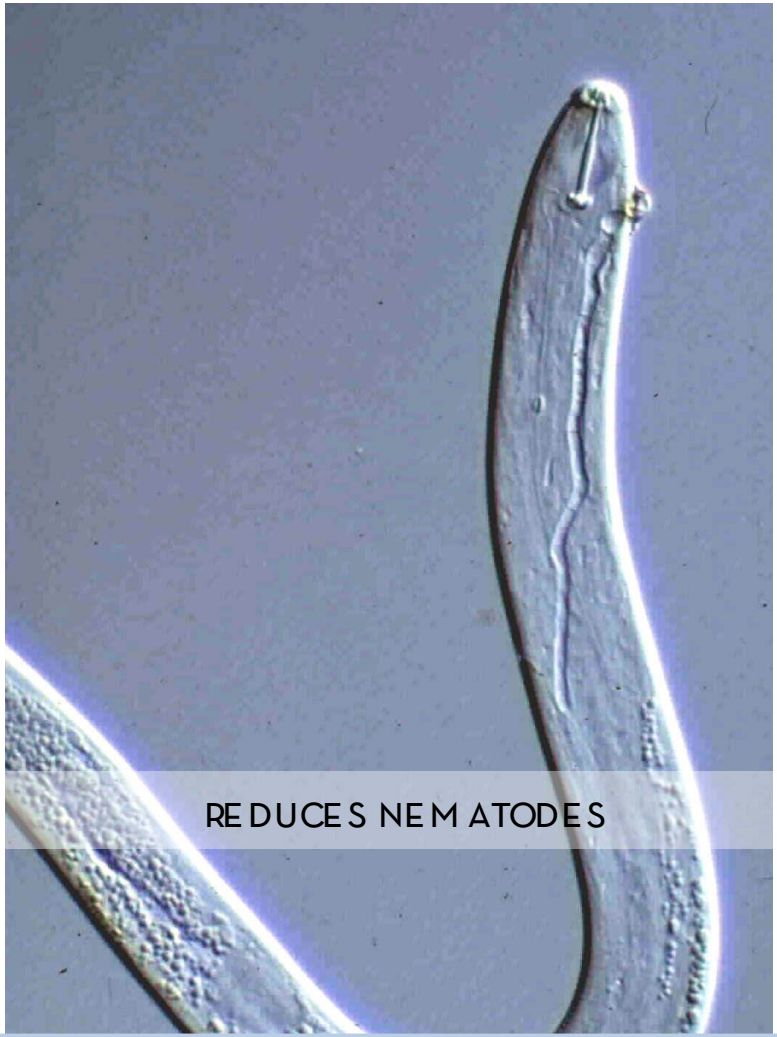
How are cover crops different from other amendments?

How do cover crops help soil?

How do cover crops help soil?



How do cover crops help soil?



How do cover crops help soil?

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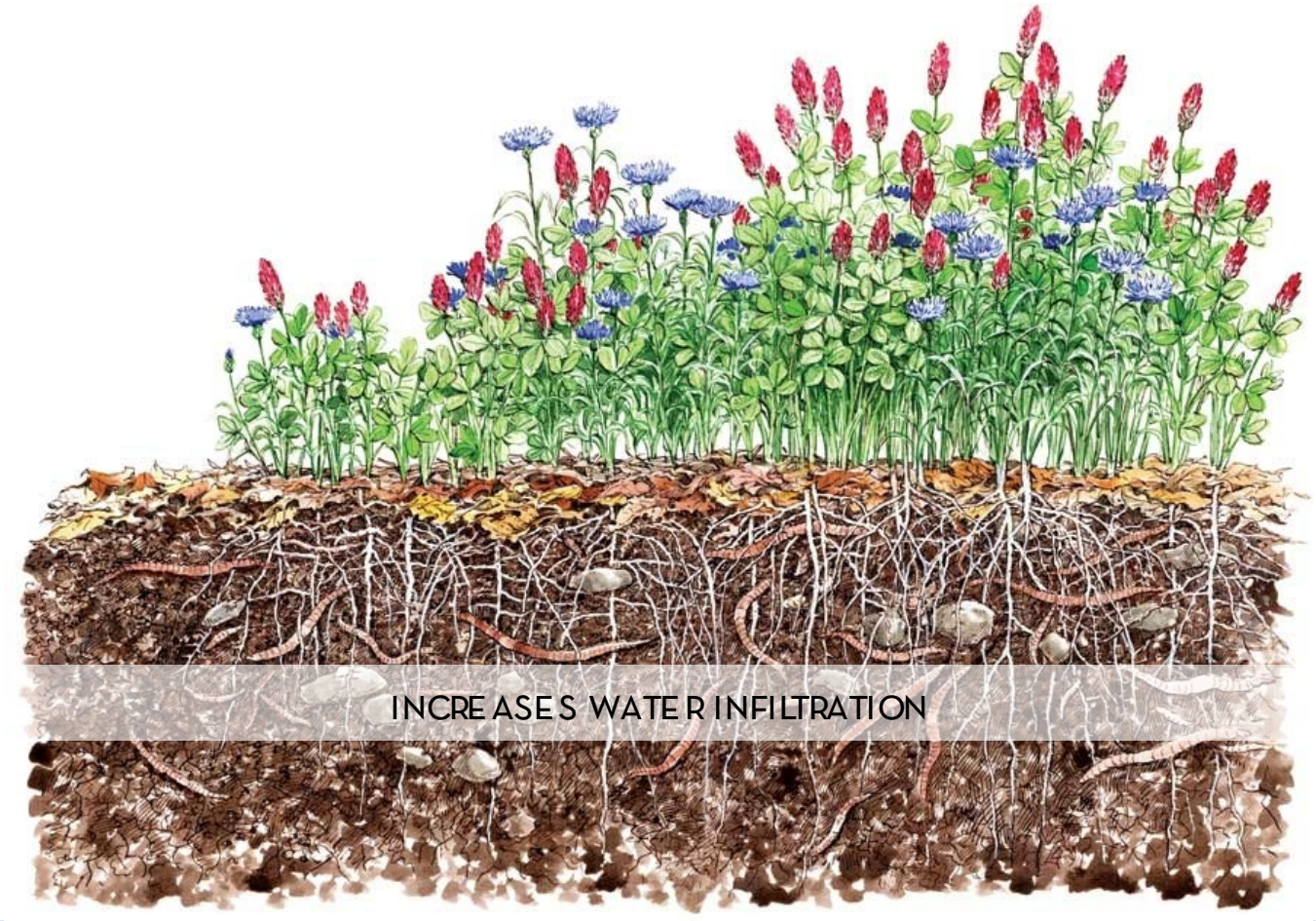

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How do cover crops help soil?

