Understanding U.P. Soils

Field, forage and horticultural crops

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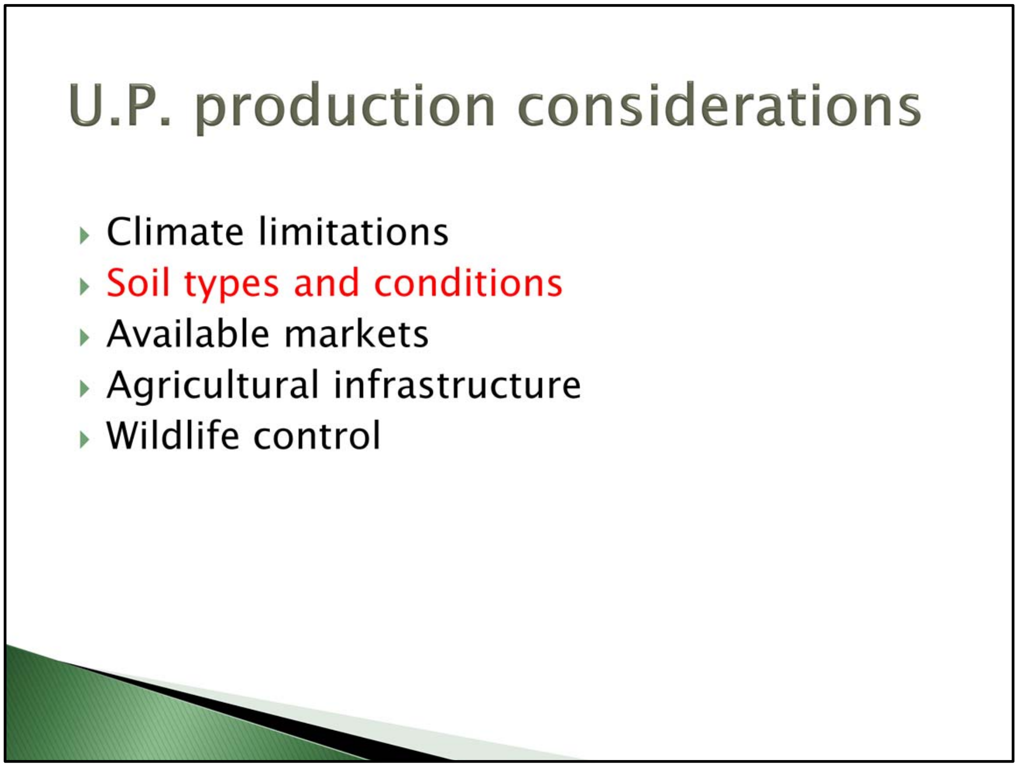
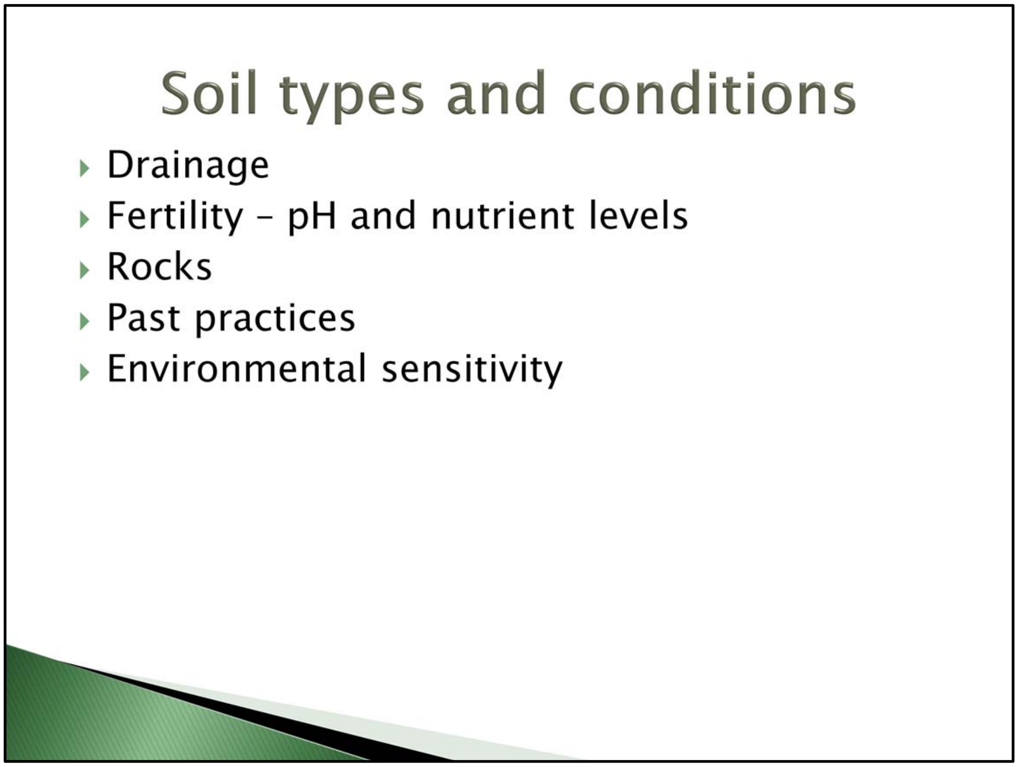
MICHIGAN STATE UNIVERSITY | Extension

This presentation is meant to provide local, Upper Peninsula insight into the different soils and soil conditions used by farmers.



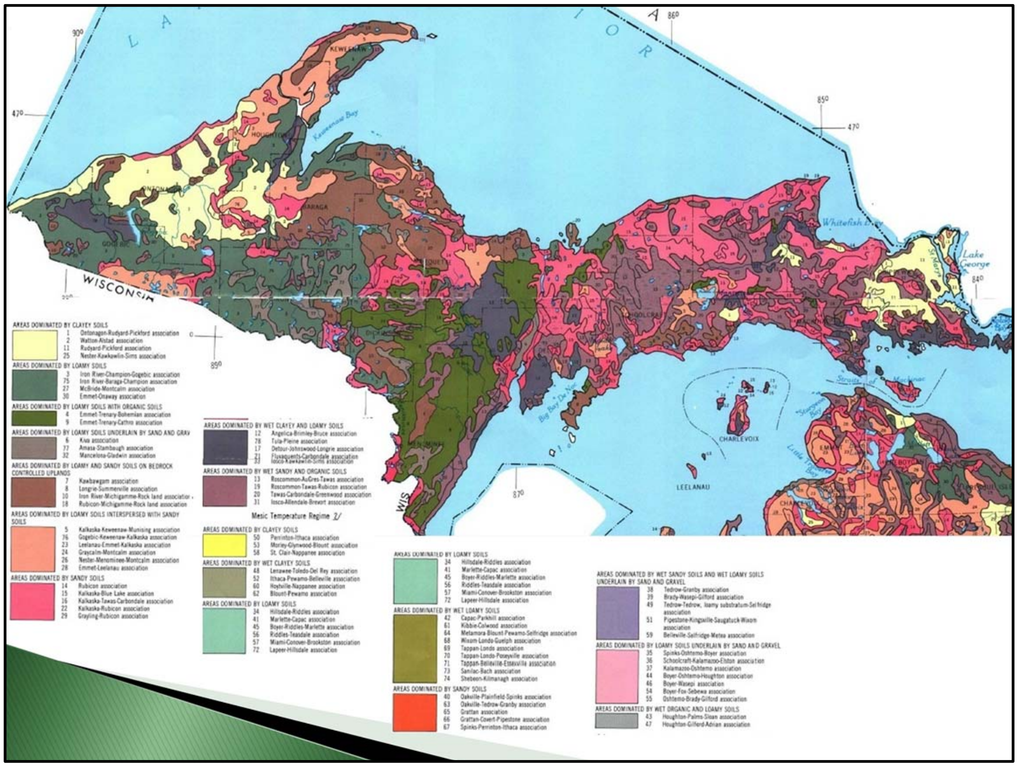
U.P. soil types are not typically the very best for agriculture. Some areas of the U.P. have better soils than others, but in general, most U.P. soils are of low-moderate fertility and are either fine (high clay content) or coarse (high sand content).

Not the best compared to the more intensive agricultural zones of lower Michigan and the midwest.

