Soil Improvement

Tennessee State University

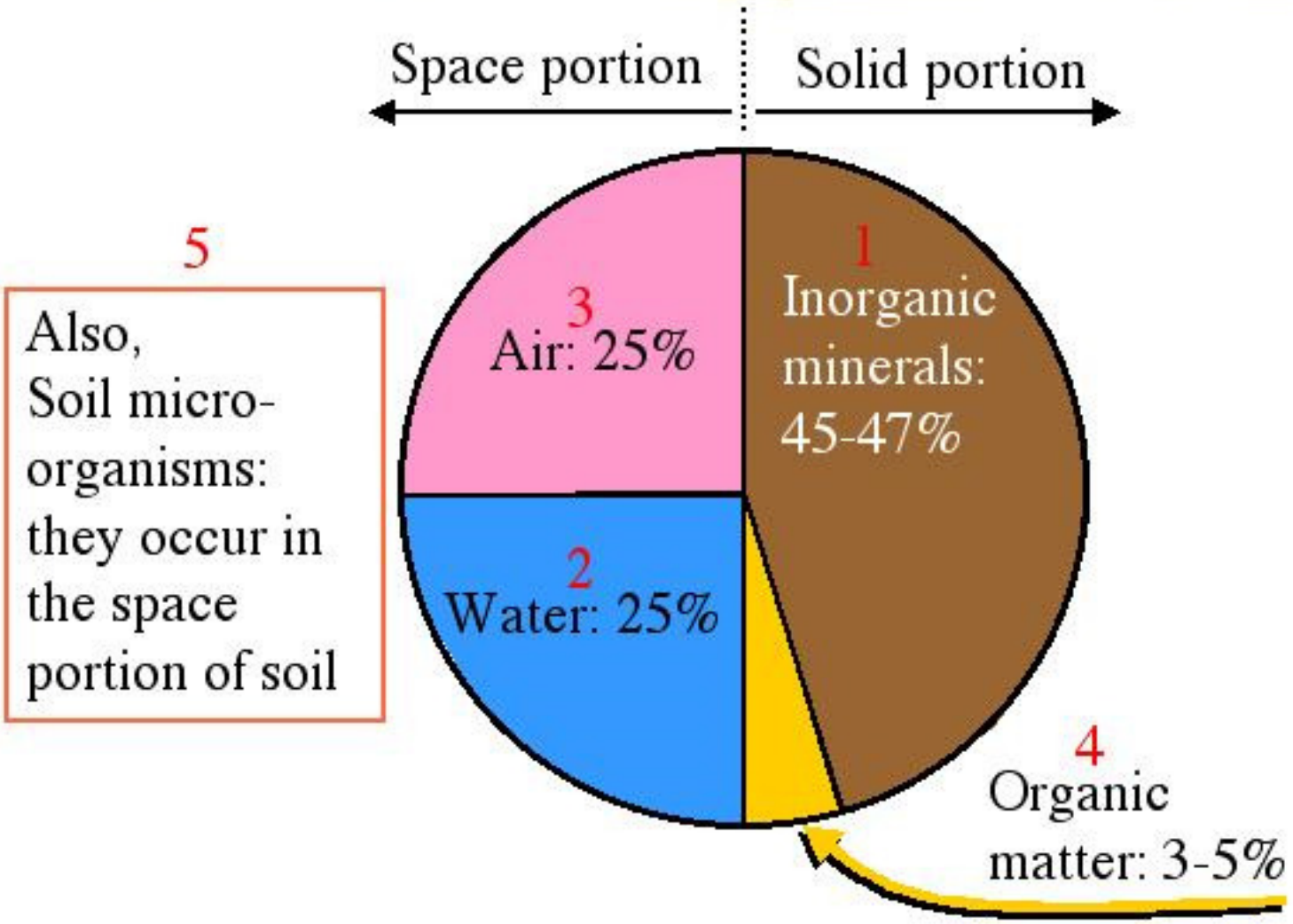
Dr. Jason de Koff
Extension Specialist – Agronomy and Soils

Tennessee State University

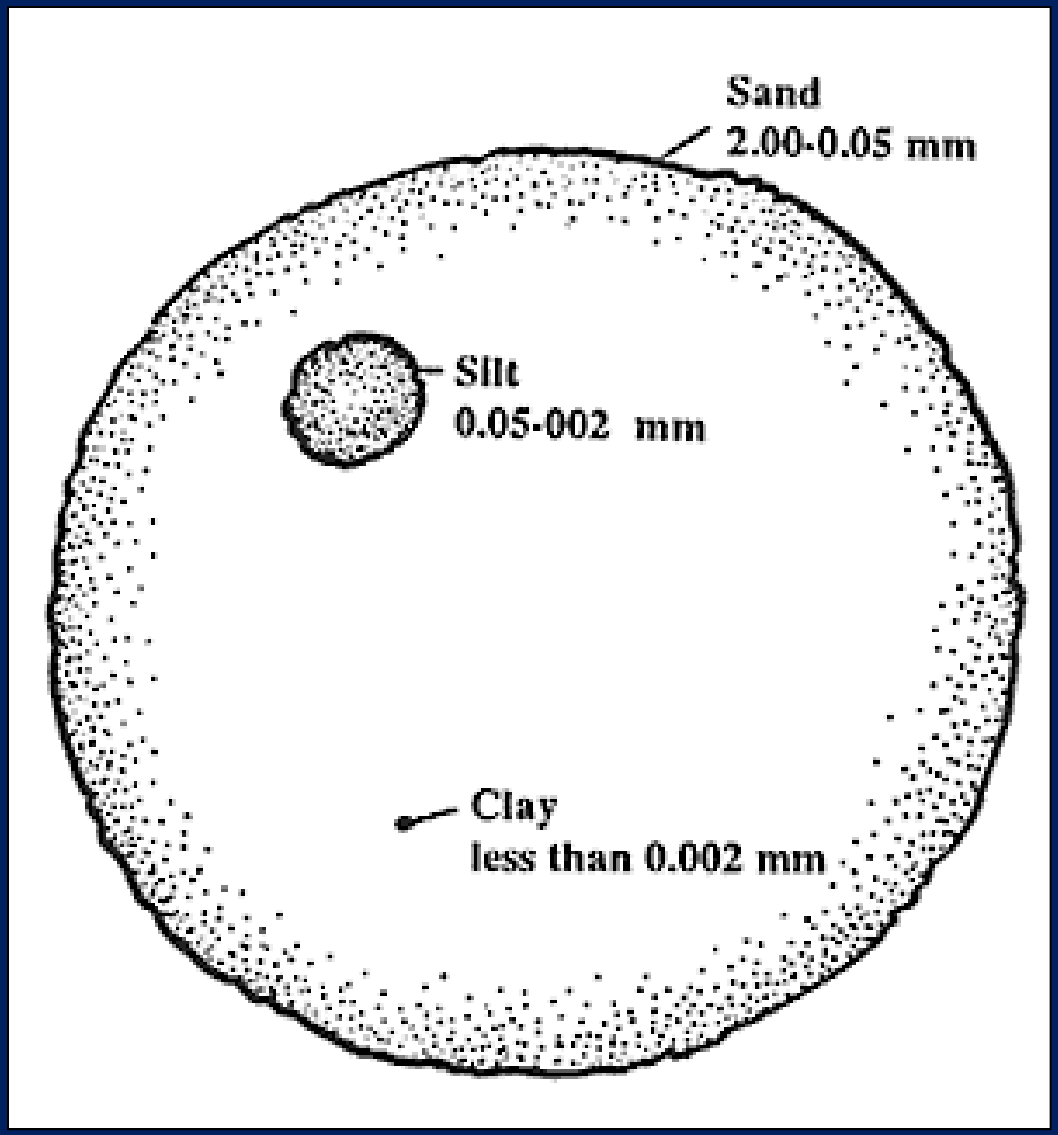
5 Soil Forming Factors

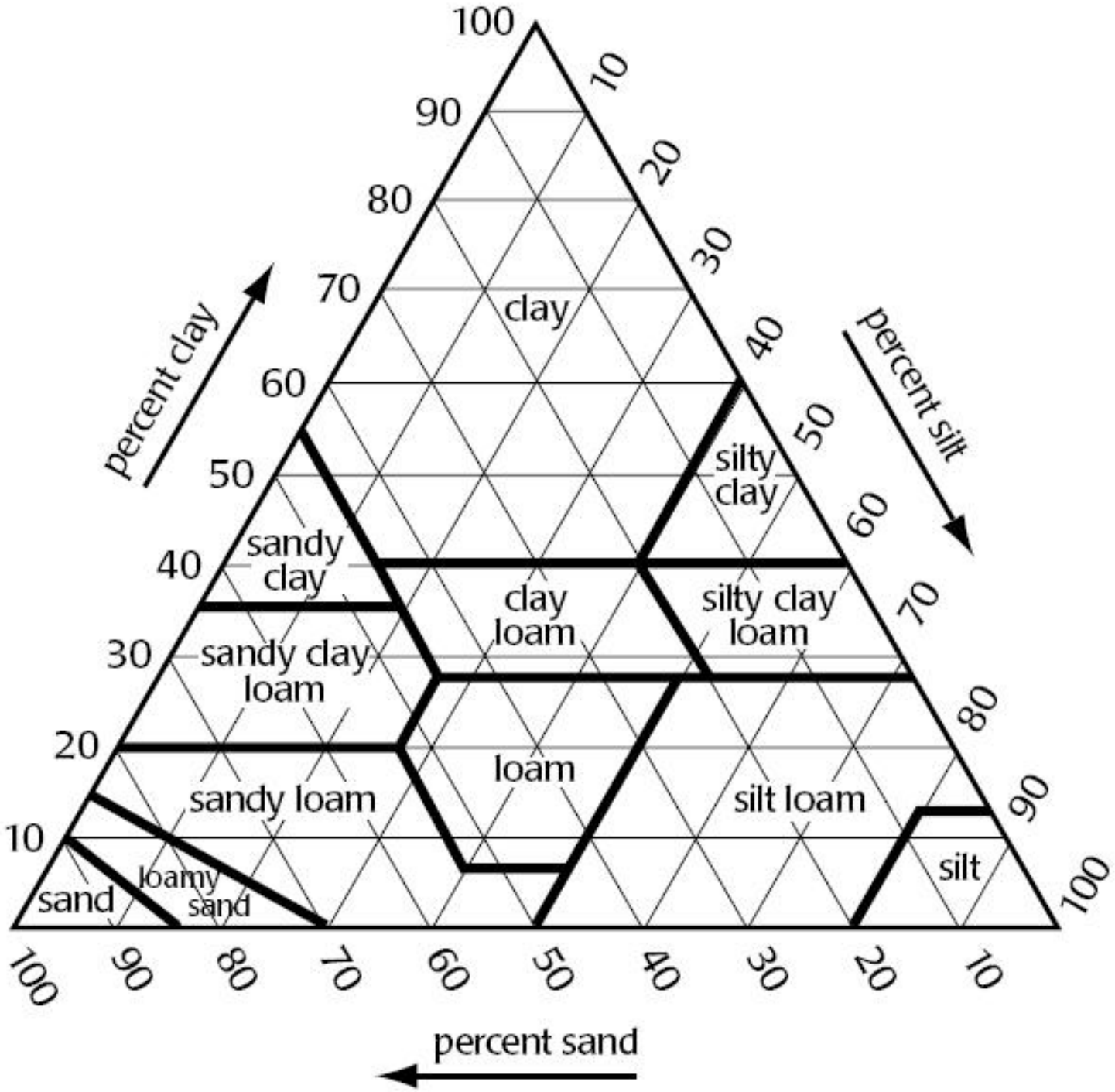
- Climate
- Relief
- Organisms
- Parent material
- Time