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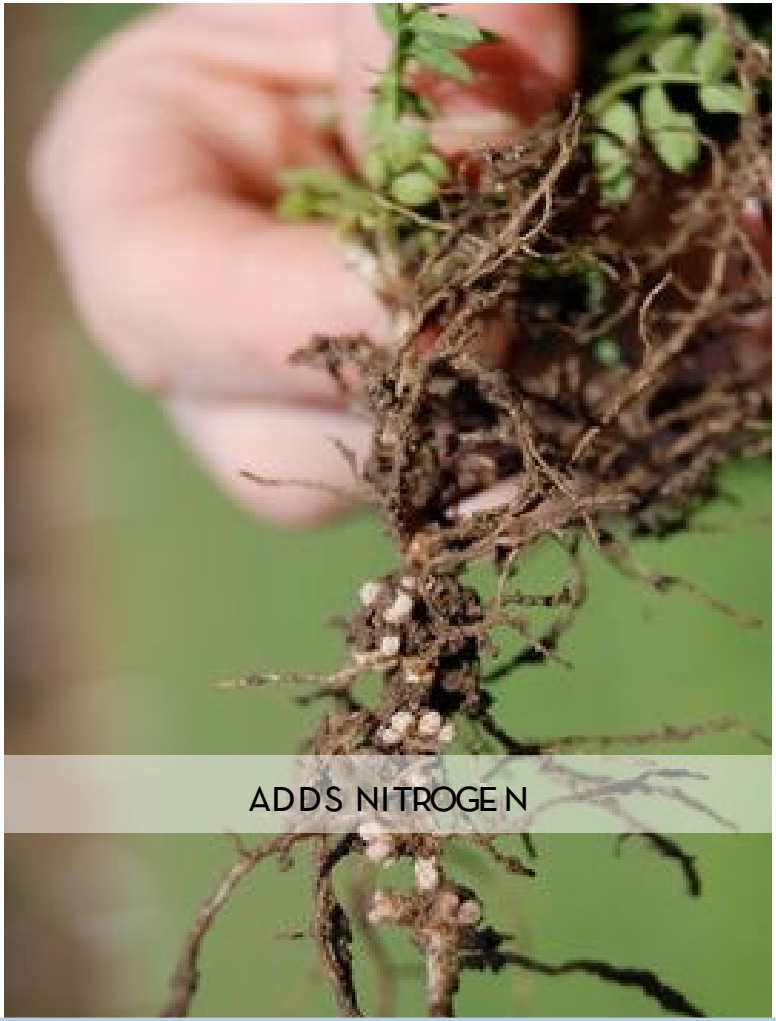
How do cover crops help soil?



How do cover crops help soil?

How do cover crops help soil?

Have you used cover crops?

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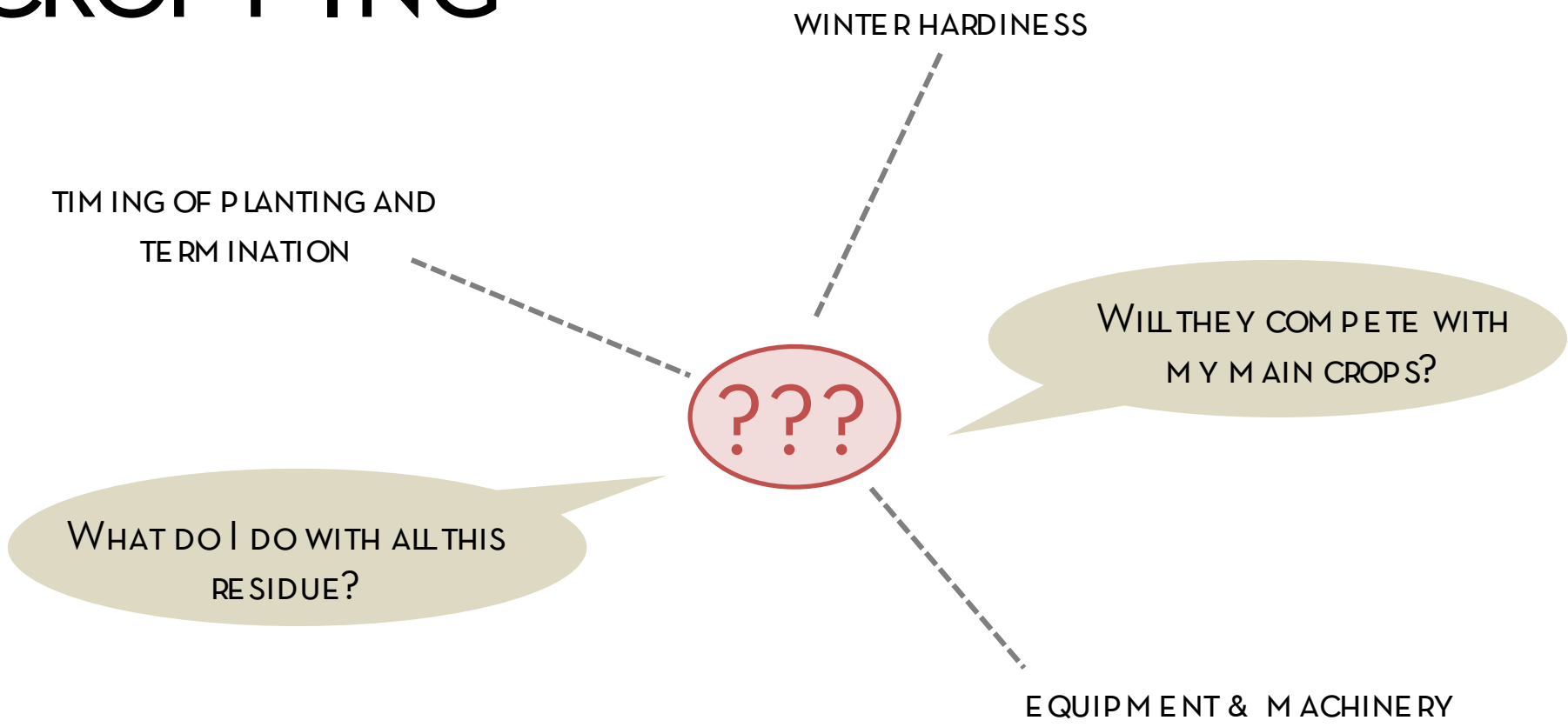
Challenges of cover cropping