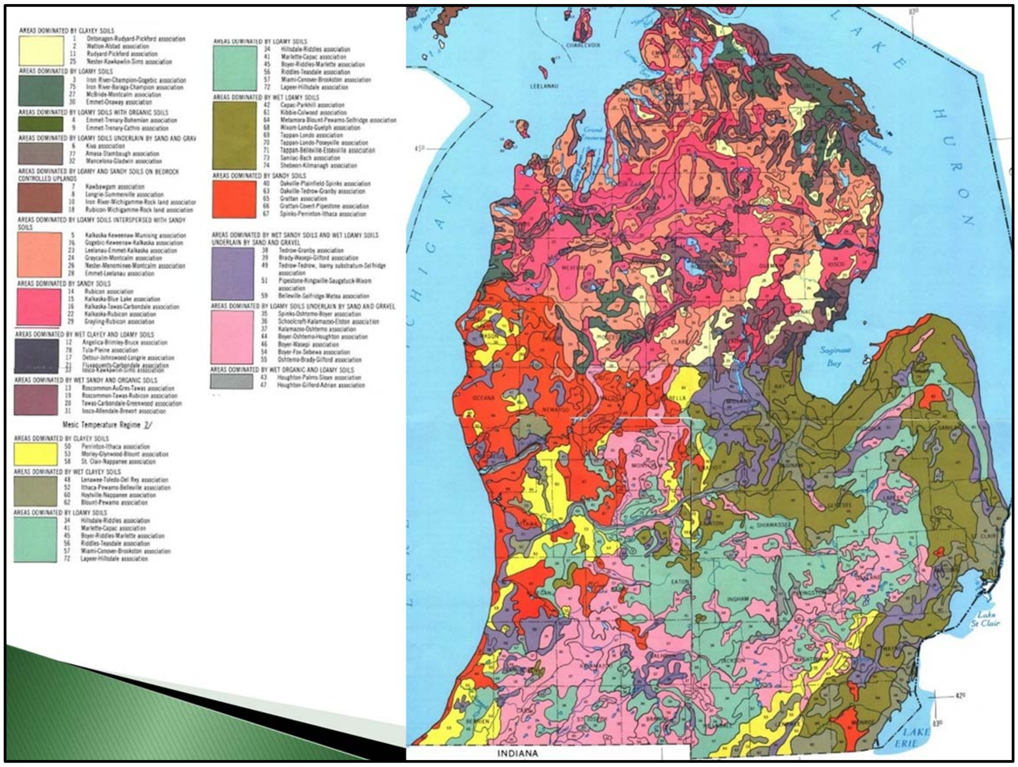


There are wide variations in drainage, fertility, presence of rocks, and environmental sensitivity across the U.P.

Past soil management practices also impact present-day ag soils. After logging, many low quality sites were hayed and grazed without additions of adequate nutrients, resulting in ‘worn-out’ fields.



This soil association map gives a good idea about the predominant types of soils in large areas of the U.P. Clay soils cover much of the far east and west farmlands in the region. Sands, sandy loams and loamy soils with much better drainage are common in the central U.P.



This is the same soil association map showing groupings of soil types in lower Michigan.
The soils north of Saginaw Bay are more similar to U.P. soil types than those further south.

Desired soil fertility levels

- pH: 6.5 – 6.8
  - Exceptions: 6.0 for potato, rhubarb, eggplant, endive, escarole
- P: 50–75 ppm
- K: 135–150
- Ca: usually OK, watch it in the western U.P.
- Mg: 35–75
- S, B: deficiencies most likely in sandy, acid soils
- Other micros: see bulletin for specific vegetable responsiveness

The soil fertility levels shown here would be good for most vegetables and field crops. This type of information is available through a soil test from a reputable soil testing lab, such as MSU or AgSource (Wisconsin).

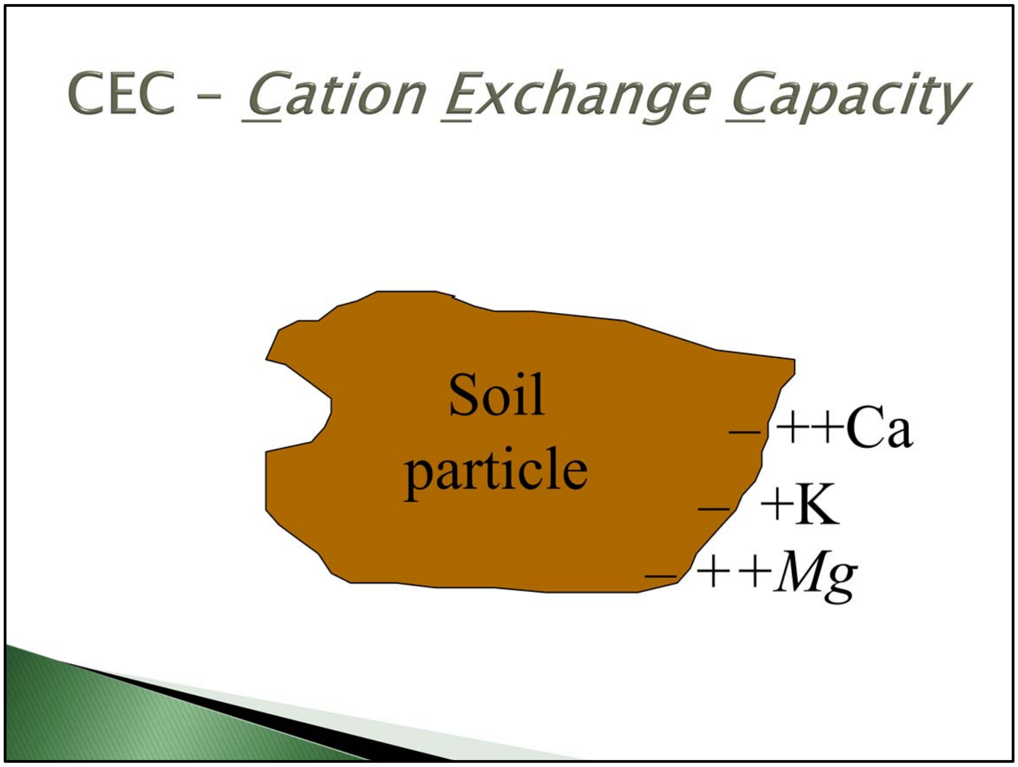
Lime Index

- Indicates the amount of reserve acidity in the soil, and how much lime it will take to adjust pH to a desirable level.
- Soil with a greater reserve acidity (lower lime index number) has more capacity to resist change in pH.
- Lime index usually falls between 70 and 60 (for soils under pH 6.8). No lime will be recommended if the lime index is above 70.
- As lime index decreases below 70, more lime is needed to bring soil pH up to the target level.
- Sandy soils typically require less lime to move up 1.0 on pH scale

pH	Lime Index	Lime required	CEC	Texture
5.8	68	1.5	5.5	Loamy sand
5.8	66	3.3	10.5	Silt loam

When called for by a soil test report, lime is the most important soil fertility amendment of all. When soil pH is too low (acidic) or too high (alkaline), plants are chemically unable to extract the nutrients they need from the soil, even if those nutrients are present in adequate amounts. In other words, fertilizers (synthetic or natural) don't work right if the soil pH is too acidic or alkaline.

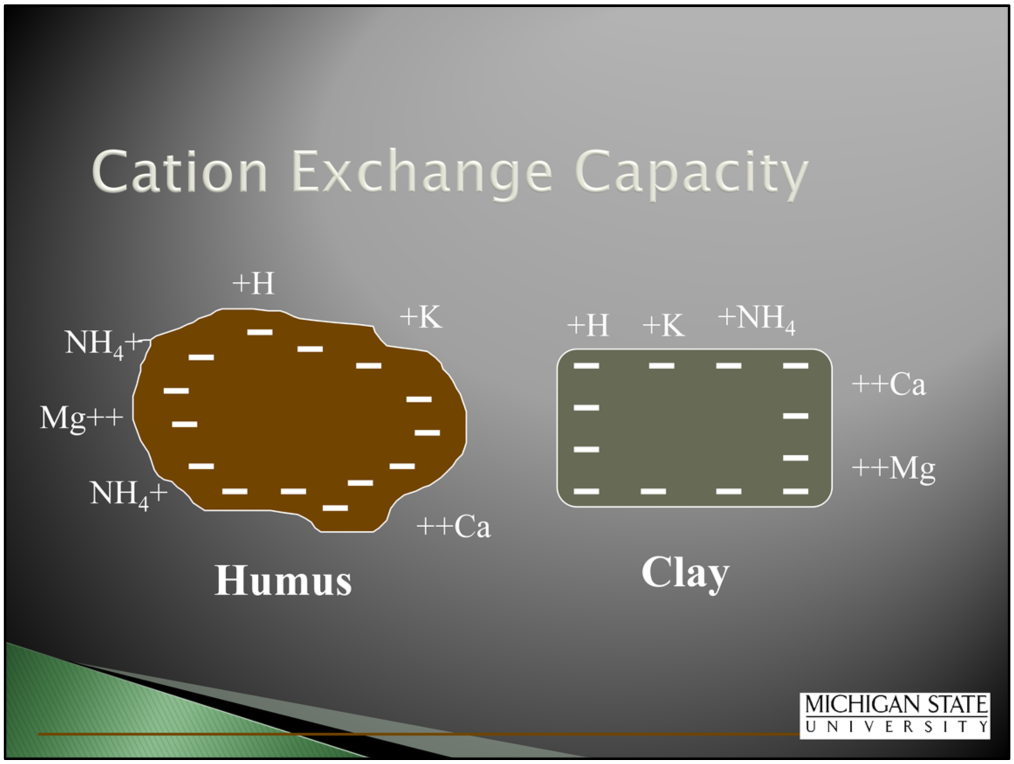
The example here is meant to show that different soil types with the same pH can require different lime rates to correct pH to a desired level. CEC is 'cation exchange capacity', a measurement of a soils ability to hold onto positively charged ions (many plant nutrients like calcium, magnesium, and potassium are only available as positively charged ions in the soil water solution).