5 Soil Components - *Ideal Soil*

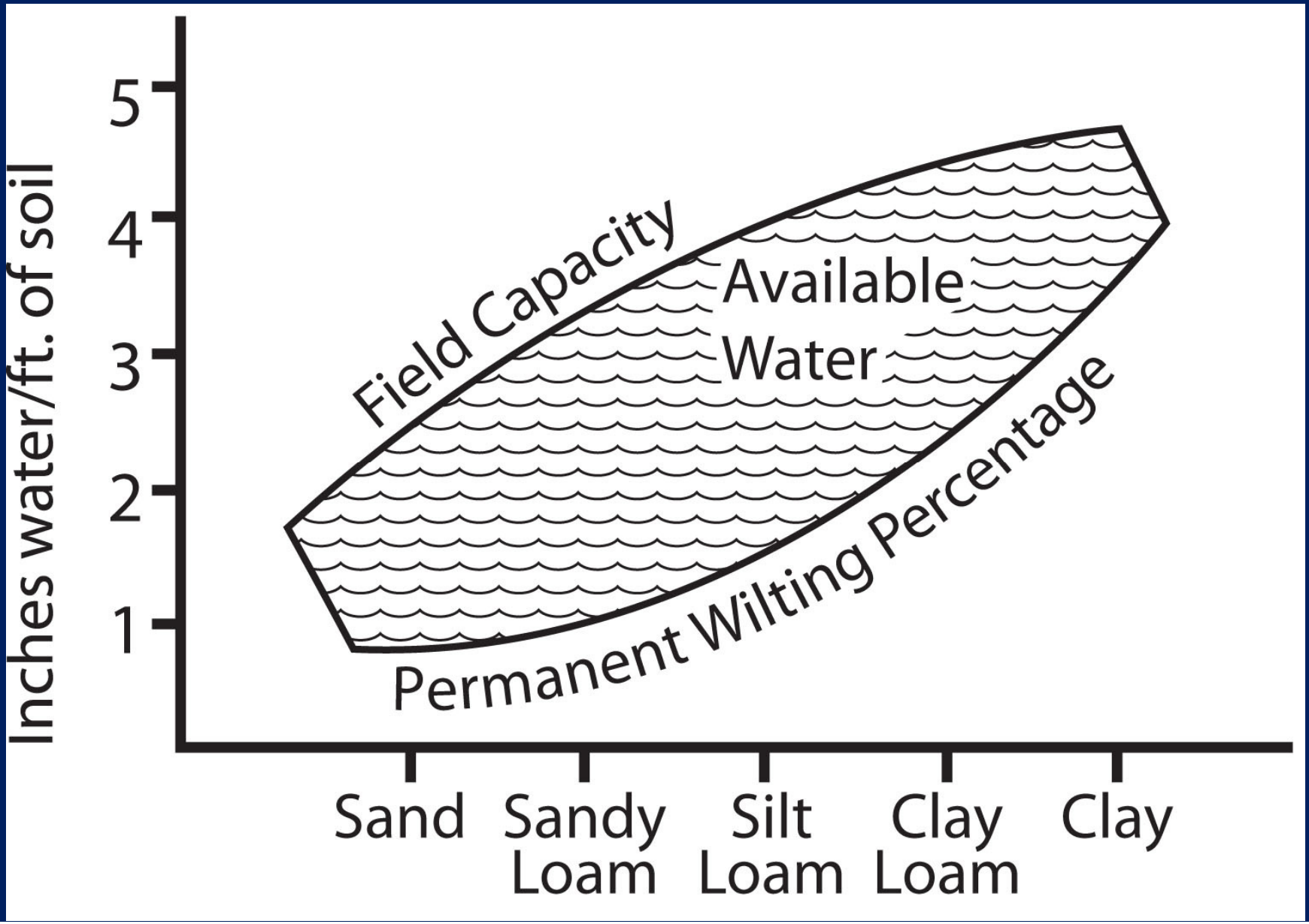


Soil Particle Sizes




100
90
80
70
60
50
40
30
20
10
percent clay
clay
silty clay
sandy clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
loamy sand
sand
silt
percent silt
percent sand

Available Water in Soils



Drainage

Soil Perc Test

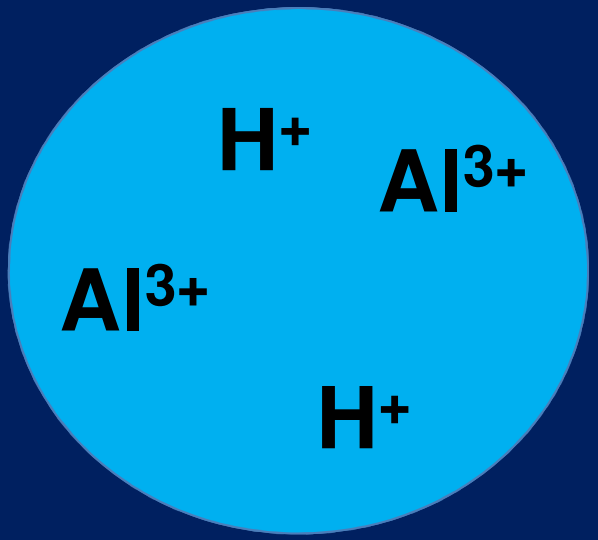
Steps

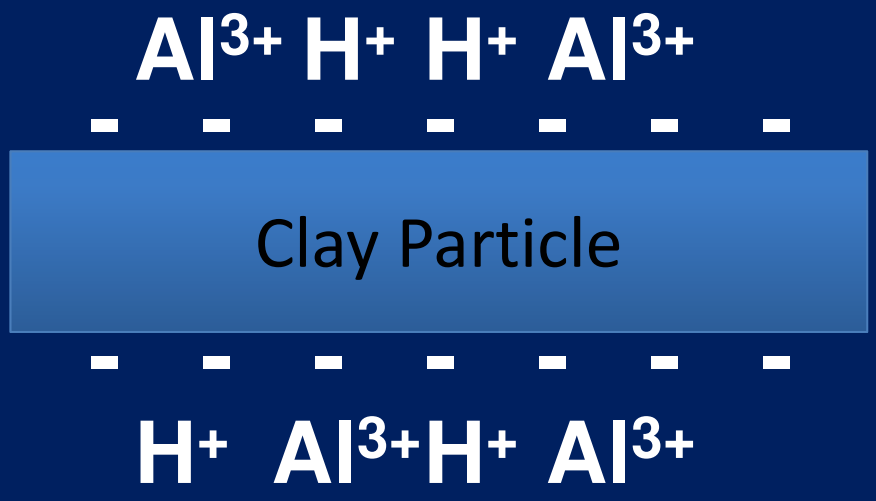
1. Dig a hole about 0.5 ft. wide and 1 ft deep.
2. Place a yardstick in the hole so that one of the inch marks is level with the top of your hole.
3. Fill the hole with water and let it completely drain out.
4. Fill the hole again and note the time.
5. If the water drains at 1-2” per hour, your soil is draining well. Above 4” is too fast and below 1” is too slow.

Soil Chemistry and Plant Nutrition

- Soil pH
- Essential Plant Nutrients
- Soil Testing
- Soil Amendments and Fertilizers