Selecting a cover crop

1. Make a goal
2. Establish seasonal windows
3. Make plans for termination

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Estimating N credits

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Estimating N credits

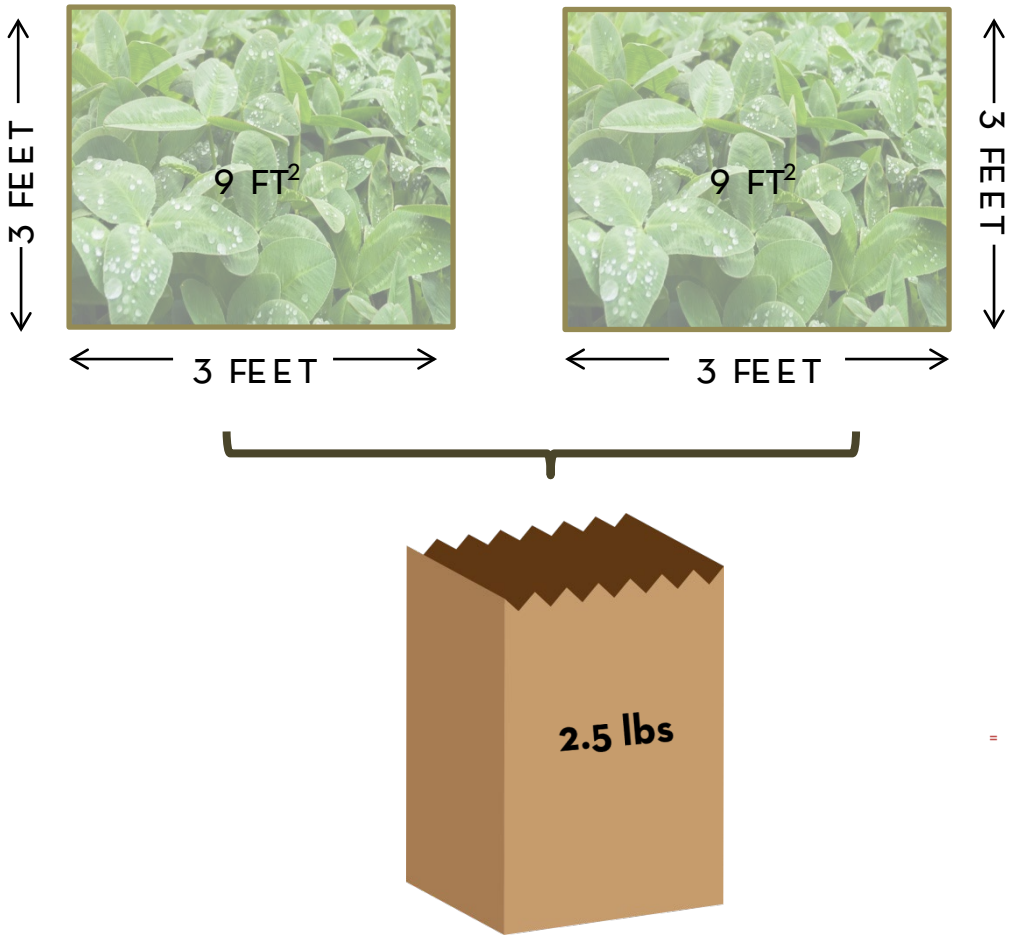
1. How much plant material is in a given area?
2. How much nitrogen is in that material?
3. How quickly will the material decompose and become available?
4. Do you need extra nitrogen?

Estimating N credits

- Use a ruler or yardstick to measure out a known area in your cover cropped area
- Clip the plants within the square *at several places in your field*
- Dry the samples in the oven until they are crunchy dry

1. How much plant material is in a given area?

Estimating N credits



How much biomass per acre do I have?

$$\text{LB BIOMASS/AC} = \frac{\text{DRY SAMPLE WEIGHT (LB)}}{\text{AREA SAMPLED (FT}^2\text{)}} \times \frac{43{,}560 \text{ FT}^2}{\text{AC}}$$

$$= \frac{2.5 \text{ LB}}{18 \text{ FT}^2} \times \frac{43{,}560 \text{ FT}^2}{\text{AC}} = 6{,}050 \text{ LB BIOMASS}$$

1. How much plant material is in a given area?

Estimating N credits

Cover Crop	Examples	% N
Legumes	Hairy vetch Clovers Pea Sunn hemp	4% at flowering 3% is seeds are maturing
Non-legume grasses	Rye Oat Sorghum sudangrass	3% at flowering 2% is seeds are maturing
Non-legume broadleaves	Buckwheat Tillage radish Canola	Similar or a little less than grasses

2. How much nitrogen is in that material?

Estimating N credits

The cover crop was flowering red clover
→ 4% N

6,050 lb/ac x 0.04 = 242 lb N/ac

Estimating N credits

MICROBES HAVE TO EAT THE MATERIAL
FOR IT TO BE AVAILABLE FOR PLANTS

Will you leave the cover crop on the surface, or incorporate it belowground?

40% will be available in year 1

242 lb N x 0.4 = 97 lb N/ac

50% will be available in year 1

242 lb N x 0.5 = 121 lb N/ac

Estimating N credits

What are you planting now?

Cabbage removes approx. 220 lb N/ac

→ will need 220 – 121 = 99 more lb N if we tilled in the clover

WHAT NOW?

Use manure, compost, or fertilizer; or, rely on accumulated soil organic N from all the organic matter you have been adding!