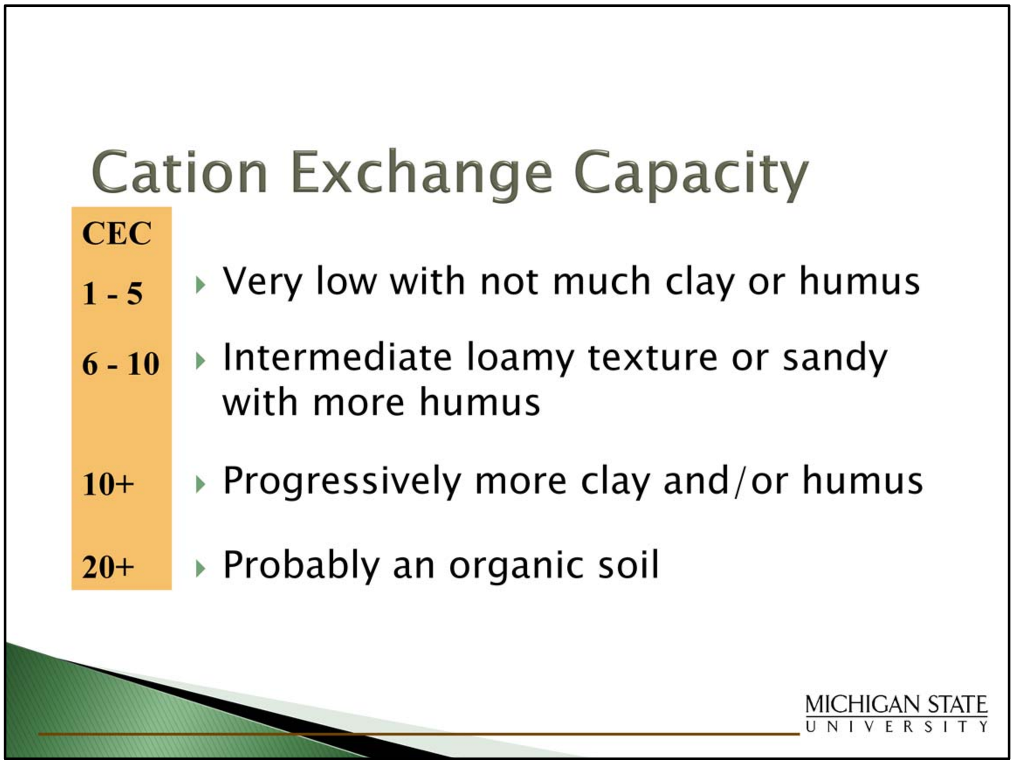
Cations ‘stick’ to negatively charged sites on soil particles.

Plant nutrients available as cations include
Calcium, Ca++
Potassium, K+
Magnesium, Mg++
Ammonium, NH_4+

Sulfate, nitrate, phosphate, borate, and chloride are all negatively charged ions in soil water solution and not held by soil the same way.



Clay and organic matter particles have more negatively charged sites on their surfaces than sand or silt particles. Therefore, clay soils and soils with higher levels of organic matter usually have higher cation exchange capacity and are more fertile than sandier and siltier soil types.



Whenever you read a soil test from a professional laboratory, such as the MSU Soil Lab, you will see a CEC value printed. A generalized interpretation is that

- If the CEC is between one and five, the cation exchange capacity of the soil is very low and there is not much clay or humus present.
- If the CEC is between six and 10, the soil has an intermediate loamy texture or is sandy with more humus.
- If the CEC is between 10 and 20, there is progressively more clay and/or humus as the value increases.
- And, if the CEC is greater than 20, you are probably dealing with an organic soil.

A soil's CEC is very important because it can affect fertilizer management which affects the cost of growing plants and the environment through contamination of groundwater due to over-fertilizing.

UP County soil tests compared

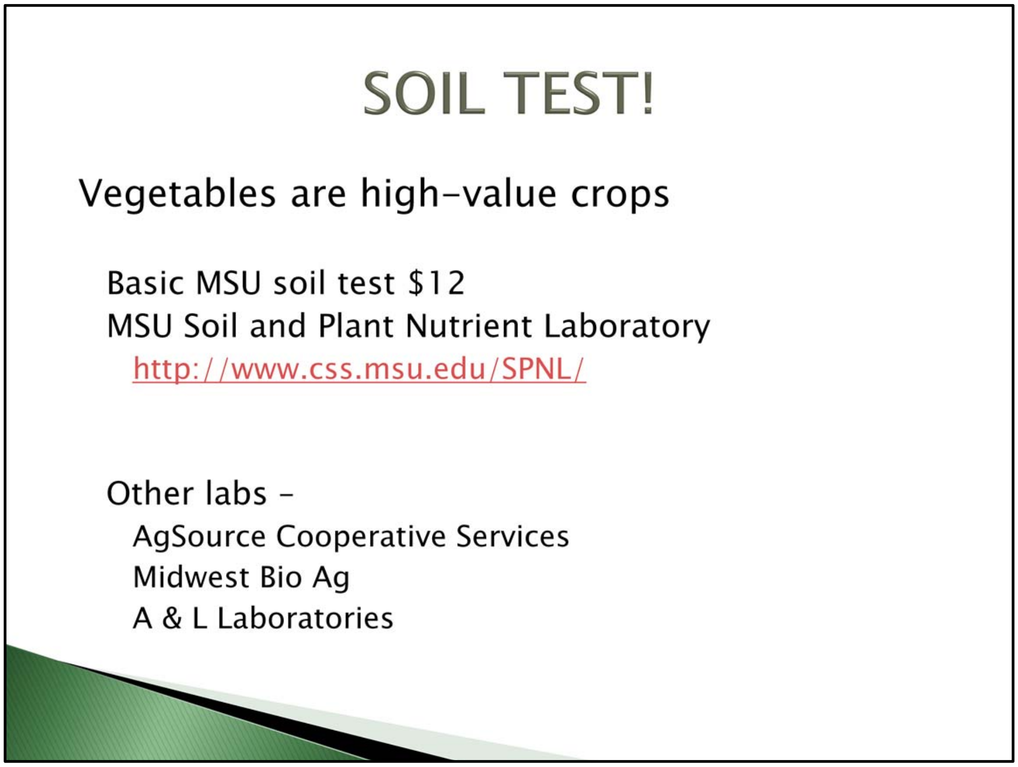
	pH		Lime Index		CEC	
	Avg	Median	Avg	Median	Avg	Median
Delta 62 tests	6.4	6.2	66	66	10.4	10.1
Chippewa 51 tests	5.9	5.8	65	64	14.5	15.0
Marquette 41 tests	6.2	6.1	66	66	9.1	8.8
Alger 48 tests	6.4	6.2	66	66	11.6	10.5

This chart shows average pH, lime index and CEC values from MSU soil tests from the counties indicated over the entire year 2012. The differences in pH and CEC are of interest. Chippewa County has a lot of clay farming soils.

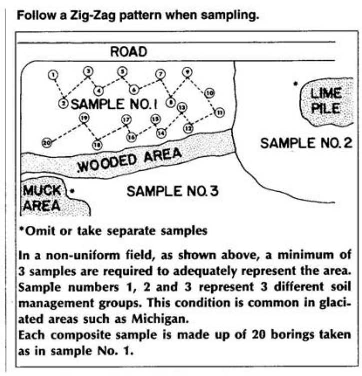
UP County soil tests compared

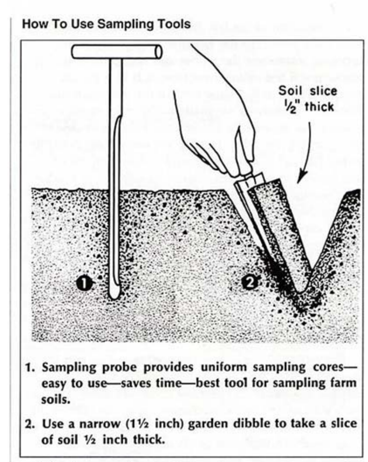
Targets: P: 50-75 ppm K: 135-150 Mg: 35-75	P		K		Mg		Ca	
	Avg	Median	Avg	Median	Avg	Median	Avg	Median
Delta 62 tests	43	32	94	52	156	156	1225	1114
Chippewa 51 tests	36	19	96	91	265	266	1267	1183
Marquette 41 tests	63	38	94	60	103	75	858	711
Alger 48 tests	73	39	108	99	167	138	1253	1056

These are the same soil tests. All county averages for potassium and phosphorus are lower than desirable. On average, all counties have adequate magnesium and calcium, although magnesium is sometimes low and magnesium-containing lime or fertilizer is recommended.