Soil pH

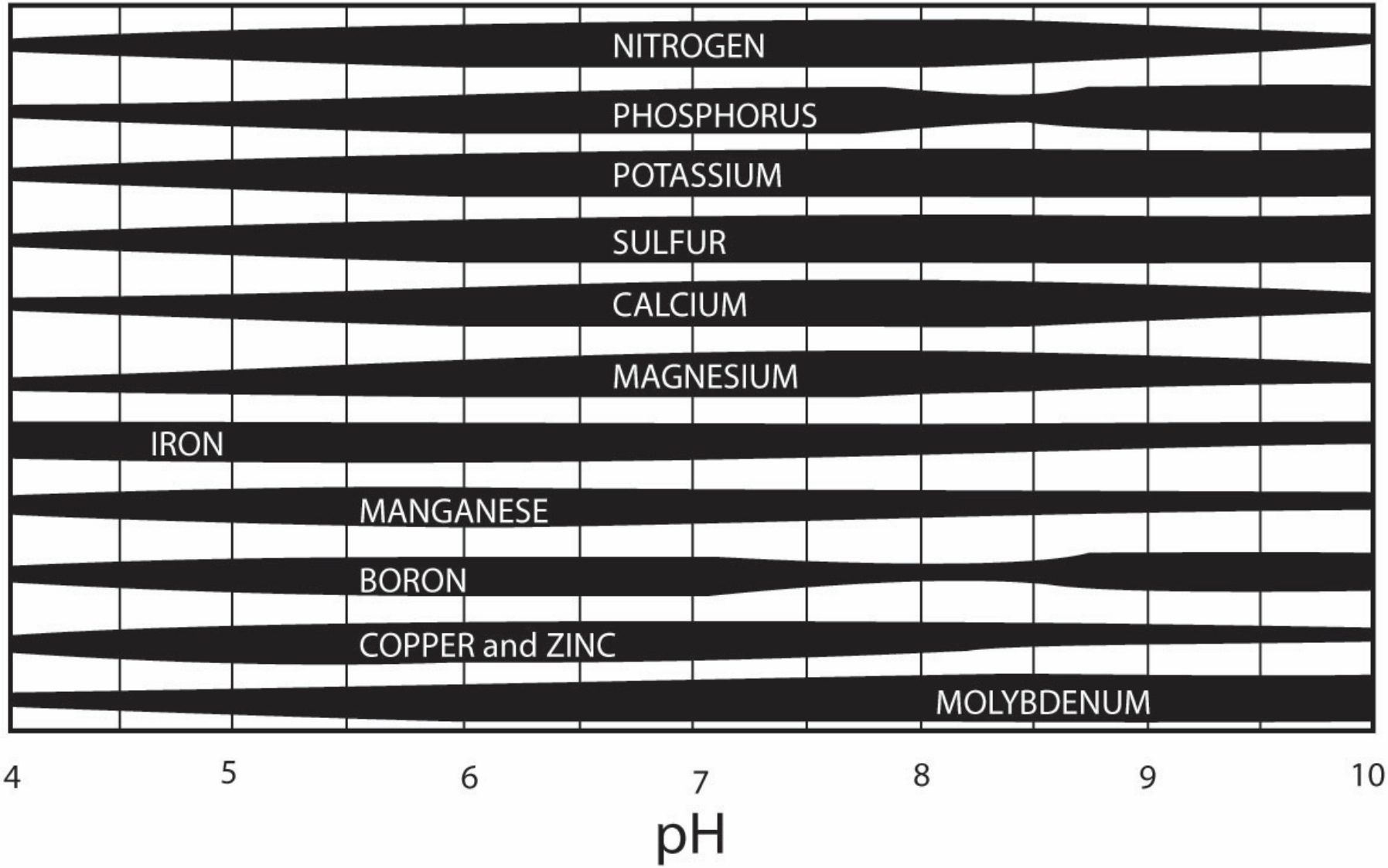




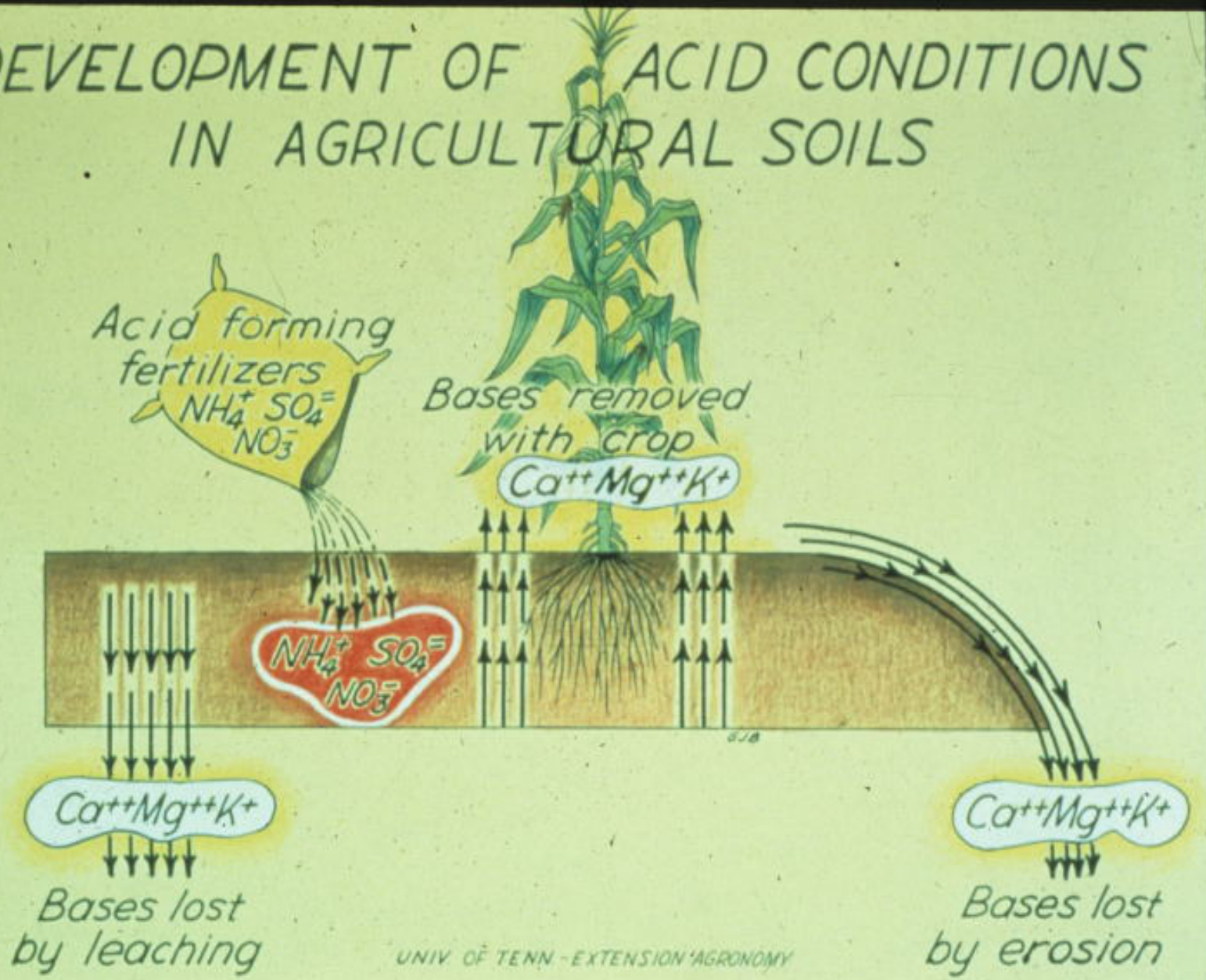
$$Al^{3+} + -O\begin{matrix}H\\+\\H\end{matrix} \longrightarrow Al(OH)_3 + 3H^+$$

Soil pH

pH and Nutrient Availability



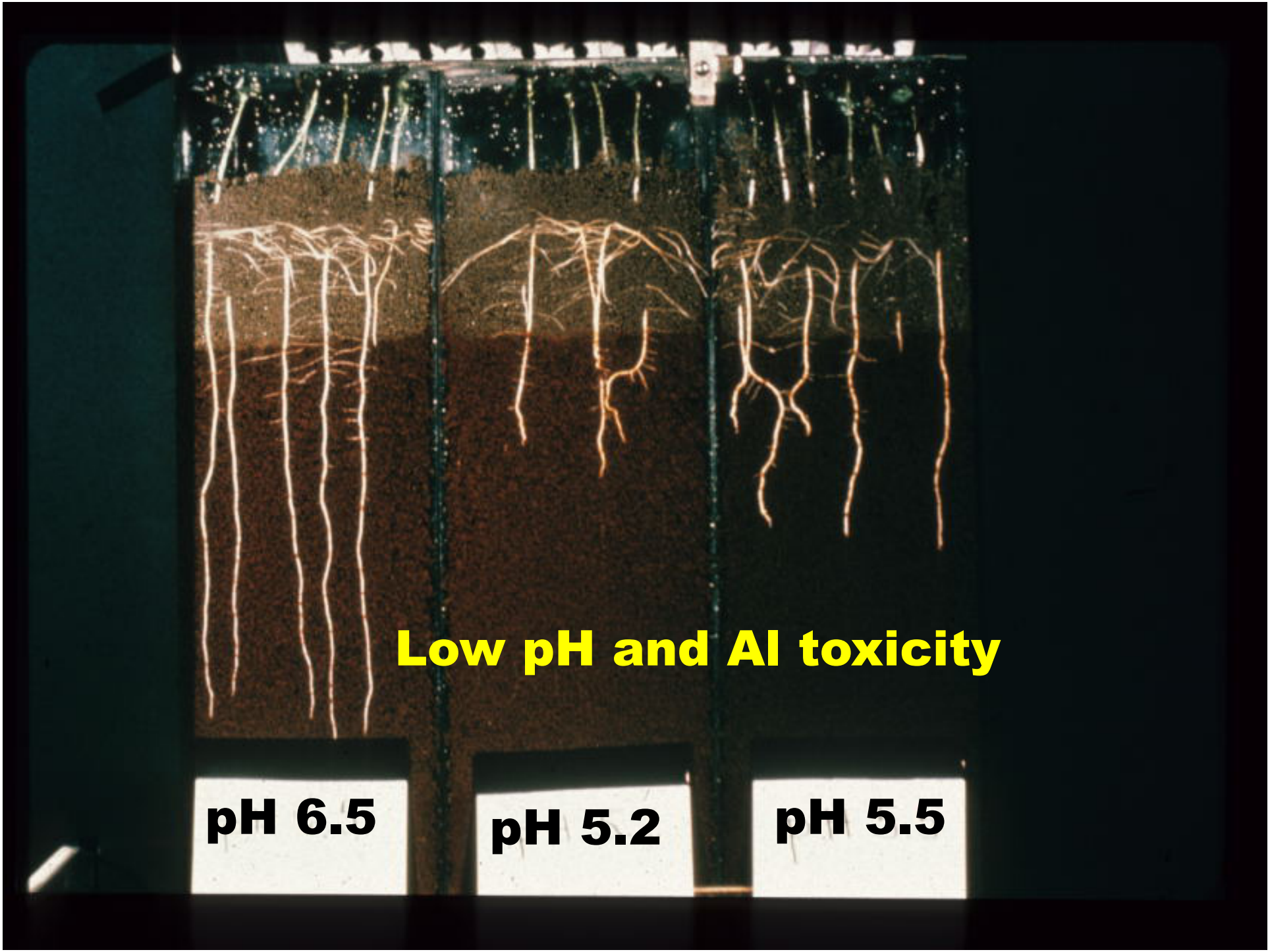
DEVELOPMENT OF ACID CONDITIONS IN AGRICULTURAL SOILS



Benefits of Lime

- Supply Ca and Mg
- Enhance microbial activity
- Enhance nutrient availability
- Reduce Al and Mn Toxicity

Mn Toxicity from low pH


Low pH and Al toxicity
pH 6.5
pH 5.2
pH 5.5

Liming Soil Reactions

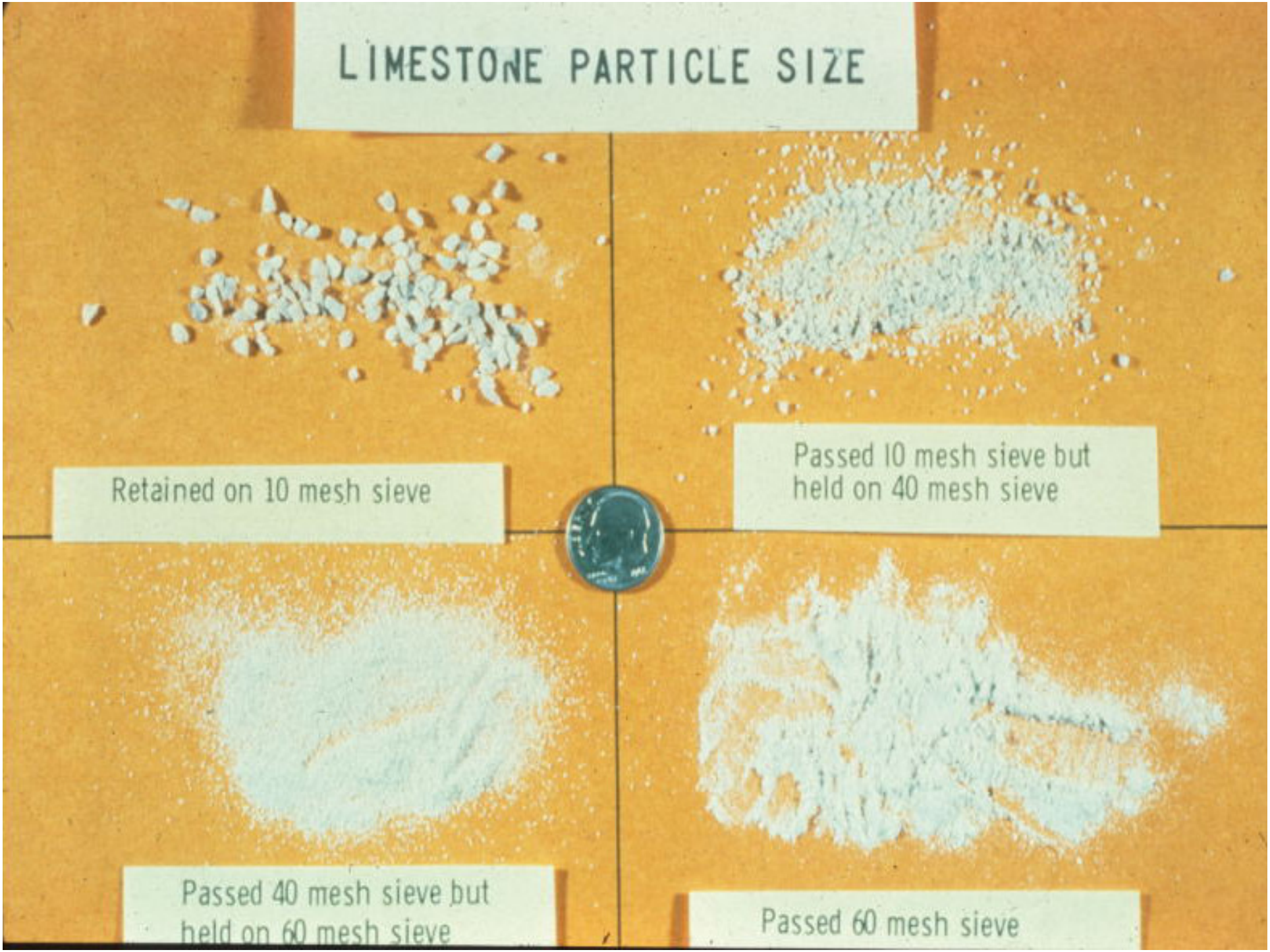
$$CaCO_3 + H_2O \longleftrightarrow Ca^{2+} + H_2CO_3 + 2H^+$$