Nutrient Management

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University of Minnesota

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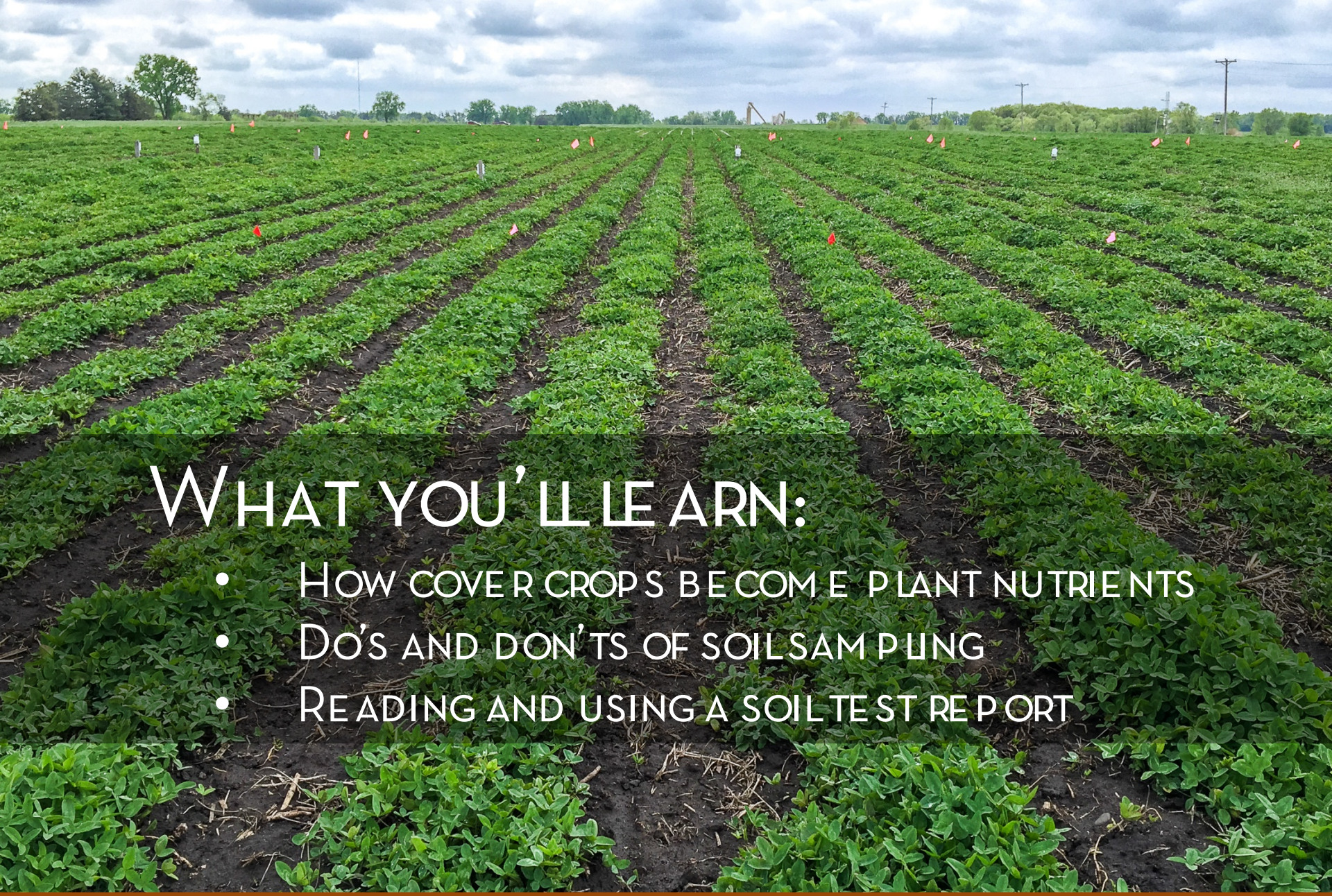

What you'll learn:

- How cover crops become plant nutrients
- Do's and don'ts of soil sampling
- Reading and using a soil test report

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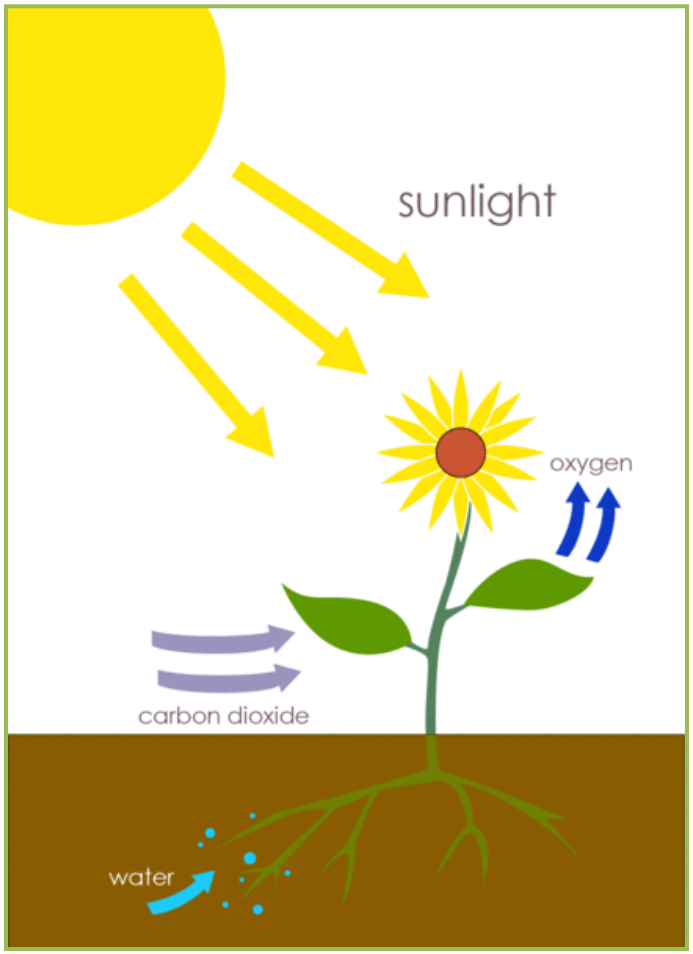
Where does it come from?

Plants grow through *photosynthesis*, which uses:

- sunlight
- CO_2 from the air
- water

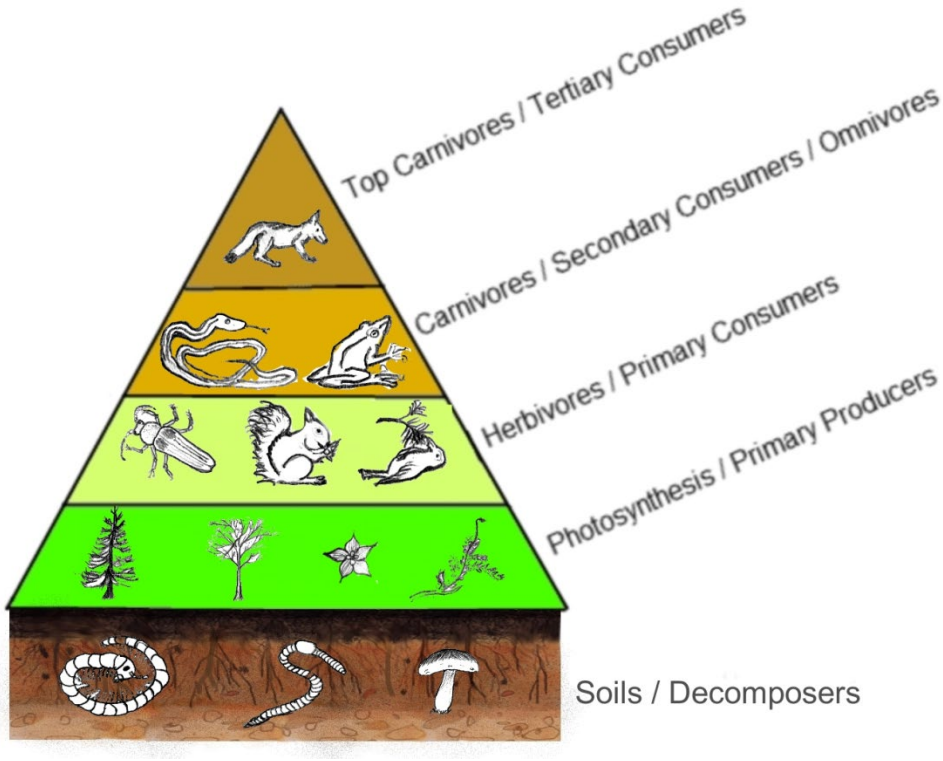
to make carbon-based plant matter.