The cost of a soil test from MSU for commercial farms is currently $12. The farmer pays the postage to send the sample to MSU, maybe another $4-5. Compared to the benefit received and potential improvement in profitable crop performance through judicious use of lime and fertilizer, the cost of soil testing is a bargain.





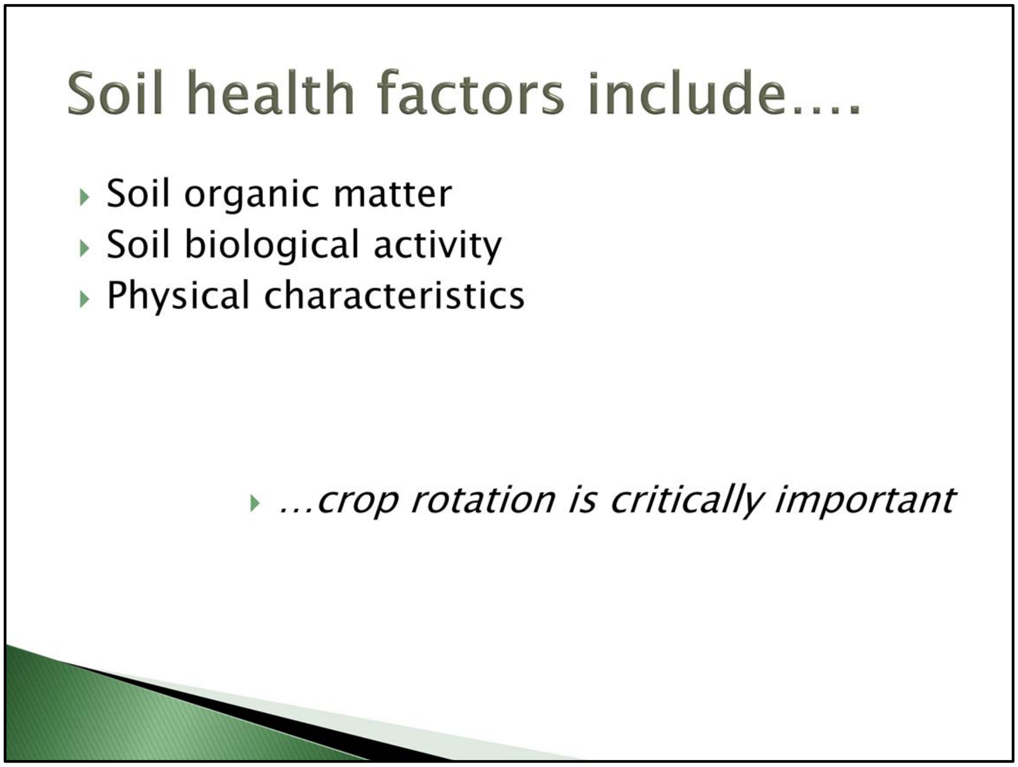
MSU recommends that a single soil test should represent not more than 20 acres. It is critically important to collect a good, representative soil sample. Sample only as deeply as you will till the soil, and indicate on your submittal form how deep you will till, otherwise your lime recommendation will be incorrect. Be sure to get a sliver of the soil profile, not just a 'scoop' of soil, for each subsample.

Use clean implements and bucket, take many subsamples (20 is good) for each area tested. Mix thoroughly in the bucket before taking your final representative sample.

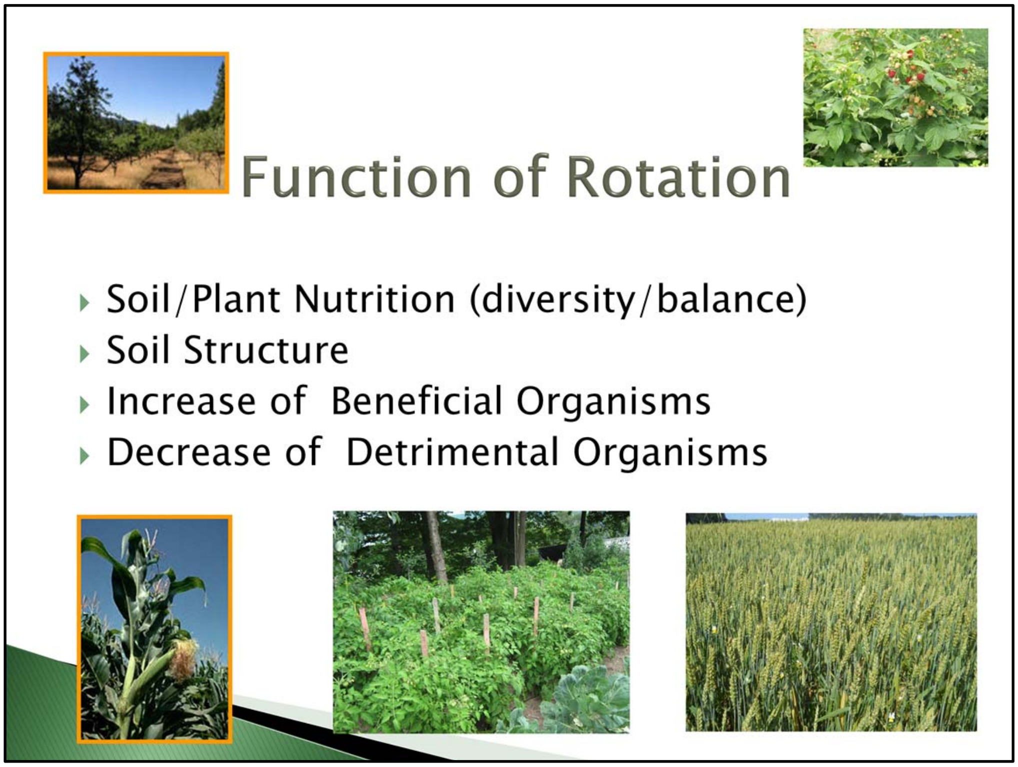
But chemical soil fertility isn't all….

Soil fertility and health involves more than simply plant nutrient levels. The presence of adequate amounts of organic matter and soil building microbes and other organisms has great importance.

The use of animal manures (like what was going on here, before the wheel came off) helps maintain organic matter and nutrient levels.



Manure application, good crop rotations, appropriate tillage practices (including low-till and no-till), good grazing management practices and use of cover/green manure crops all help to build and maintain soil health and fertility.



A well-planned crop rotation accomplishes several things. The added diversity from introducing different plant species on the same ground helps build and maintain a diverse set of soil microbial organisms. Soil structure can be improved when crop residues are incorporated into soil, and when deep rooted crops like legumes or oilseed radish are included in the rotation. Crop rotation can also slow or prevent the build-up of soil born plant diseases when non-susceptible crops occupy the field long enough for the disease-causing pathogens to die out.