Liming Materials for pH Adjustments

Material	Composition	Calcium Carbonate Equivalent (%)
Calcium Carbonate	$CaCO_3$ (pure)	100*
Calcitic limestone	$CaCO_3$	80-100
Dolomitic limestone	$CaCO_{3-}$ $MgCO_3$	95-108
Basic Slag (byproduct)	$CaCO_{3-}$ CaO- MgO mixture	variable
Burned or Quick lime	CaO (calcium oxide)	150-175
Hydrated or Slaked lime	$Ca(OH)_2$ calcium hydroxide	120-135
Marl	$CaCO_3$	70-90
Ground Oyster shells	$CaCO_3$	90-100
Cement Kiln dusts	Ca Oxides	40-50
Gypsum**	Ca SO4	None
Byproducts and biosolids	variable	Variable to none

*Calcium carbonate equivalent (CCE) is the acid-neutralizing value for a liming material relative to pure calcium carbonate that has a CCE value of 100. This is the standard method of estimating Agricultural lime purity.
** Gypsum does not affect soil pH but is sometimes used as a source of calcium or sulfur.

Savoy and Joines, 2014. UT Extension Publication #PB 1096


LIMESTONE PARTICLE SIZE
Retained on 10 mesh sieve
Passed 10 mesh sieve but held on 40 mesh sieve
Passed 40 mesh sieve but held on 60 mesh sieve
Passed 60 mesh sieve

Liming Materials for pH Adjustments

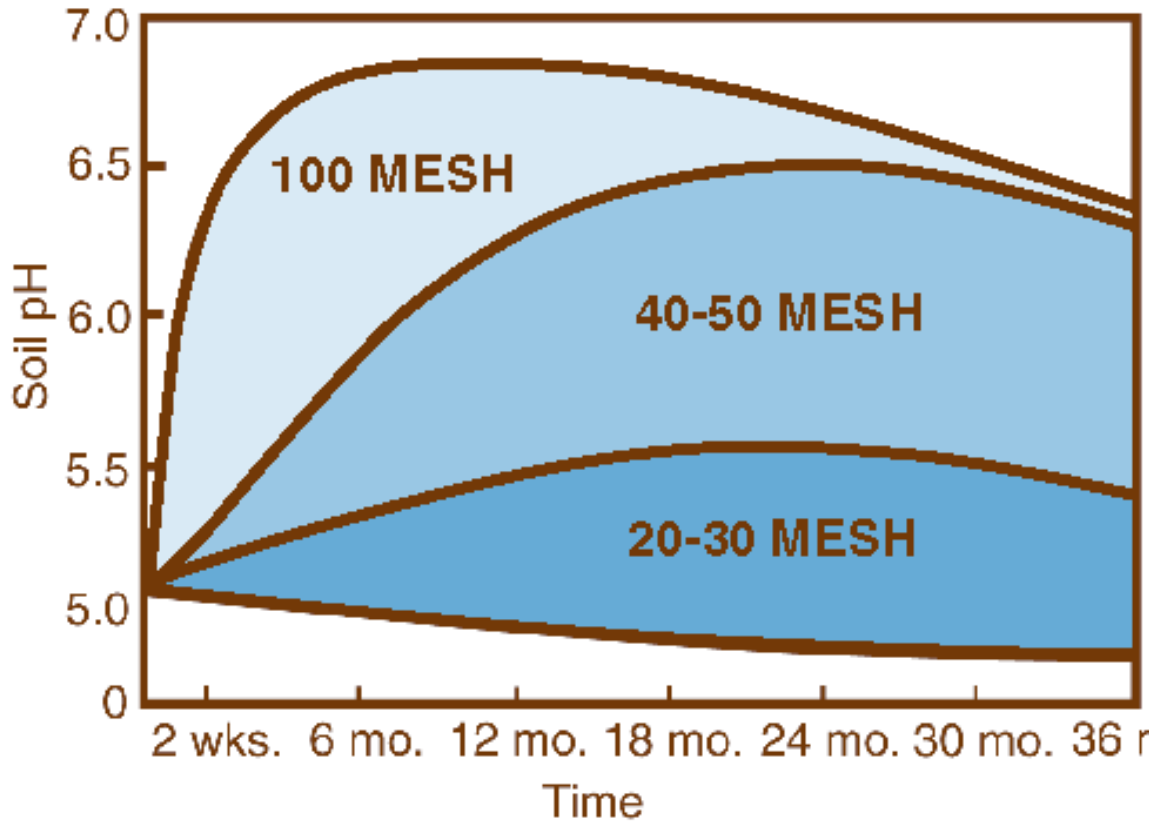


Figure 3. Relation between particle size and rate of change in soil pH when equal amounts of limestone are applied under similar conditions.

Savoy and Joines, 2014

Essential Plant Nutrients

Macronutrients

- Nitrogen
- Phosphorous
- Potassium

- "Secondary"
- Calcium
- Magnesium
- Sulfur

Micronutrients

Boron
Chlorine
Cobalt
Copper
Iron
Manganese
Molybdenum
Nickel
Zinc

Correcting Problems

Macronutrients

- Usually corrected by fertilizer

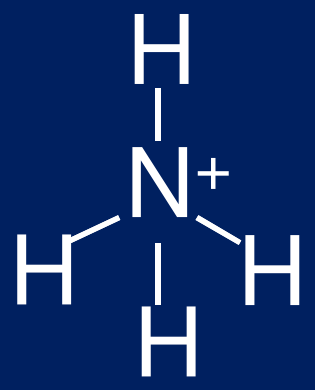
Micronutrients

- Indicate poor soil pH
- Choose a fertilizer with micronutrients and build soil with compost or OM

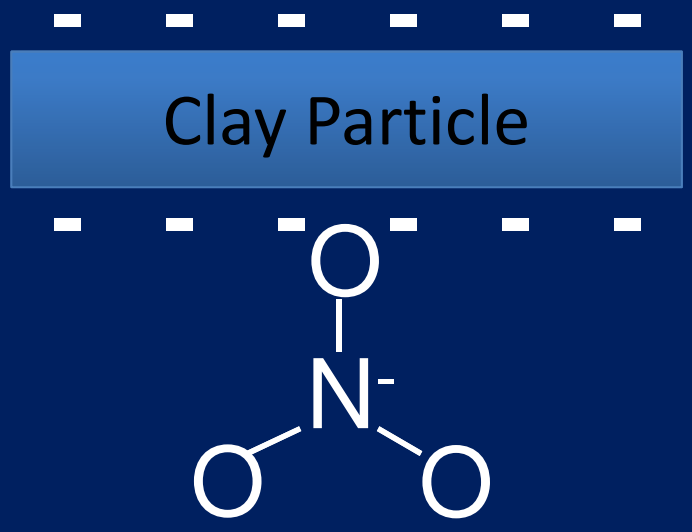
Nitrogen Basics

- Air is 80% nitrogen gas (N_2)
- Most organisms cannot use nitrogen in this form.
- Plants must secure their nitrogen in "fixed" form
- Incorporated in compounds such as:
  - nitrate ions (NO_3^-)
  - ammonium (NH_4^+)
  - urea $(NH_2)_2CO$

Chemical Forms of Nitrogen

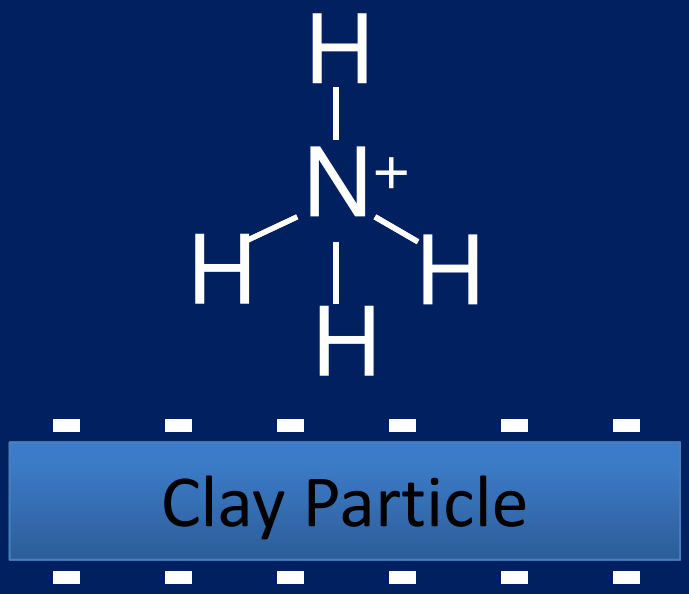


- NO_3^- and NH_4^+ react differently in soil.
- Ammonium (NH_4^+) is a positively charged ion and is attracted to the negatively charged sites on clay particles.
- It is available to plants but held tightly enough to prevent leaching.

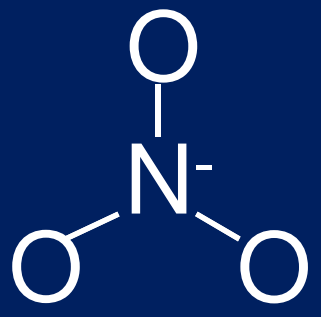


Chemical Forms of Nutrients

- Use ammonium form if leaching or denitrification are serious potential problems.



- In subsoils with a high iron oxide content, nitrate is absorbed to some extent.