Where does it come from?

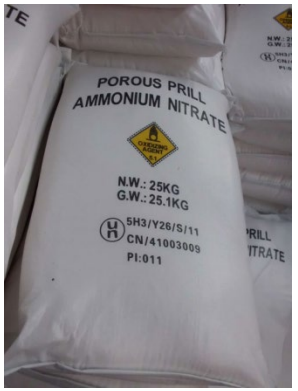
All living things (plant or animal) contain carbon, because they either photosynthesize or eat things that photosynthesize.

This process starts with plants when they fix (change) CO_2 into carbohydrates, using it to grow.



Where does it come from?

Organic (carbon-based) OR Inorganic (not carbon-based)



organic sources called "R-NH_2"

nitrate (NO_3^-) or ammonium ($NH4^+$) based

Where does it come from?

Organic (carbon-based)

organic sources called "R-NH_2"

Organic N needs to be turned into nitrate (NO_3^-) or ammonium (NH_4^+), which is called "mineralized", by soil microorganisms before plants can use it.

These are "made available" over time as microbes mineralize them, not all at once like fertilizers.

WHERE DOES IT COME FROM?

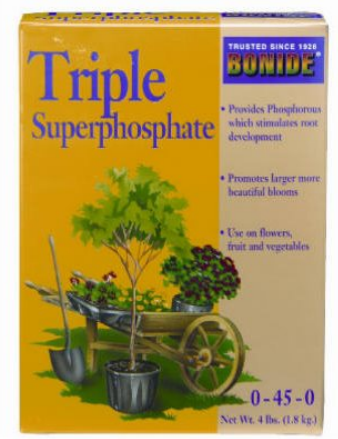
ORGANIC

SOM, PLANT MATTER, COMPOST

MINERAL

WEATHERING FROM ROCK → HPO_4^{-2} AND $H_2PO_4^{-1}$

INORGANIC



P_2O_5

Where does it come from?

Organic

SOM, plant matter, compost

Mineral

Weathering from rock → HPO_4^{-2} and $H_2PO_4^{-1}$

Plants can only take up inorganic and soluble P.

Like N, microbes mineralize P over time from organic sources.

WHERE DOES IT COME FROM?

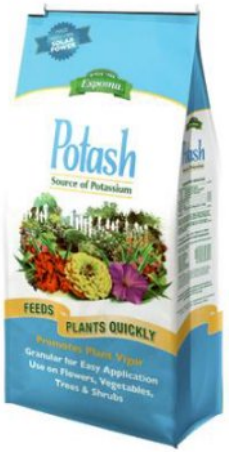
ORGANIC

SOM, PLANT MATTER, COMPOST

MINERAL

WEATHERING FROM ROCK (FELDSPAR AND MICA) → K^+

INORGANIC



K_2O

Where does it come from?

Organic

SOM, plant matter, compost

Mineral

Weathering from rock (feldspar and mica) → K^+

Plants can only take up K ions (K^+).

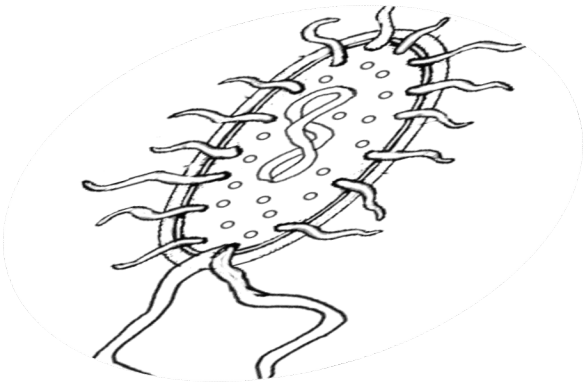
K^+ adheres to SOM, which keeps it from leaching and helps some of it stay available to plants.

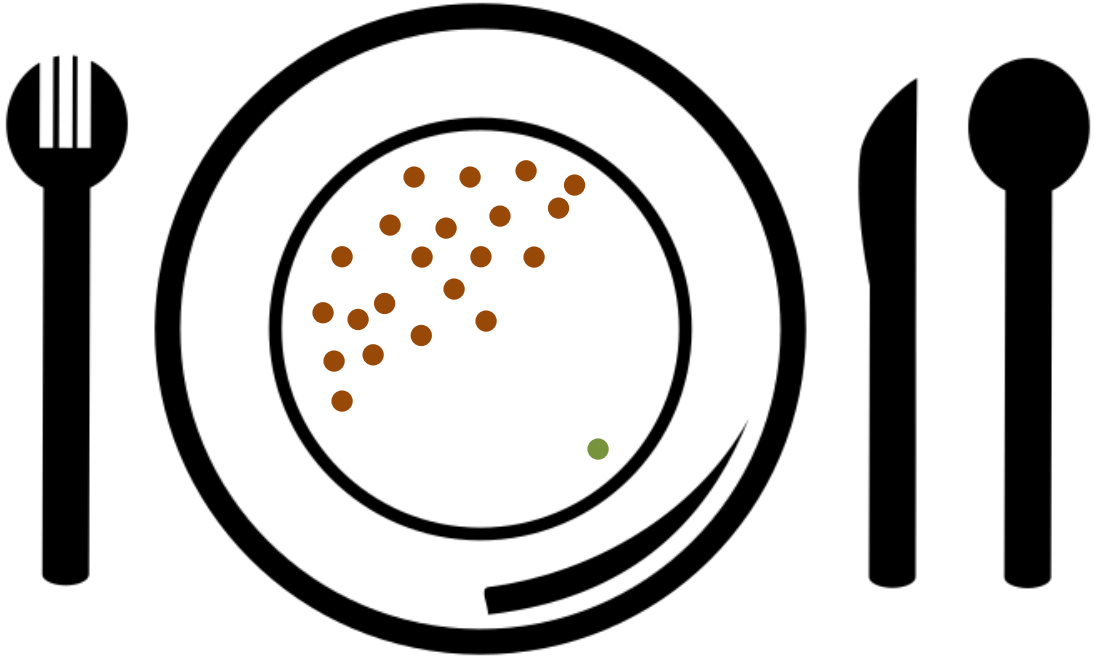
If plants get carbon from the *air*, why do we need to build SOM?

If plants get carbon from the *air*, why do we need to build SOM?

SOM holds other nutrients like nitrogen and phosphorus! When microbes eat SOM, they mineralize N and P, which makes them available for plants.