Decomposers

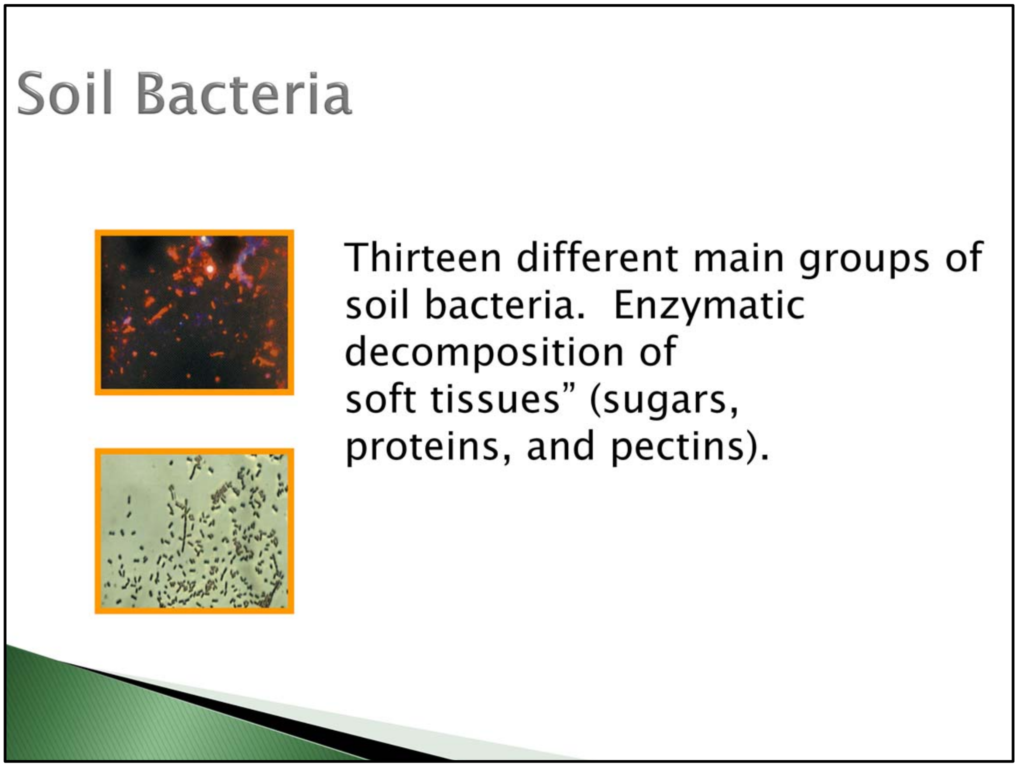
Types

- Bacteria
- Arachaea
- Fungi
- Water Molds
- Slime Molds

Functions

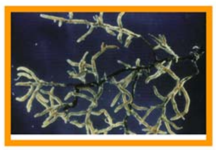
- Break down matter
  - Transform and transport nutrients
  - Mobilize or immobilize nutrients
  - Facilitate soil aggregate formation
  - Facilitate nutrient cycling

The ‘decomposer’ organisms listed here fill a critical role.



Bacteria are responsible for much of the initial breakdown of organic matter. They take care of the 'easier' work.

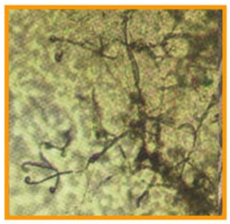
Soil Fungi



Decomposition of "intermediate tissues" (cellulose and hemicellulose)

Fungal microbes in the soil break down 'intermediate' tissues, including plant cell walls.

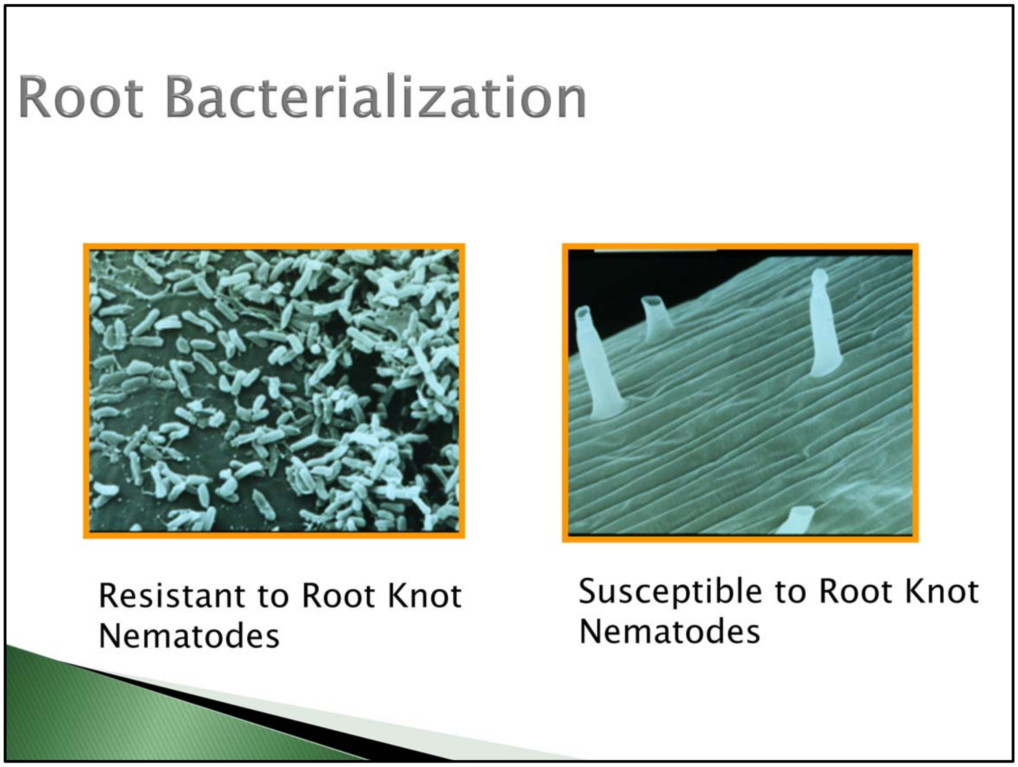
Soil Actinomycetes



Actinomycetes (bacteria)

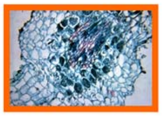
-- Responsible for soil odor
-- Decomposition of "tough tissues" (lignin).
-- Antibiotic producers

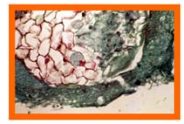
The toughest organic materials to break down are taken care of by actinomycetes, a type of bacteria.



Certain bacteria can colonize and grow around plant roots to provide a living layer of protection against plant pathogenic nematodes.

Mutualists/Symbionts





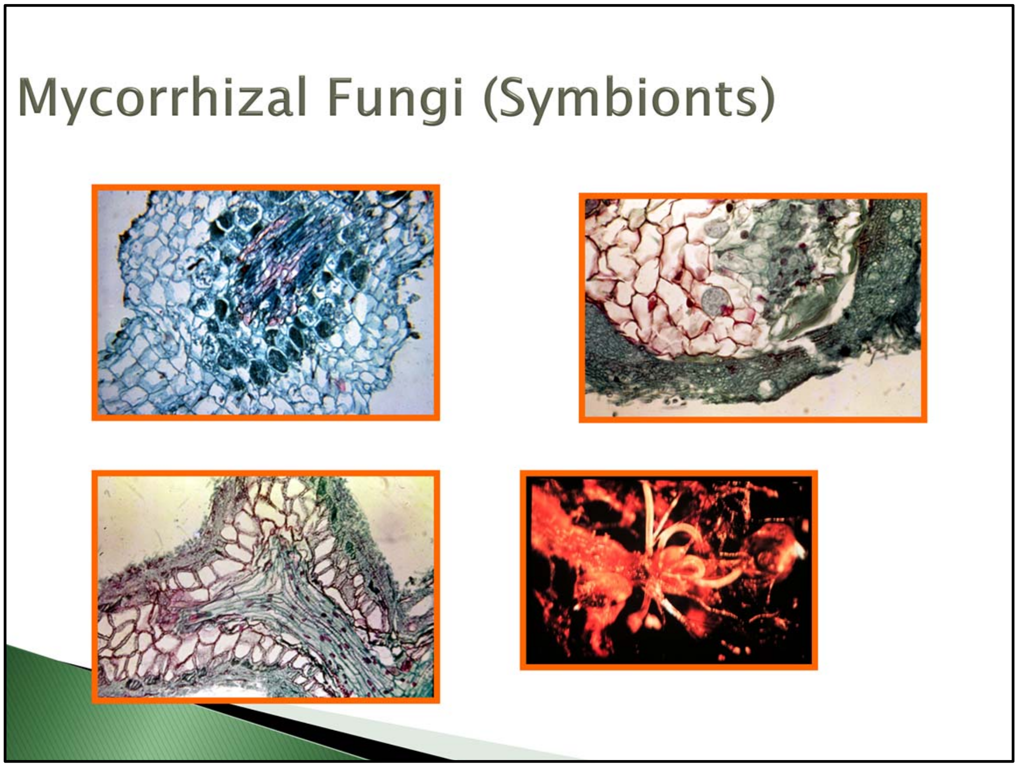
Types

- Bacteria
- Fungi

Functions

- Enhance Plant Growth
  - Fix N_2
  - Mobilize P and H_2O
  - Immunization/ Resistance