Nitrogen Sources

- Quick Release
  - Readily dissolve in water
  - Immediately plant available
  - Interval between application and visual response – three to five days
- Slow Release
  - Dissolve less rapidly
  - Breakdown over days to months
  - More expensive

Soils and N Fertilization Issues

- Denitrification
  - Prevention: Lighter, more frequent N application
- Volatilization
  - Prevention: Apply water after applying urea or NH_4^+
- Leaching
  - Prevention: Don't overapply

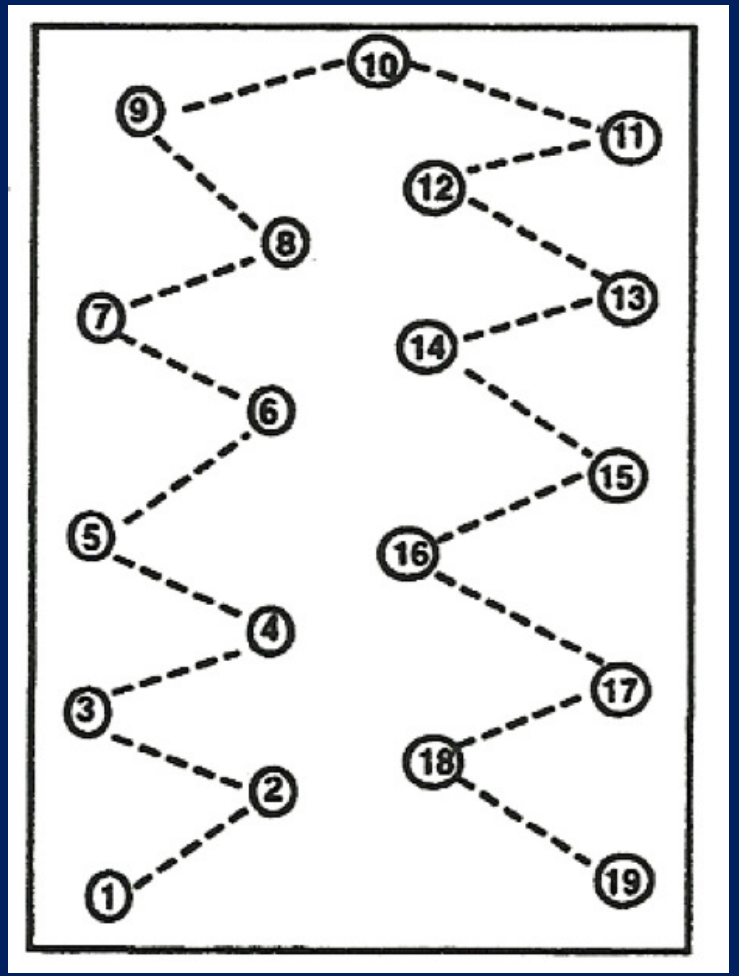
Soil Testing

Taking samples and interpreting the results

- Determines the need for lime and/or fertilizer
- Quantifies how much to apply

How to Take a Soil Test

- Determine the area to be sampled
- Have the proper tools
- Sample to the proper depth (0-6”)
- Take enough subsamples
- Properly mix subsamples into one composite sample



Soil, Plant and Pest Center Fee Schedule

Effective July 2014

Soil Analysis	**Basic** (pH, Buffer pH, Phosphorus, Potassium, Calcium, Magnesium (M1))	$7.00
	Basic Plus (pH, Buffer pH, Phosphorus, Potassium, Calcium, Magnesium, Ca, Mg, Zn, Mn, Fe, Cu, Na, and B)	$15.00
	Zinc, Manganese, Iron, Boron, Copper, Sodium	$3.00 each
	Organic Matter (combustion)	$6.00
	Soluble Salts	$4.00
	Sulfur-SO_4 (Ammonium Acetate extraction)	$5.00
	Nitrate-N (PSNT)	$5.00
	Carbon:Nitrogen Ratio	$10.00
	Container Media -Saturated Paste Extract-(pH, Phosphorus, Potassium, Ca, Mg, Ammonium and Nitrate Nitrogen, Soluble Salts)	$20.00
	Hoffer 21" Soil Sampling Probe-additional charges apply for shipping	$48.00
	Particle Size Analysis- % Sand, %Silt, % Clay (Hydrometer Method)	$14.00

THE UNIVERSITY of TENNESSEE Extension

SOIL TEST REPORT

Deborah K. Joines
Manager
Soil, Plant and Pest Center
5201 Marchant Drive
Nashville, TN 37211-5112
(615) 832-5850
soilplantpestcenter@utk.edu

Any Producer
120 Scenic Road

Any Town, USA

Water pH indicates the acidity of your soil.
Most plants grow best at a Water pH between 6.1 and 6.5. If Water pH is too low, a lime recommendation will be given if your crop (or plant) desires a higher pH.

07

County: Henderson **Lab Number**: 4959056

Mehlich 1 SOIL TEST RESULTS and RATINGS*

(Pounds Per Acre)

Sample	Water pH	Buffer Value	P Phosphorus		K Potassium		Ca Calcium		Mg Magnesium		Zn Zinc	Cu Copper
B1	5.8	7.7	28	M	190	H	1257	S	64 +	S		

Organic Matter %

Soluble Salts PPM**

Buffer Value is reported when the Water pH is too low or a lime recommendation is indicated. This value is a tool to help provide a lime recommendation suitable for your soil.

Actual laboratory test results from your soil sample reported in pounds per acre. Ratings to the right of each result are L (low), M (medium), H (high), and VH (very high). Secondary nutrients are rated S (sufficient) or D (deficient). Fertilizer recommendations are developed from this information.

RECOMMENDATIONS

Sample Number	Fertilizer/Lime Application Rate and Timing
B1	**Hybrid Bermudagrass Hay - Maintenance**

$N / P_2O_5 / K_2O$

Nitrogen/Phosphate/Potash: 120-400 / 40-80 / 40-80 pounds per acre

Fertilizer recommendations for the crop code you requested. These amounts are actual pounds of Nitrogen (N), Phosphate (P205) and Potash (K20) per acre.

Limestone: 2 tons per acre

The rate of nitrogen topdressing depends on the need for forage. Apply 60 to 100 pounds of the nitrogen May 1 and again after each cutting when conditions favor regrowth. Four cuttings are often possible. If the higher rates of nitrogen are used, use the higher rates of [illegible]roadcast all lime and fertilizer on the soil surface. If more than 4 tons of lime per a[illegible] 4 tons of lime per acre and re-test after one year.

Limestone is recommended in tons per acre or pounds per square feet. The recommendation is ground agricultural limestone or dolomitic (pelleted) lime.

When nitrogen sources containing urea a[illegible]oss of nitrogen may occur if applied to moist soils followed by three or more days of ra[illegible]out rainfall. If urea is the nitrogen source, some loss of nitrogen may occur if applied to moist soils followed by three or more days of rapidly drying conditions without rainfall.

Apply recommended amounts of phosphate and potash in one application any time during the year.

County: Henderson **Lab Number**: 04959057

Mehlich 1 SOIL TEST RESULTS and RATINGS*

(Pounds Per Acre)

Sample	Water pH	Buffer Value	P Phosphorus		K Potassium		Ca Calcium		Mg Magnesium		Zn Zinc	Cu Copper	Fe Iron	Mn Manganese	B Boron	Na Sodium
C1	6.5		20	M	81	L	1280 +	S	64 +	S						

RECOMMENDATIONS	
Sample Number	Fertilizer/Lime Application Rate and Ti

for smaller areas (less than acres) are given in pounds per square feet. This the amount and type of fertilizer recommended to optimize your soil for growing a vegetable garden in this case.

C1 **Vegetable Garden**

$N / P_2O_5 / K_2O$

Nitrogen/Phosphate/Potash: - / - / - pounds per 1,000 square feet

Limestone: Lime is not recommended at this time

Broadcast 25 lbs. 6-12-12 per 1000 sq. ft. before planting.

Apply as a sidedressing 1-1.5 lbs. of ammonium nitrate(34-0-0)per 100 ft. row as follows: cucumbers, cantaloupe, pumpkins, squash and watermelon when vines are 1 foot long; tomatoes, pepper and eggplant when first fruits are 1 inch or more in diameter; sweet corn when 12-18 inches tall; okra after first picking; lettuce 3-4 weeks after seeding; broccoli, cabbage, cauliflower and brussel sprouts 3-4 weeks after transplanting. For turnip greens, spinach, collards, kale and mustard use 2-3 lbs. per 100 ft. row.

Notes provide more detailed advise such as timing and additional fertilizer applications.

***Ratings: Indicates relative availability of nutrients to plants. (See back of this form for detailed explanation.)**

****PPM = Parts per Million**

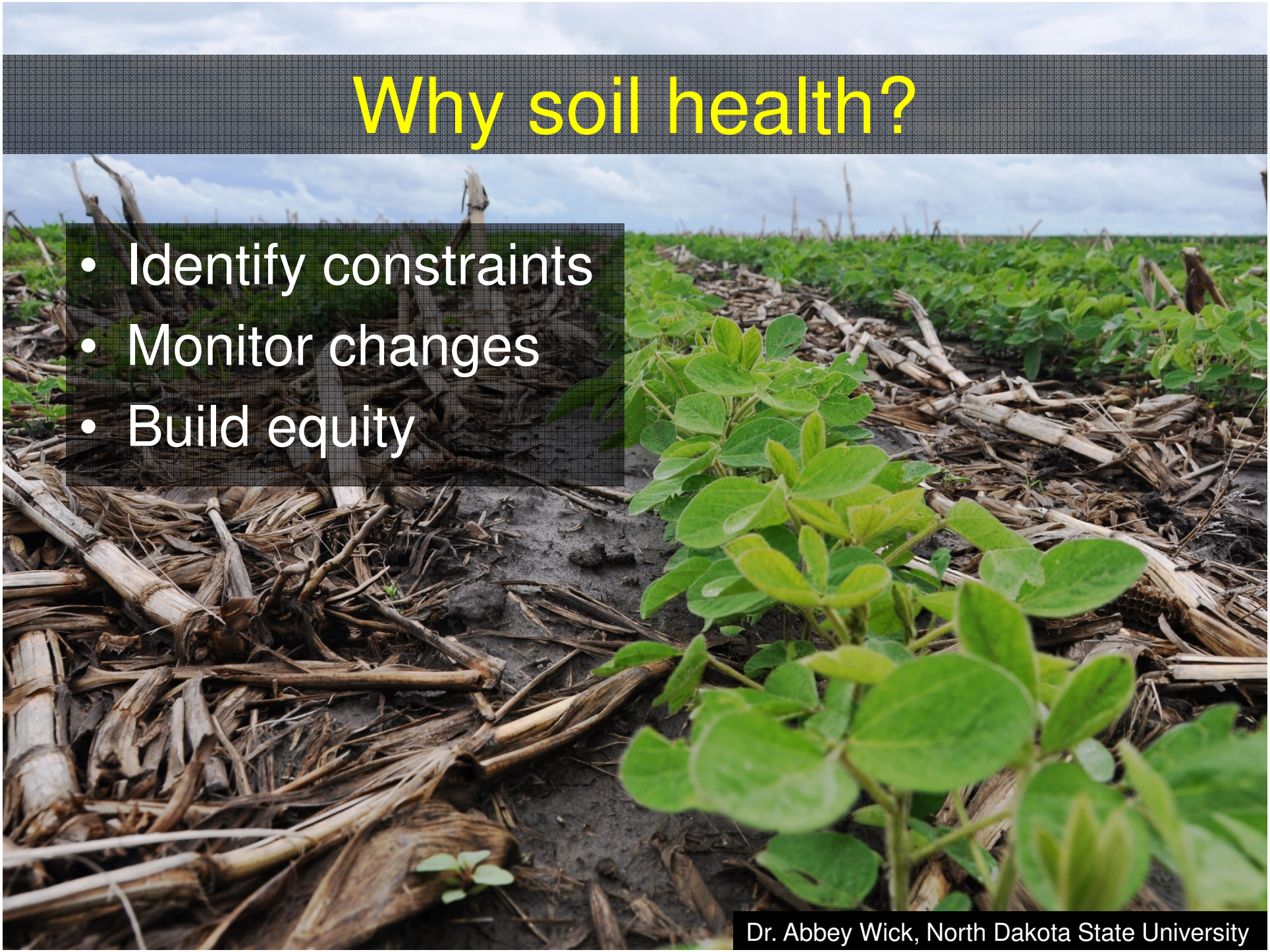
If you have questions about these recommendations, contact your County Extension office.