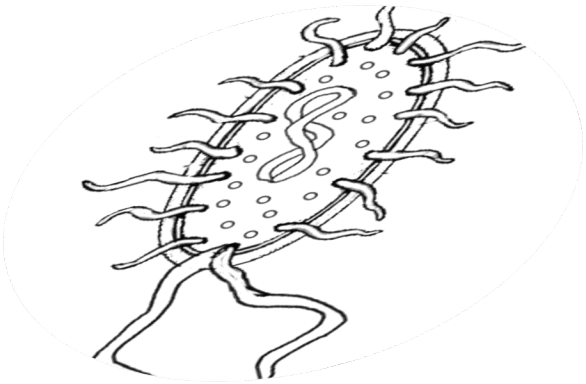
C AND N IN SOM

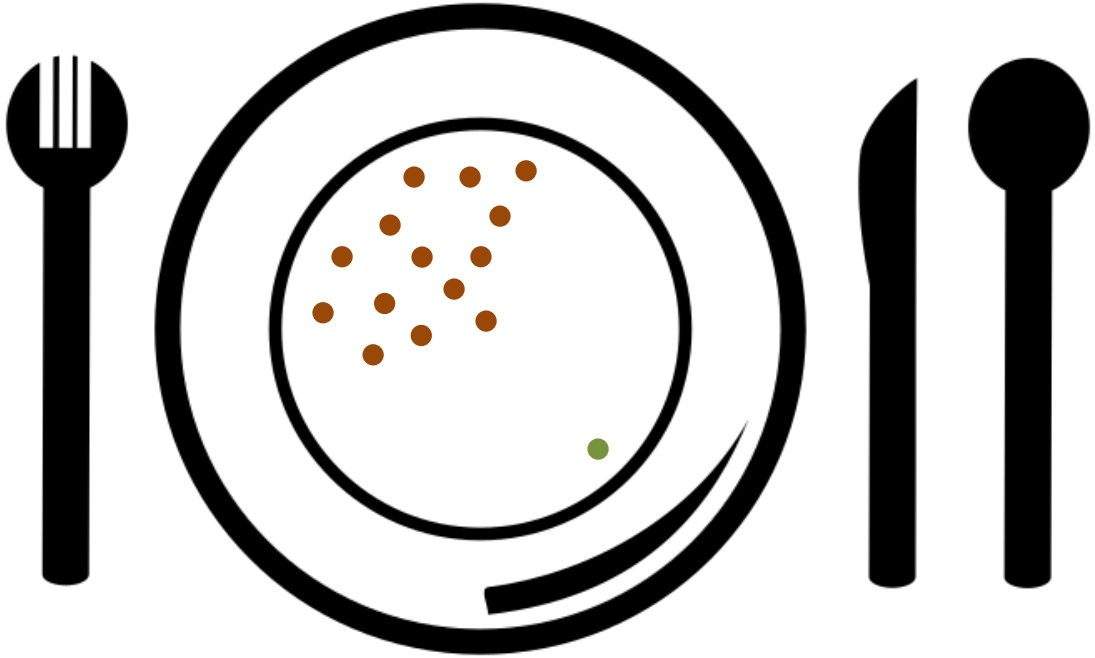




C AND N IN SOM

MINERALIZATION….



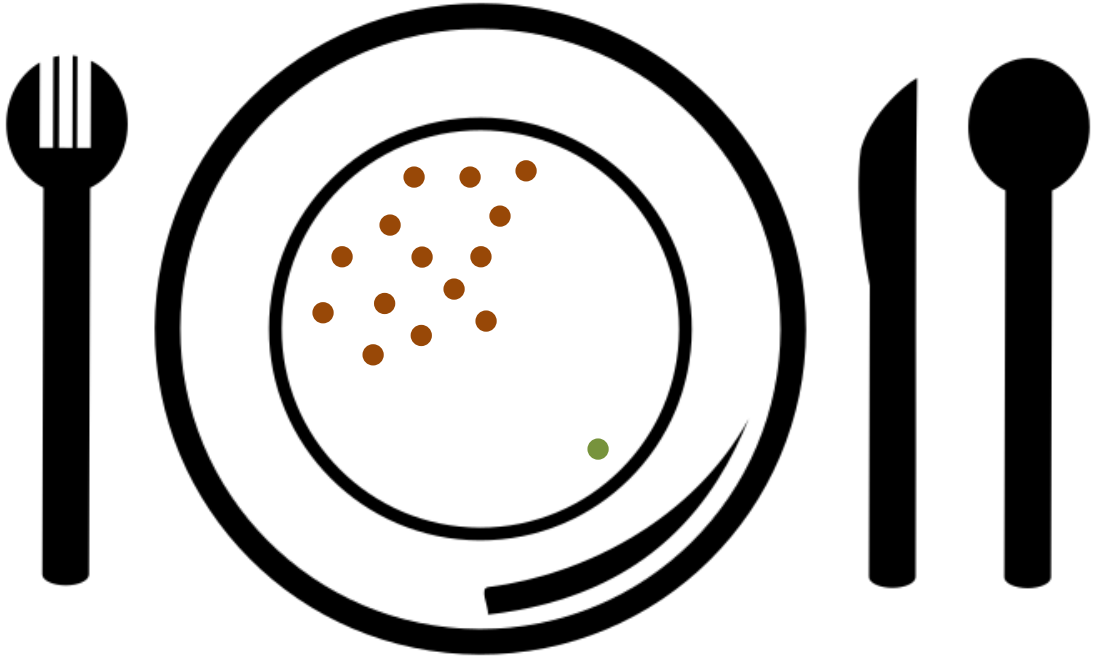


25 (*OR LESS*) PARTS C TO 1 PART N

C AND N IN SOM

MINERALIZATION….

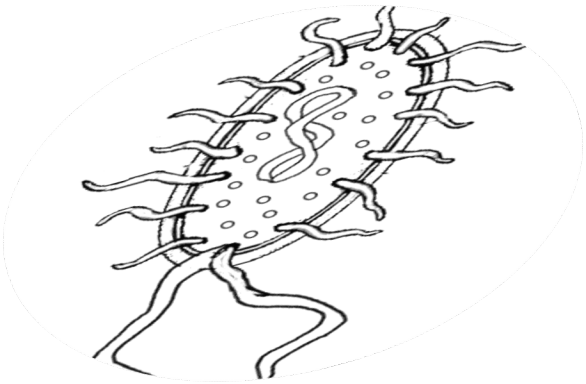
WHEN MICROBE FOOD IS HIGH IN N, THEY EXCRETE EXCESS N BACK INTO SOIL AS MINERAL FORMS THAT PLANTS CAN USE