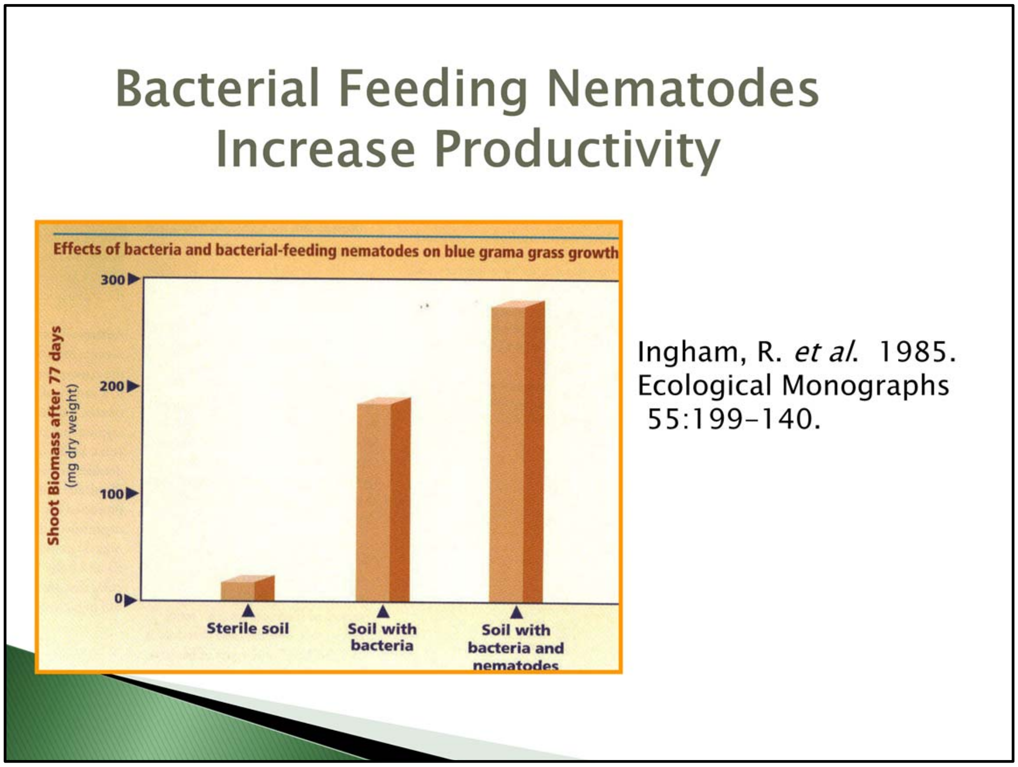
Also, in a healthy soil containing a broad variety of microbes, certain beneficial bacteria and fungi live in association with desired plants in a symbiotic relationship, where both organisms benefit.



In effect, the mycorrhiza extends and enhances the plant’s root system in return for carbohydrates sent down from leaves.

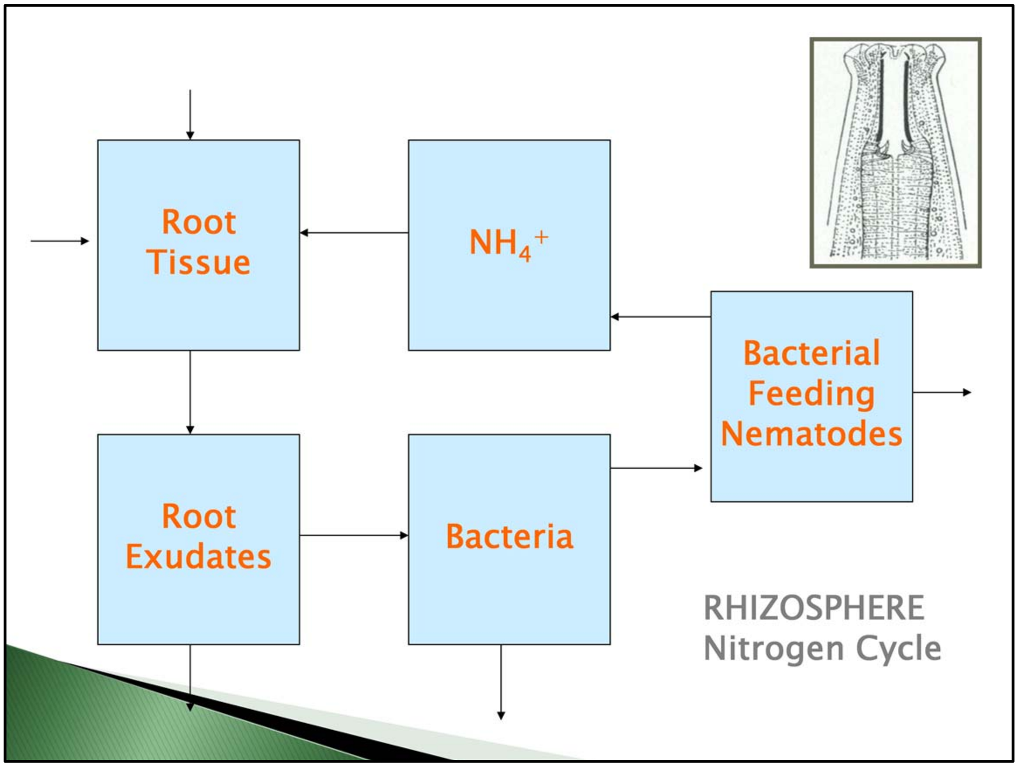
Details:

This mutualistic association provides the fungus with relatively constant and direct access to carbohydrates, such as glucose and sucrose.[The carbohydrates are translocated from their source (usually leaves) to root tissue and on to the plant's fungal partners. In return, the plant gains the benefits of the mycelium's higher absorptive capacity for water and mineral nutrients due to the comparatively large surface area of mycelium: root ratio, thus improving the plant's mineral absorption capabilities.[



Only a few of the many types of nematodes present in a healthy soil cause plant disease. Some are very beneficial, and many are sort of 'neutral' to plant health.

Bacterial-feeding nematodes serve a very useful purpose in making nitrogen from soil organic material available to plants. They consume large numbers of bacteria and excrete excess nitrogen into the soil environment, which becomes available to plants.



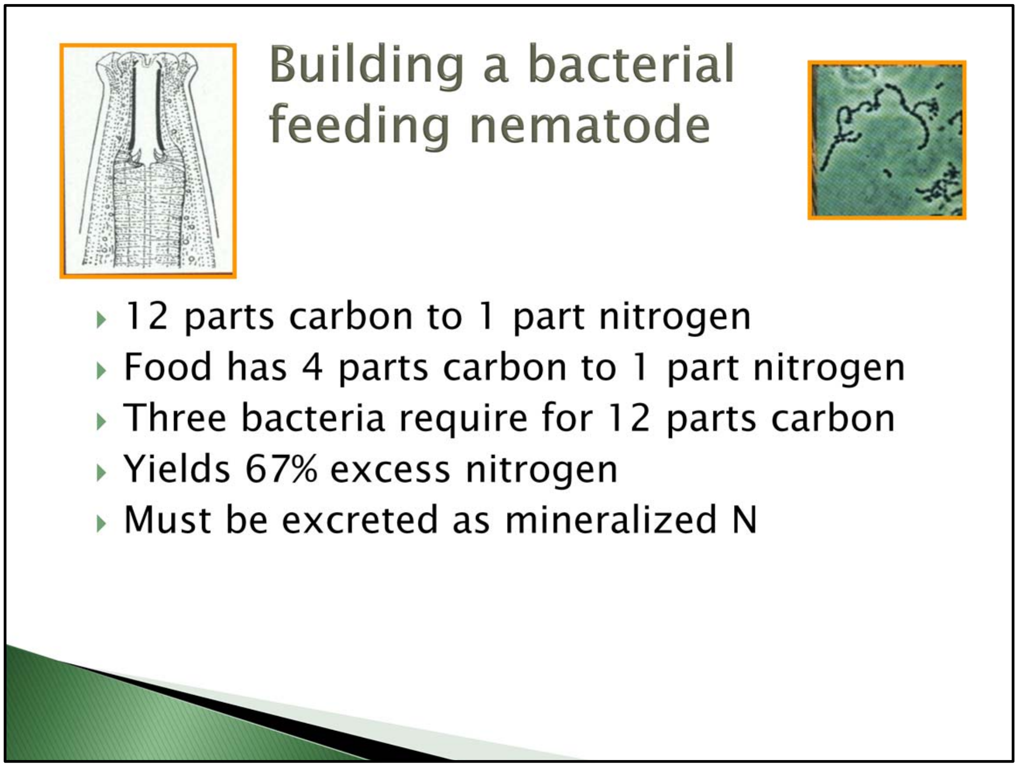
The flow chart indicates that root tissues grow in the soil and naturally exude substances which are then consumed by soil-dwelling bacteria. Some of these bacteria are eaten by beneficial nematodes, which then excrete excess nitrogen as NH_4 into the soil environment. This is taken up by plant roots.