Visit our web site at http://soilplantandpest.utk.edu for additional information.

http://soilplantandpest.utk.edu

Why soil health?

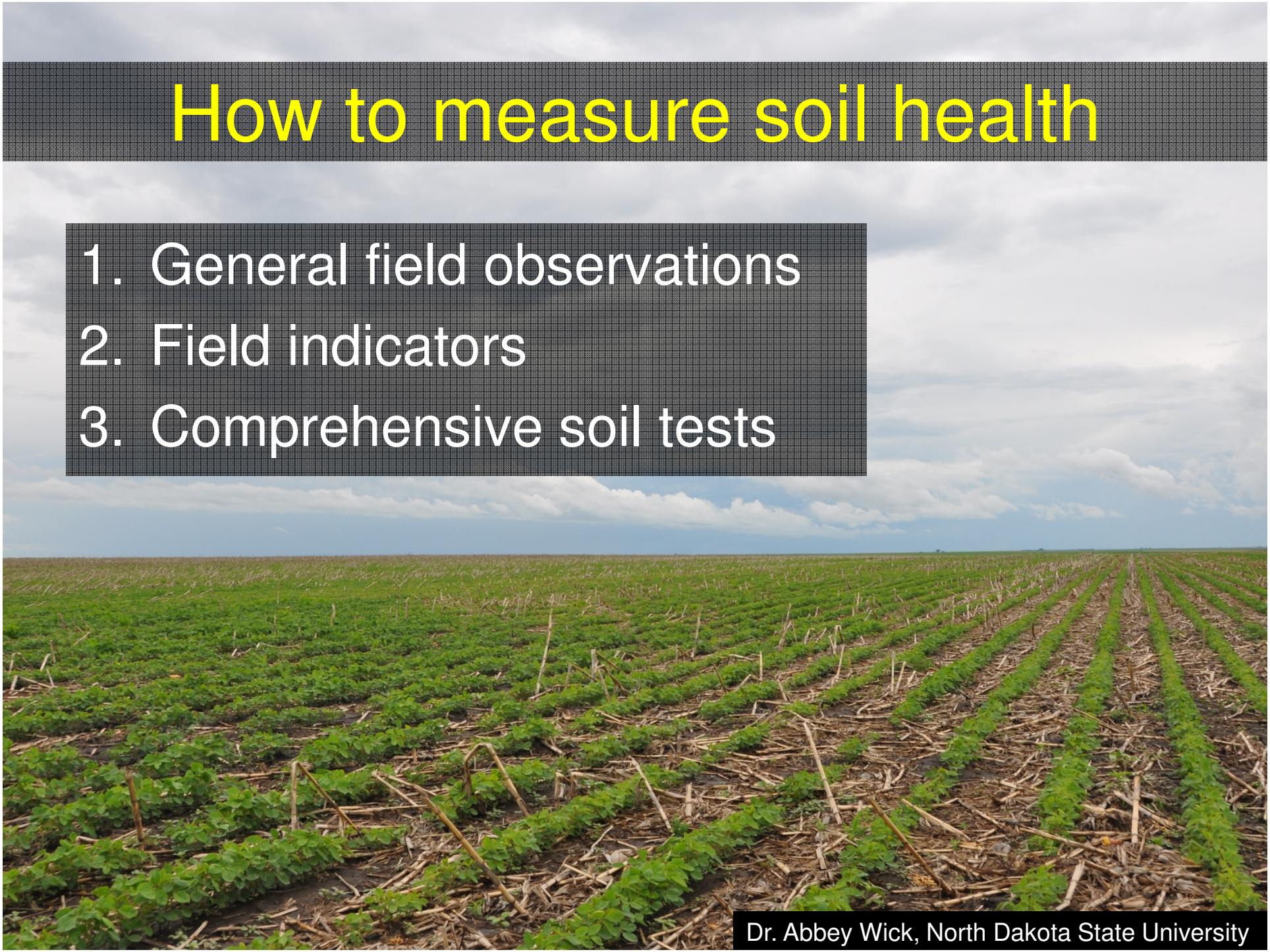
- Identify constraints
- Monitor changes
- Build equity



Dr. Abbey Wick, North Dakota State University

How to measure soil health

1. General field observations
2. Field indicators
3. Comprehensive soil tests



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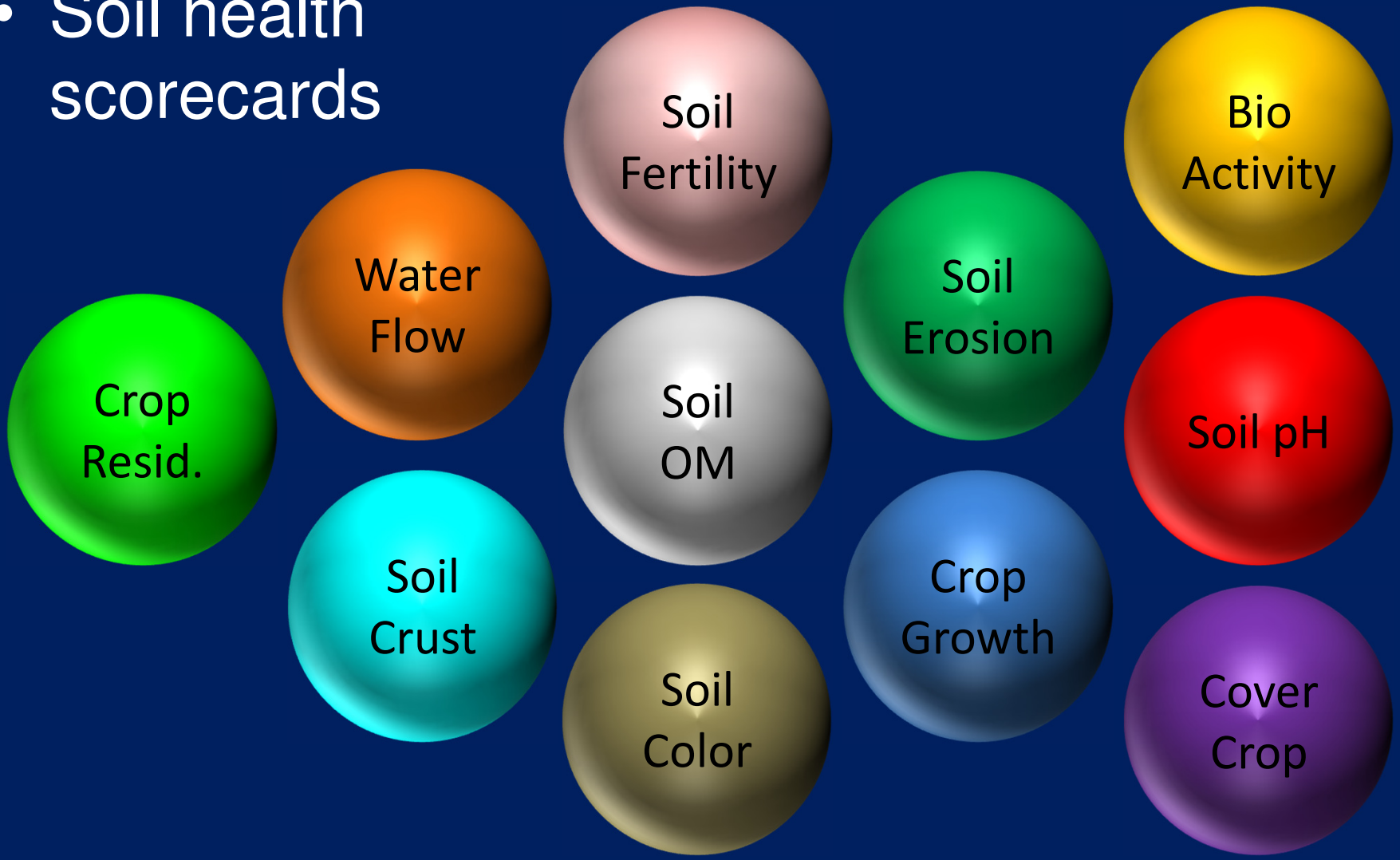
General field observations

- How is your health?