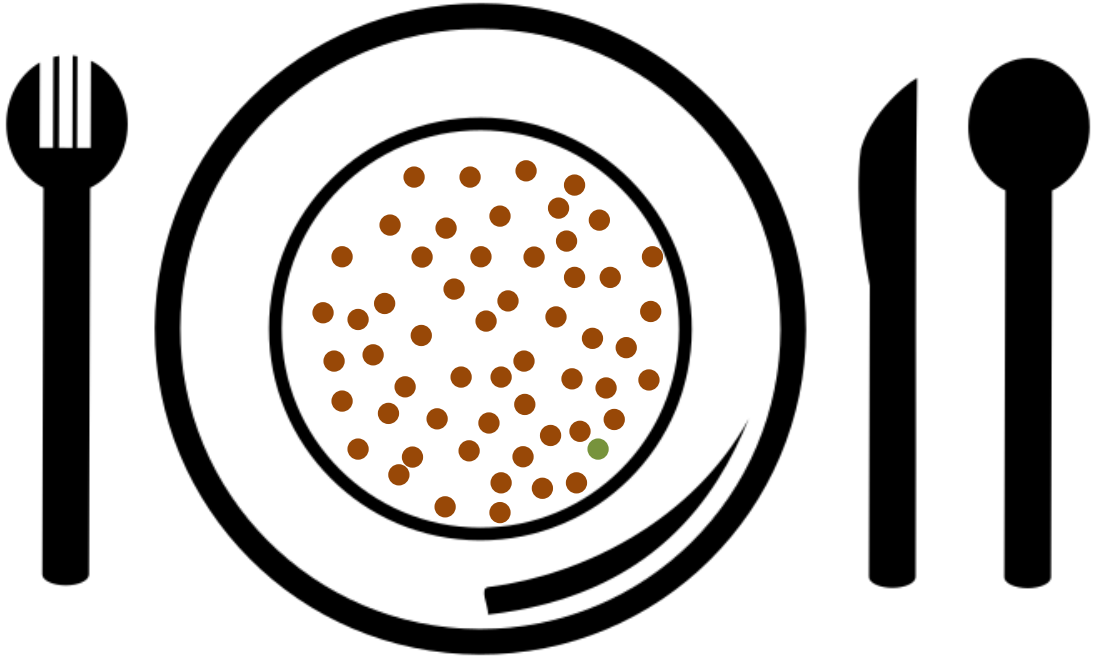


25 (*OR LESS*) PARTS C TO 1 PART N

C and N in SOM

….or Immobilization



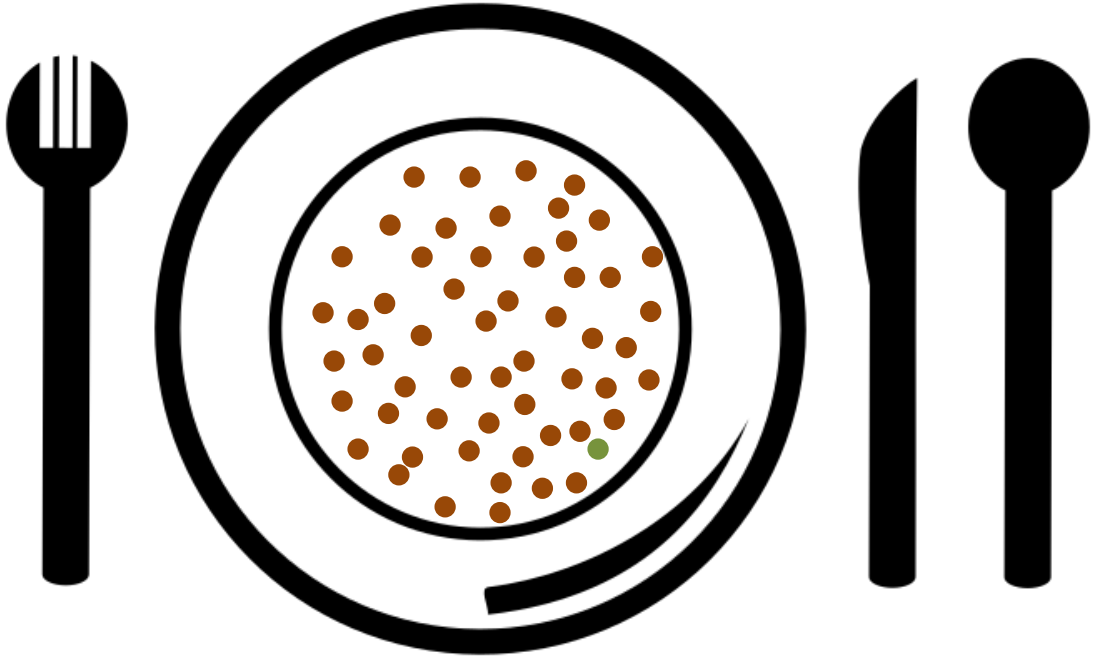


25 (*or more*) parts C to 1 part N

C AND N IN SOM

….OR IMMOBILIZATION

WHEN MICROBE FOOD IS LOW IN N, THEY HAVE TO USE N FROM THE SOIL TO METABOLIZE THE AVAILABLE CARBON, EFFECTIVELY TAKING AWAY N THAT PLANTS COULD HAVE USED



25 (*OR MORE*) PARTS C TO 1 PART N

C and N in SOM

Low C:N (10:1) is better than High C:N (40:1)

http://farmanywhere.growmycitygreen.com/blog/how-to-make-your-own-compost

Soil Testing

- You can submit multiple *samples*
- Many "composites" make up one *sample* – for instance, take 10 soil cores and combine them in a bucket, and submit the total
- Take representative *samples* (only composite soil from uniform areas)
- Don't include surface plant material
- Sample as deeply as you till (usually 6-8" deep)
- The more variable your landscape (hilly, different crop rotations, different soil types, etc.), the more composites you should take!

Soil Testing

The University of Minnesota has a Soil Testing Laboratory!

- Drop off samples at the Crops Research Building, rm 135
  (1902 Dudley Ave, St. Paul MN 55108)
- They have a great website: soiltest.cfans.umn.edu
- A normal soil report costs $15 per sample
  - NOTE: this does *not* include nitrogen!
- However, plant available nitrogen can be estimated from other values on the soil test report
- When you drop off the samples, you will be asked to fill out the following form….

UNIVERSITY OF MINNESOTA
Soil Testing Laboratory

FARM/FIELD AND COMMERCIAL HORTICULTURE CROPS
SOIL ANALYSIS REQUEST SHEET

Report No.