Fungal Feeding Nematodes Increase Nitrogen Mineralization

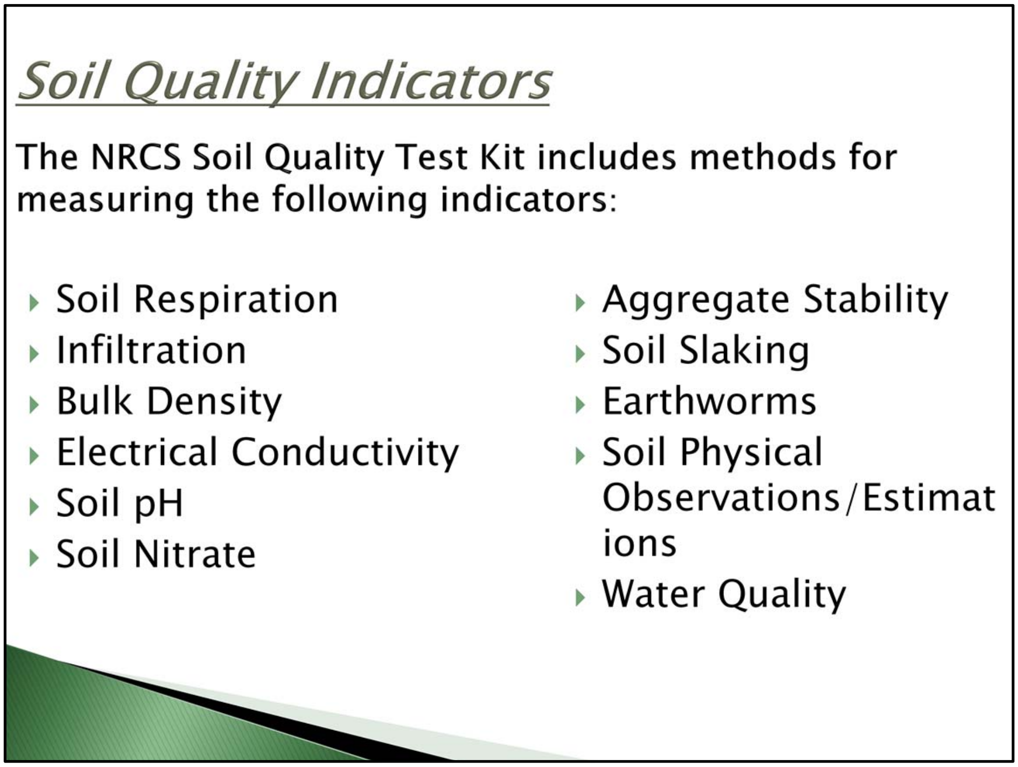
Treatment	Ammonium nitrate ($\mu g\ NH_4^+$-N) recovered*		
	7 days	14 days	21 days
Fungus	25.9	39.5	1.9
Fungus & nematode	26.1	50.5	19.9

Chen, J. and H. Ferris. 1997. Journal of Nematology 29:571.

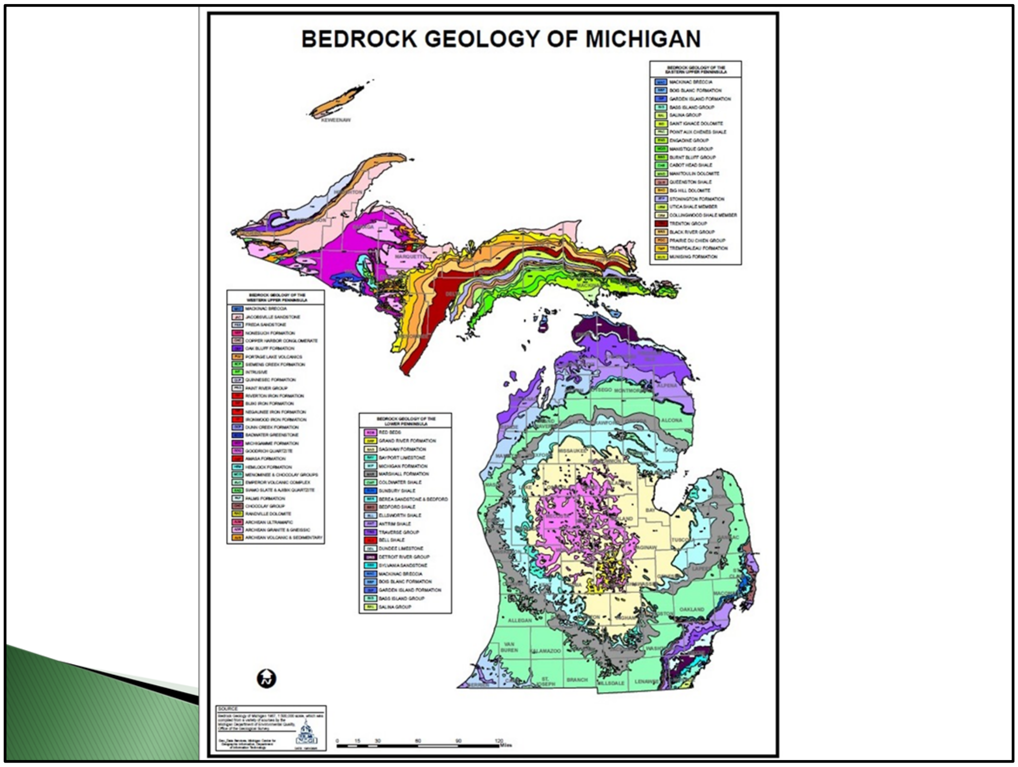
Nematodes which feed on fungus have a similar beneficial effect on nitrogen availability to plants.



This slide explains the math. The nitrogen becomes available because bacteria are richer in nitrogen than nematodes. When nematodes consume them, there is excess nitrogen, which passes through the nematode back into the soil and is available to plants.

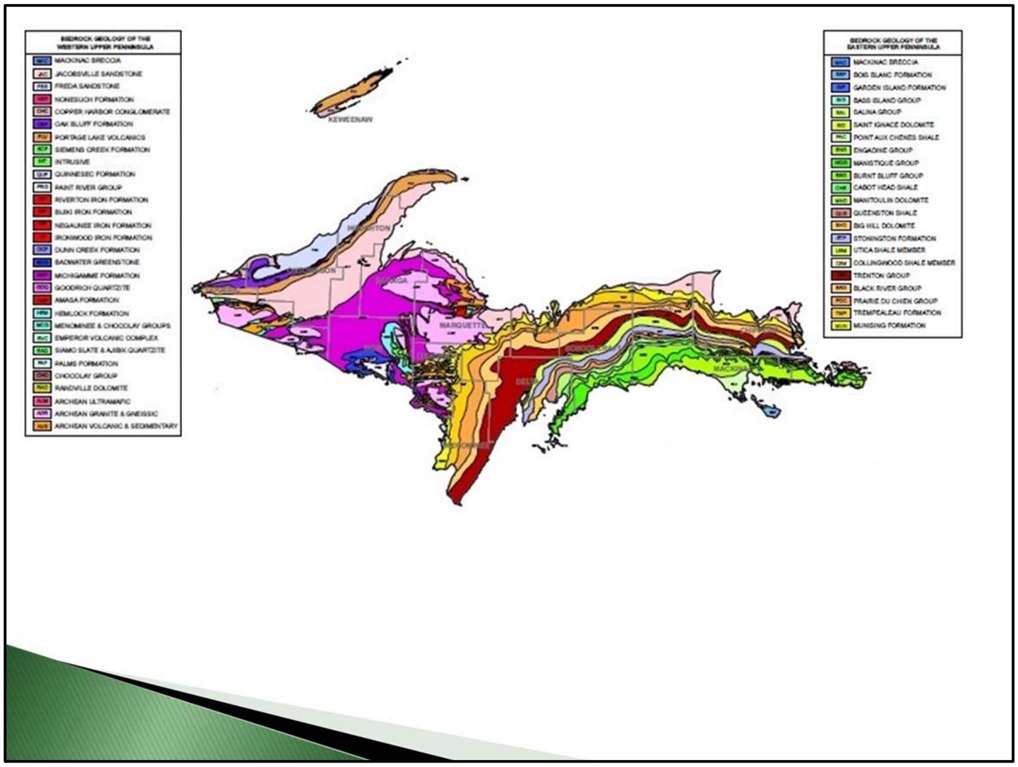


The soil quality parameters listed are measurable with the NRCS soil quality test kit. In effect, these are the soil characteristics NRCS thinks are highly important.