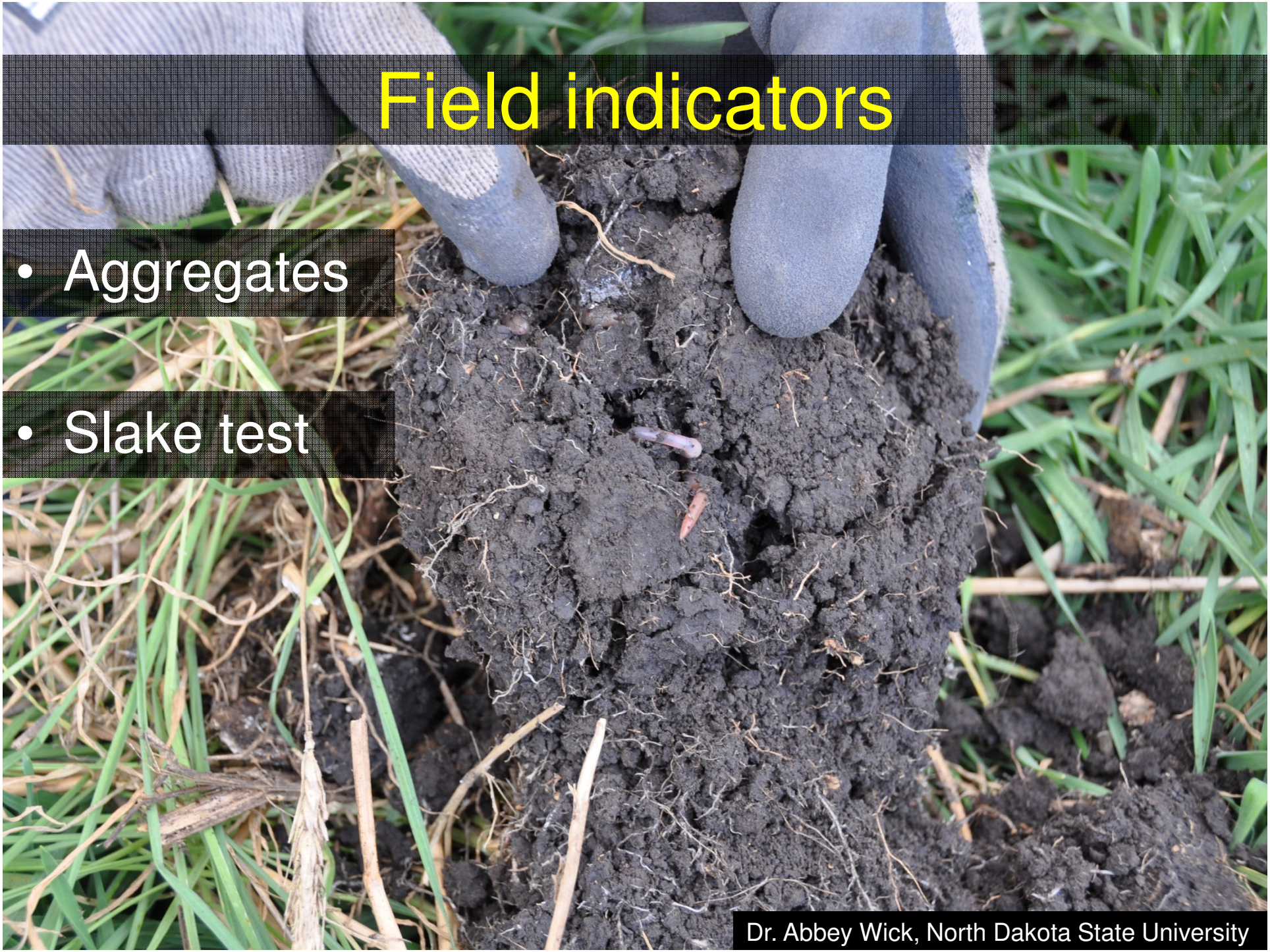
Field indicators

- Soil health scorecards



Field indicators

- Aggregates
- Slake test



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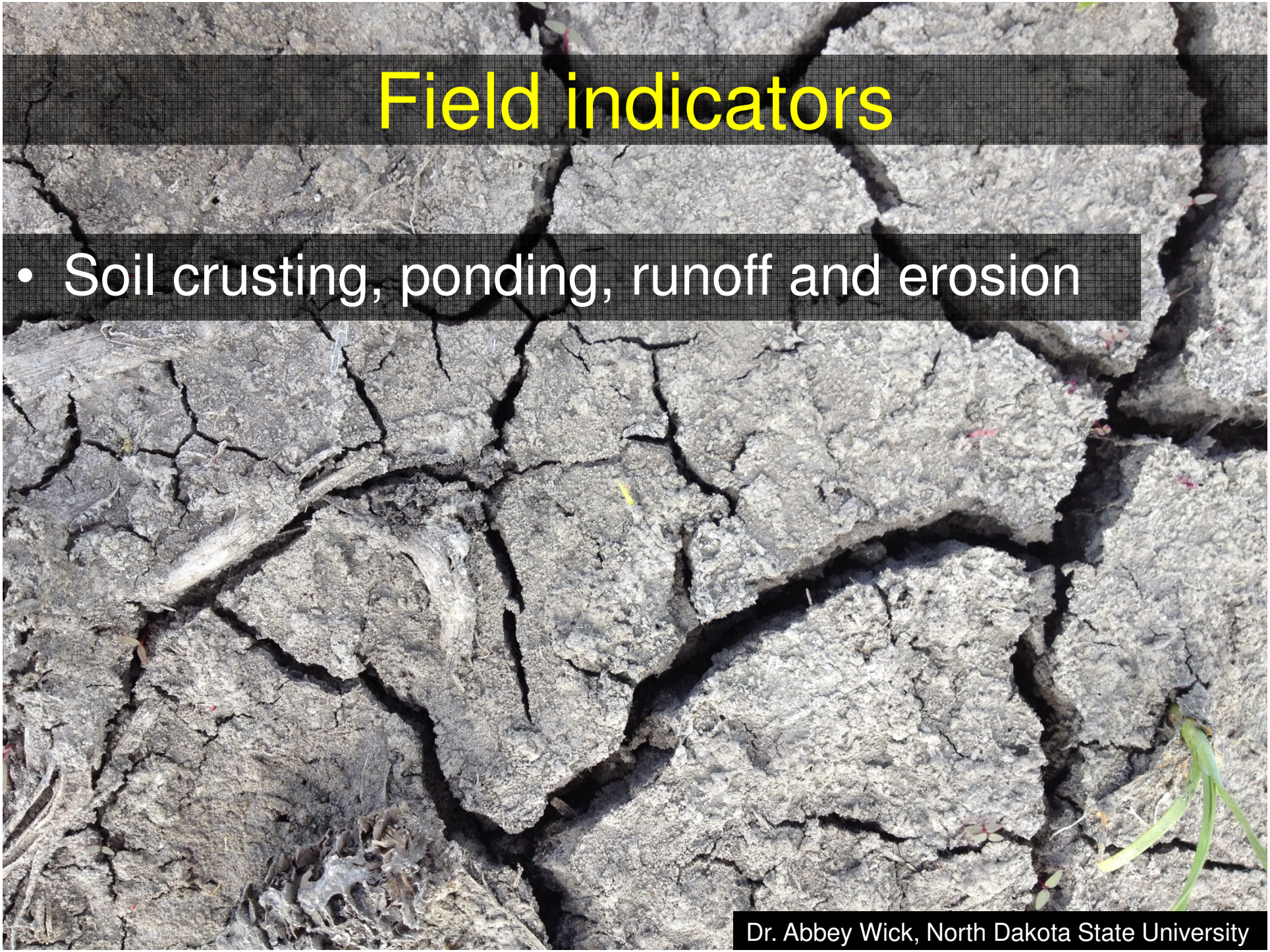
Field indicators

- Soil crusting, ponding, runoff and erosion



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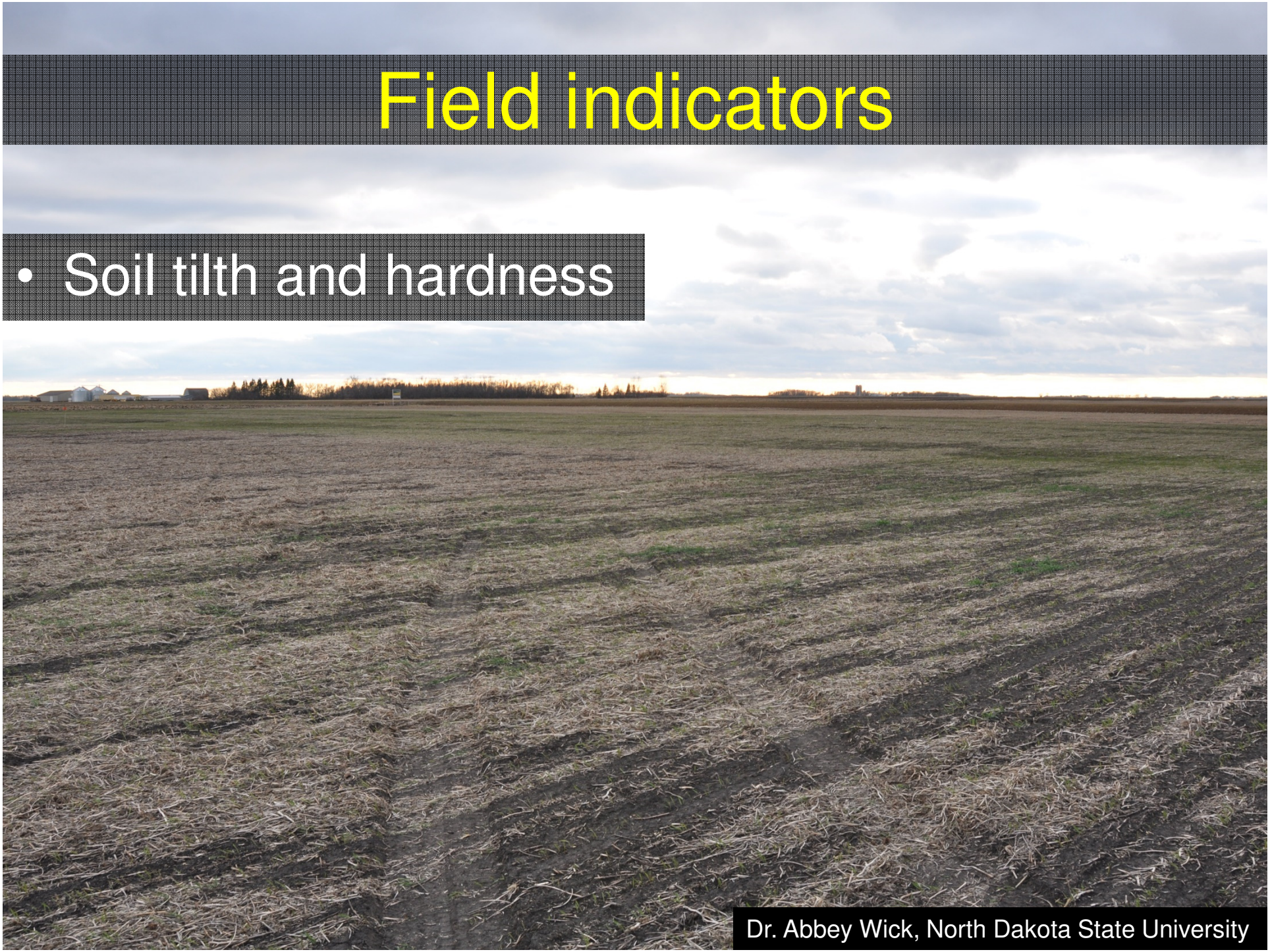
Field indicators