Instructions for filling out this form are given on the back side

LOCATION REFERENCE (If different than "mail reports to" address)	Soil Location:	MAIL REPORTS TO:
Name ____	County ____	Name ____
Address ____	Township ____	Address ____
City, State, Zip ____		City, State, Zip ____
Phone ____	Check for $ ____ enclosed	Phone ____

Sample Identification			1 Crop History				2 Proposed Crops						3 Check Test Requested (plow layer sample)								
			Crop Grown Before Last		Last Grown Crop		Option 1		Option 2		Option 3		* Regular Series P, K, pH, %OM	Sulfur**	Zn, Fe, Mn, Cu	Boron	Calcium and Magnesium	Lead	Nutrient Mgmt.	Soluble Salts	Nitrate Before selecting this test please read the section on nitrate on the BACK SIDE Sampling to 24" is required for this test.
Laboratory Number (Lab Use Only)	Field or Sample No. or Letter	Check if Irrigated	Crop Code No.	If Alfalfa check plants per sq ft	Crop Code No.	If Alfalfa check plants per sq ft	Crop Code No.	Expected Yield	Crop Code No.	Expected Yield	Crop Code No.	Expected Yield	$15	$7	$12	$7	$7	$16	$7	$7	
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample

Recommendations available for these crops: **See comments on back side *THE REGULAR SERIES INCLUDES PERCENT ORGANIC MATTER

Crop Code	Name	Yield Unit
	LEGUMES	
01.	Alfalfa, New Seed	ton/acre
02.	Alfalfa, Established	ton/acre
03.	Birdsfoot Trefoil	ton/acre
04.	Legume/Grass Hay	ton/acre
05.	Legume/Grass Pasture	–
06.	Red Clover	ton/acre
	CORN	
07.	Corn, Grain	bu/acre
08.	Corn, Silage	ton/acre
09.	Sweet Corn	ton/acre
	SMALL GRAINS	
10.	Barley	bu/acre
11.	Oats	bu/acre
12.	Rye/Triticale	bu/acre
13.	Wheat	bu/acre
	MISCELLANEOUS	
14.	Buckwheat	lb/acre
15.	Edible Beans	lb/acre
16.	Fallow	–
17.	Flax	bu/acre
18.	Grass Hay	tons/acre
19.	Grass Seed Prod.	lb/acre
20.	Grass Pasture	–
21.	Millet	lb/acre
22.	Native Grasses	tons/acre
23.	Potatoes	cwt/acre
	MISCELLANEOUS (continued)	
24.	Rape/Mustard/Canola	cwt/acre
25.	Sorghum Sudan	–
26.	Soybeans	bu/acre
27.	Sugarbeets	tons/acre
28.	Sunflowers	lb/acre
29.	Wild Rice	–
	VEGETABLES	
30.	Asparagus, New Planting	
31.	Asparagus, Establ. Planting	
32.	Beans, Snap	
33.	Beets, Table	
34.	Broccoli	
35.	Brussels Sprouts	
36.	Cabbage	
37.	Cauliflower	
38.	Carrots	
	VEGETABLES (continued)	
39.	Celery	
40.	Cucumbers	
41.	Lettuce	
42.	Melons	
43.	Onions, Dry	
44.	Onions, Green	
45.	Parsnips	
46.	Peas	
47.	Peppers	
48.	Pumpkins/Squash	
49.	Radishes	
50.	Turnips	
51.	Rhubarb	
52.	Rutabagas	
53.	Spinach	
54.	Tomatoes	
	FRUITS	
55.	Apples	
56.	Blueberries	
57.	Grapes	
58.	Raspberries/Brambles	
59.	Strawberries	
	TURF	
60.	Cultured Sod	
61.	**NURSERY - FIELD STOCK TREES/SCRUBS** Suggested tests: Regular, Soluble Salts, Nitrate. For sampling instructions, please see Nursery Form	
62.	Other ____	

Soil Testing

- pH – alkaline or acidic? ★
- % organic matter ★
- soil texture ★
- potassium (K) and phosphorus (P)
- *can* measure micronutrients (Ca, Mg, Zn, B, Cu, Mn)
- can also measure nitrate
  - both add to cost
- soluble salt concentrations

University of Minnesota
Soil Testing Laboratory

SOIL TEST REPORT
Farm and Field

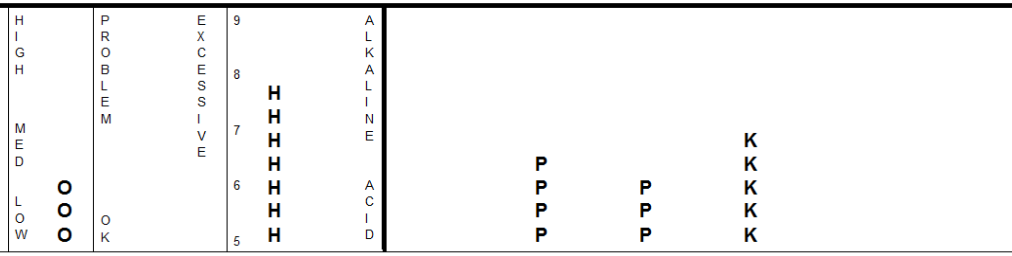
Client Copy
Department of Soil, Water, and Climate
Minnesota Extension Service
Agricultural Experiment Station

FARMER DOE
ROUTE 1
ANYWHERE MN 55000

Page **1**
Report No. **12**
Laboratory No. **18**
Date Received **10/16/07**
Date Reported **10/18/07**

INTERPRETATION OF SOIL TEST RESULTS

Soil Texture Code:
C (coarse):
sand, loamy sand, sandy loam
M (medium):
loam, silt loam
F (fine):
clay loam, silty clay loam, silty clay



SOIL TEST RESULTS

Sample/ Field Number	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
1	**Medium**	**3.0**		**7.6**			**6**	**4**	**75**								

RECOMMENDATIONS
Crop Before Last: Sweet Corn; Last Crop: Cabbage

Crop and Yield Goal	Method	Lime #ENP/A	N lb/A	P2O5 lb/A	K2O lb/A	S lb/A	Zn lb/A	Fe lb/A	Mn lb/A	Cu lb/A	B lb/A	Ca lb/A	Mg lb/A
Sweet Corn	Broadcast	**0**	**150**	**60**	**100**								
8 tons/acre	Row/Drill			**35**	**40**								
Comments: 4,5,18													
Cabbage	Broadcast	**0**	**180**	**150**	**200**								
	Row/Drill												
Comments: 18,50,57													
Tomatoes	Broadcast	**0**	**130**	**150**	**200**								
	Row/Drill												
Comments: 18,50,57													

Soil Testing

So what if you want to know how much nitrogen you have, but you don't want to pay (and wait) for nitrate measurements?

We can do the math!

- All the soil in the top 6 inches of an acre weighs about 2,000,000 pounds.
- If we have 3% SOM, like in the report, that means we have
  0.03 x 2,000,000 = 60,000 lb/ac of SOM
- But SOM is only about 7% nitrogen...
- So in the soil, about 60,000 x 0.07 = 4,200 lbs of nitrogen exist as SOM (org N)
- BUT, finally, only about 2% of this is mineralized annually...
  - 4,200 x 0.02 = 84 lb mineral N per acre (quite a lot!)