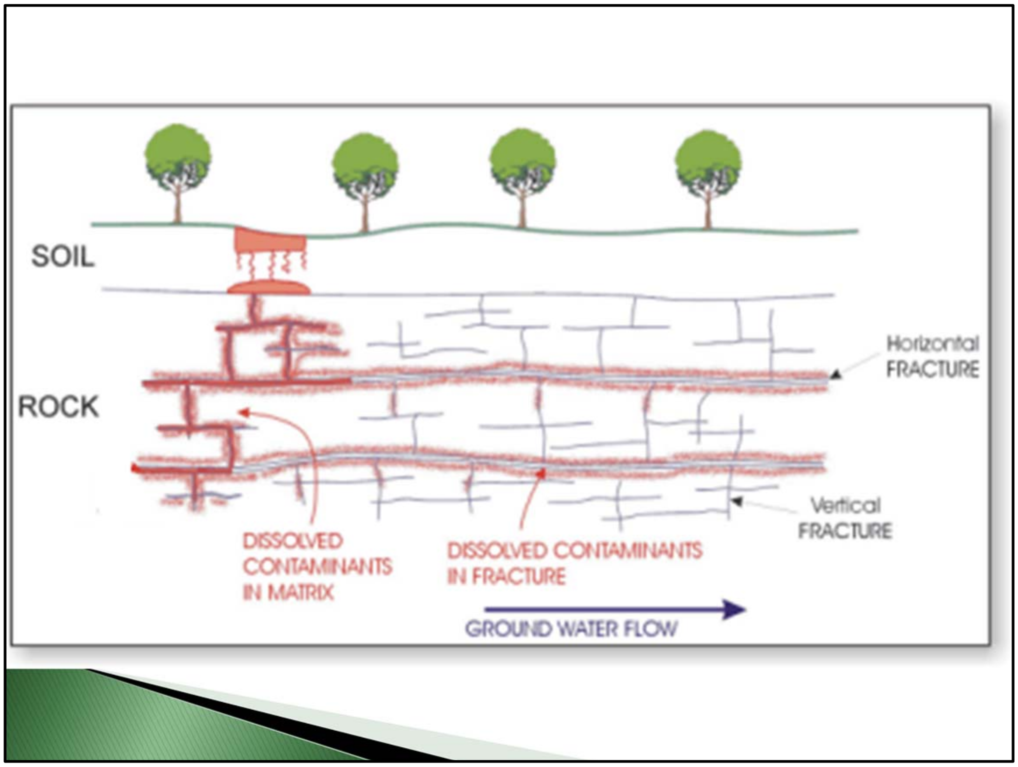


In some cases, bedrock geology can explain things about existing soils. Where glacial or lakebed deposits cover bedrock, this connection is not as strong.

Note the ‘bulls-eye’ formation extending halfway across the U.P. The eastern part of the U.P. has sedimentary bedrock. The western end, especially Keweenaw, Houghton, Ontonagon and western Gogebic counties are mostly igneous rock, and include the iron and copper-containing formations.

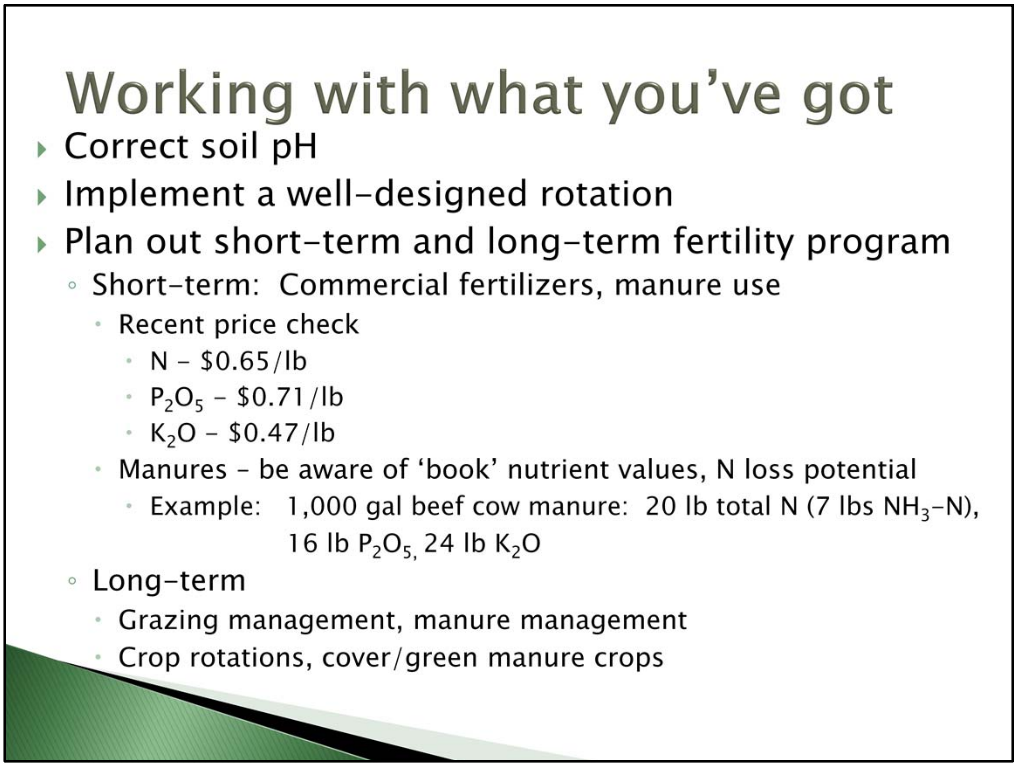


The shallow limestone bedrock of the lake Michigan shoreline areas has resulted in higher pH, calcareous soils.   Commercial ag lime sources are currently located in Gulliver and Cedarville, Michigan.

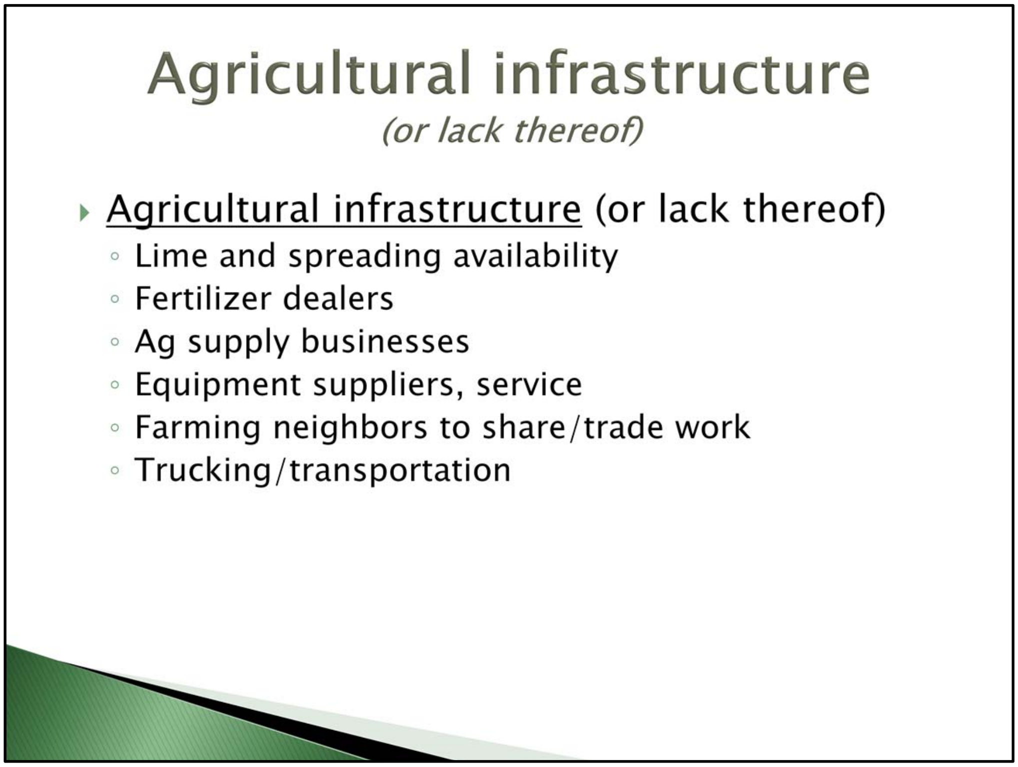


Soils over fractured bedrock create an environment where groundwater is more vulnerable to contamination. The fractures in bedrock create direct avenues for contaminants to flow quickly into aquifers. Some areas in the Upper Peninsula with shallow topsoil over fractured limestone are good examples of this.

Where groundwater is protected by layers of clay or other less pervious material, aquifers are less vulnerable, but care must still be taken to avoid ground and surface water contamination.



Of course, farmers can't make major changes in the soils they farm quickly. Improving soil fertility takes time, careful planning, and patience. This slide summarizes general steps to take.



One of the big challenges faced by Upper Peninsula farmers is the limited infrastructure serving the industry here. This can relate directly to soil improvement issues.

Lime is available at a reasonable price, but trucking is expensive and spreading involves renting and transporting a spreader, often at quite a long distance.

We have good well-established ag businesses in the Upper Peninsula. However, fertilizer, ag supplies and equipment dealers are often at a long distance from the farm.

In many U.P. areas, there aren't many farming neighbors to call upon when a need arises for help, or to share work.

All in all, the agricultural infrastructure in the Upper Peninsula is challenging for many producers.

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