- Soil tilth and hardness



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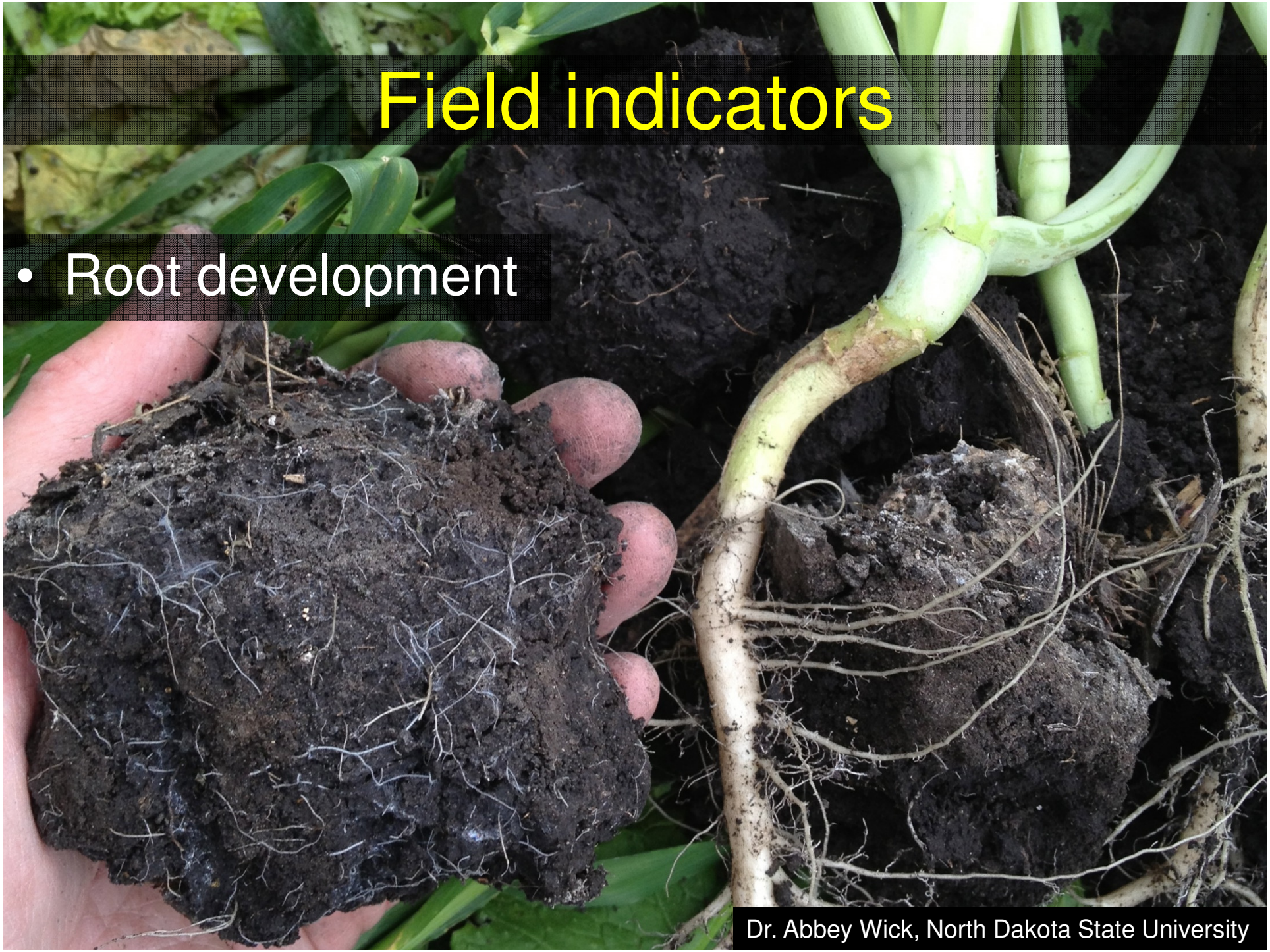
Field indicators

- Soil organisms

Field indicators

- Root development



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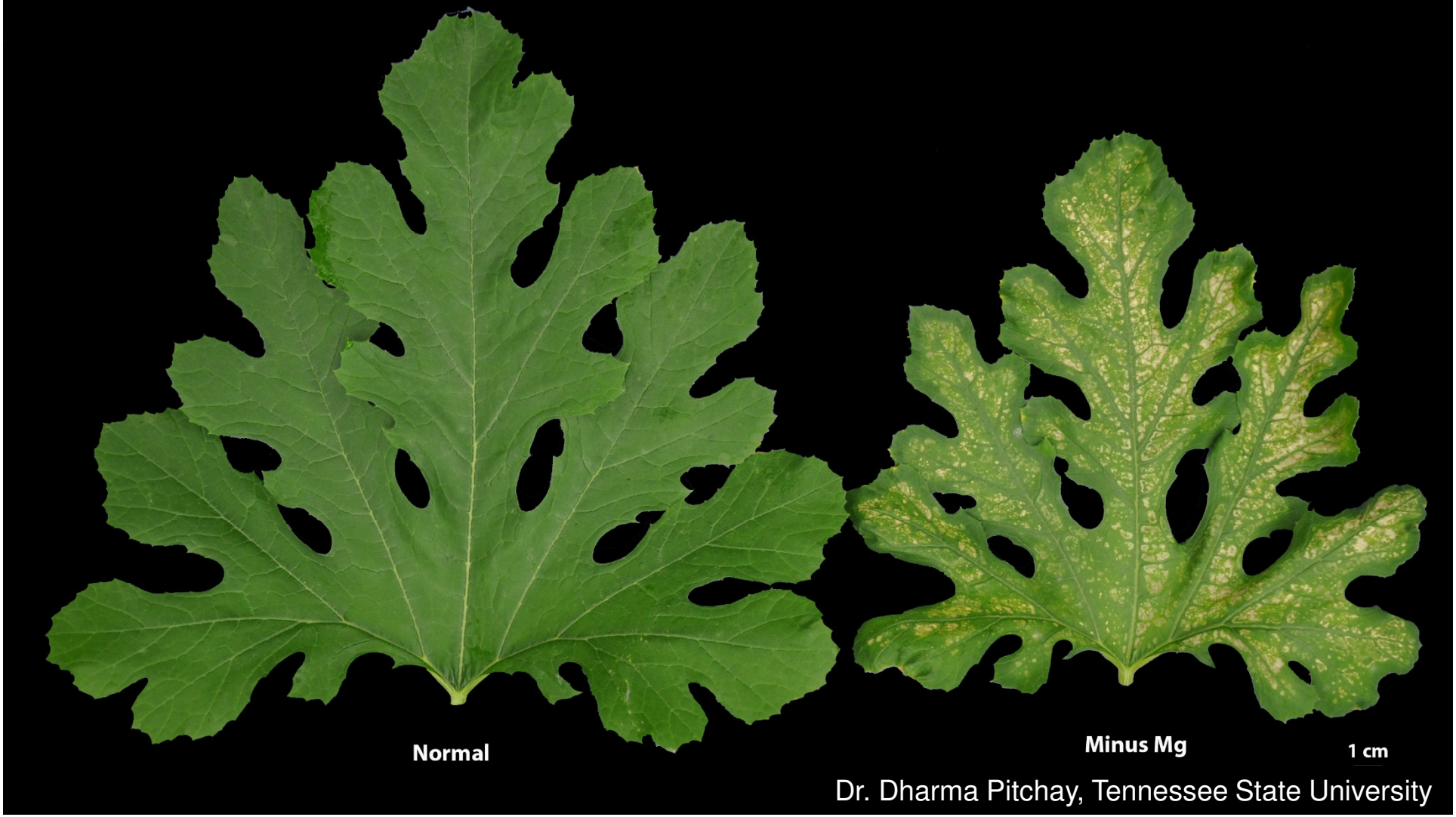
Field indicators

- Nutrient deficiency symptoms



Dr. Dharma Pitchay, Tennessee State University

Comprehensive soil tests

- Cornell Soil Health Test

Package $50 - $140 per sample

Individual tests $15-25 per sample

http://soilhealth.cals.cornell.edu/index.htm

Test Results

	Indicator	Value	Rating	Constraint
Physical	Available Water Capacity	0.14	53	
	Surface Hardness	240	22	Rooting, Water Transmission
	Subsurface Hardness	310	53	
	Aggregate Stability	56.6	47	
Biological	Organic Matter	3.3	55	
	ACE Soil Protein Index	5.8	25	Organic Matter Quality, Organic N Storage, N Mineralization
	Respiration	0.37	26	Soil Microbial Abundance and Activity
	Active Carbon	366	28	Energy Source for Soil Biota
Chemical	pH	6.9	100	
	Phosphorus	7.5	100	
	Potassium	65.3	91	
	Minor Elements Mg: 213 Fe: 13.7 Mn: 7.8 Zn: 1.4		100	
	Overall Quality Score		58	Medium

Comprehensive soil tests

- Midwest Labs

SOIL HEALTH ASSESSMENT

ANALYTICAL LABORATORY FINDINGS

SAMPLE IDENTIFICATION		1	
LABORATORY NUMBER		26605562	
ANALYTE	UNITS	RESULTS	LOW MEDIUM OPTIMUM VERY HIGH
H3A EXTRACTION			
NITRATE-N	ppm	1.0	
AMMONIACAL-N	ppm	2.0	
ORTHOPHOSPHATE-P	ppm	2.0	
PHOSPHORUS	ppm	7	
POTASSIUM	ppm	59	
MAGNESSIUM	ppm	51	
CALCIUM	ppm	147	
SODIUM	ppm	17	
IRON	ppm	46	
ALUMINUM	ppm	83	
WATER SOLUBLE			
NITRATE-N	ppm	1	
AMMONIACAL-N	ppm	2.0	
ORTHOPHOSPHATE-P	ppm	1.0	
CARBON	ppm	370.0	
TKN	ppm	31.0	
1 DAY CO_2C BURST		134.11	
ORGANIC CARBON	ppm	370.0	
ORGANIC NITROGEN	ppm	29.0	
ORGANIC C/N RATIO		12.8	

ADDITIONAL NITROGEN CREDIT IDENTIFIED VIA HANEY TEST: 57 lbs/A

SOIL HEALTH CALCULATION

17.1

0 50

The **H3A Soil Extractant** was developed by Haney*. This extract is designed to mimic organic acids produced by living plant root systems. These organic acids increase nutrient availability in the root zone.

The **Water Soluble Extract** provides a snapshot of nutrients that are immediately available to the plants.

The **CO_2 Burst** test is very good indicator of soil health. This test measures the amount of CO_2 naturally released from the soil due to the activity of the soil microbes through microbial respiration. This test is very dependant on the amount of carbon that is available to the soil microbes and the form that the carbon is in. As the available carbon increases in your soil the Microbial respiration will increase.

Organic Carbon is the available total water extractable organic carbon from your soil. This pool of carbon is roughly 80 times smaller than the Soil Organic Matter. The organic carbon pool reflects the energy/food source that is driving the soil microbes.

The **Organic Nitrogen** pool is replenished by fresh plant residues, manure, composts, and dying soil microbes.

The **Organic C/N ratio** is a critical component of the nutrient cycle. A soil C/N ratio above 20 generally indicates that Nitrogen will be tied up and not available to plants. The ideal range for the Organic C/N ratio will be from 8:1 to 15:1.

The **Soil Health Calculation** uses the CO_2 Burst, Organic Carbon, Organic Nitrogen, and the C/N ratio to generate the soil health number. This calculation looks at the balance of soil carbon and nitrogen and their relationship to microbial activity. This number represents the overall health of your system. Soil values will range from 0 to 50. A soil with a value below 7 would be considered low. You want to see this number increase as you make changes and adjustments. Keeping track of this number will allow you to gauge the effects of your management practices over time.

$75/sample, not based on soil physical properties

Comprehensive soil tests

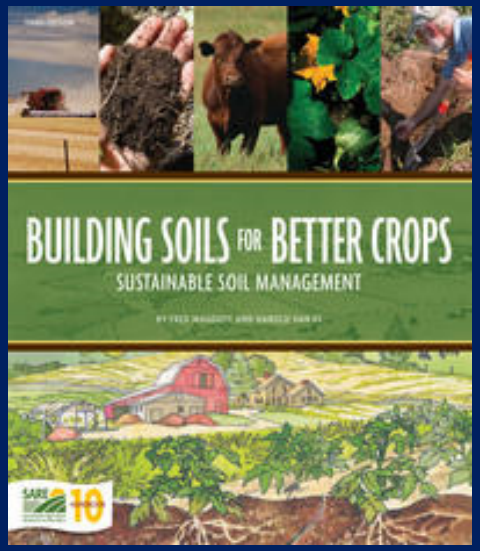
- Other options

Soil Quality Kit NRCS


Now that I know what's wrong, what do I do about it?
• Reduce tillage
• Avoid soil compaction
• Grow cover crops
• Use better crop rotations
• Apply organic amendments
• Apply inorganic amendments
Dr. Abbey Wick, North Dakota State University

For more information

Building Soils for Better Crops
www.sare.org



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