SOIL HEALTH
2013 NM PECAN CONFERENCE

The maintenance of a high degree of soil aggregation is one of the <u>MOST</u> important goals of soil management (The Nature and Properties of Soil, 4th edition revised).

Agronomy Technical Note 76

(http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

NRCS Natural Resources Conservation Service

USDA is an equal opportunity provider and employer

Rudy Garcia
NM State Agronomist, USDA/NRCS

Conventional Tillage in Pecans

Bermuda grass planted in pecan orchard (1st Irrigation).

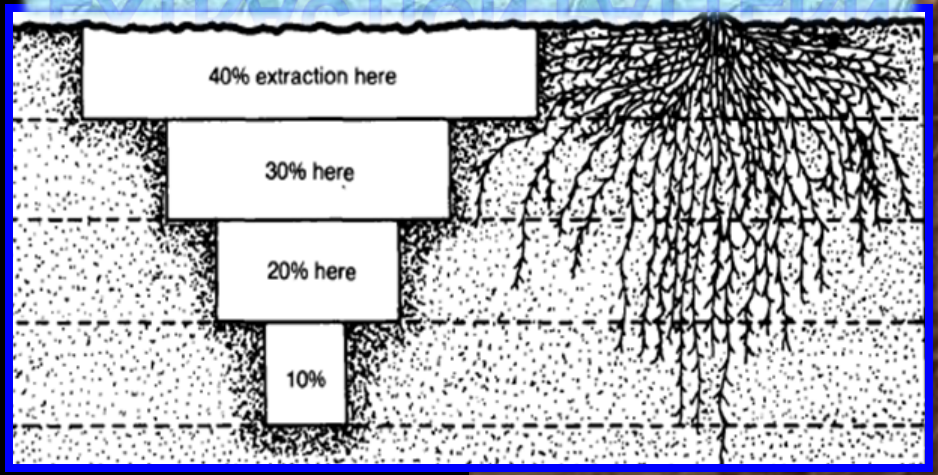
Bermuda grass established in pecan orchard.

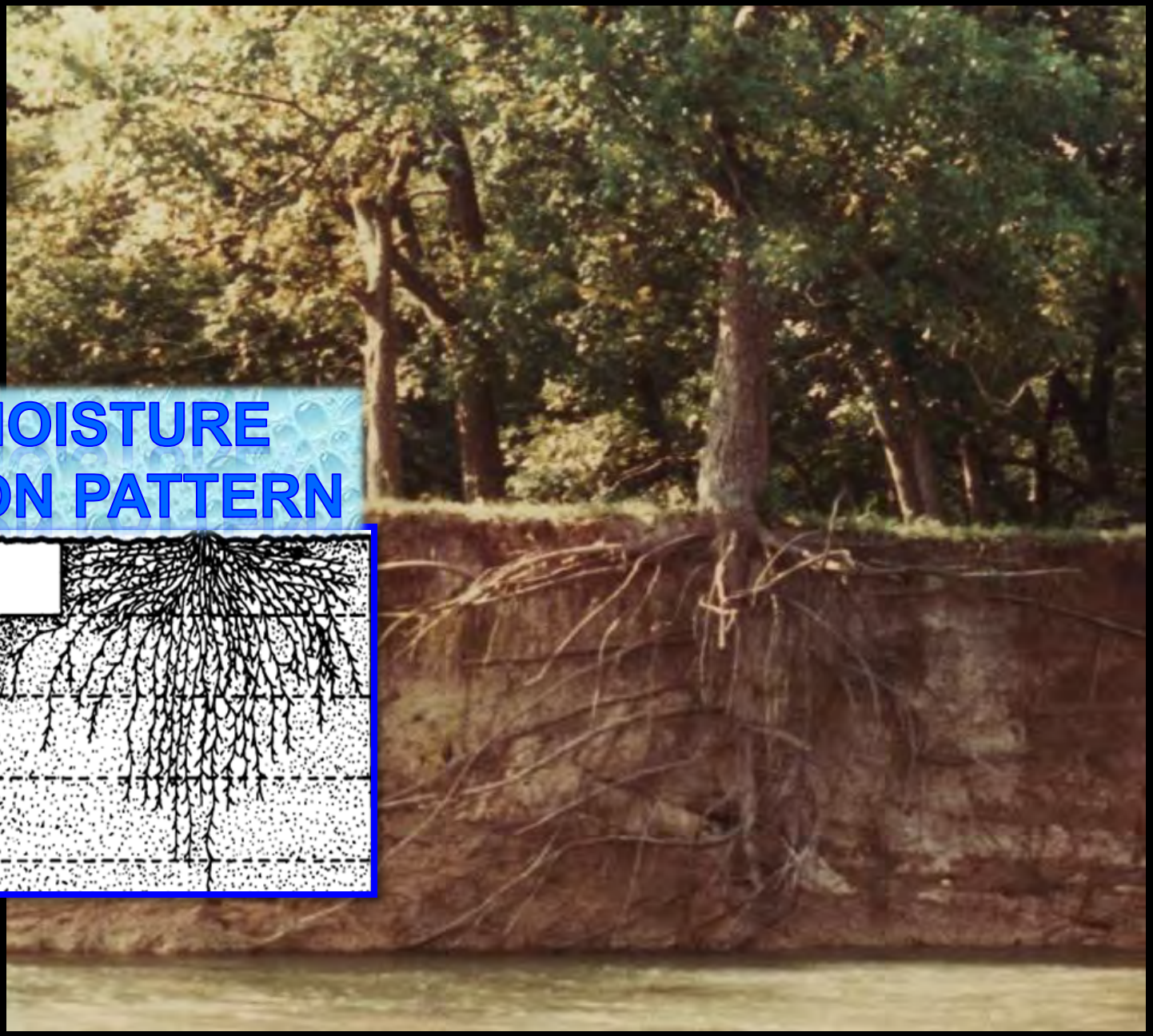
Applying compost.

Compost applied on top of dormant Bermuda Grass.

Bermuda grass (early growth).

PLANT MOISTURE EXTRACTION PATTERN





Emphasis on understanding the soil profile (texture & structure), stratification, root depth, water quality (ECiw, SAR, ph), crop salt tolerance, drainage, etc.

Earthworm openings.

Soil is beginning to develop soil structure.

Managing the soil's living organims.
This entails working to maintain favorable conditions of moisture, temperature, nutrients, pH, and aeration. It also involves providing a steady food source of raw organic material.

Biological habitat is dramatically improved with the grass and compost (enhanced Nutrient Cycling).

Soil surface darkened with compost.

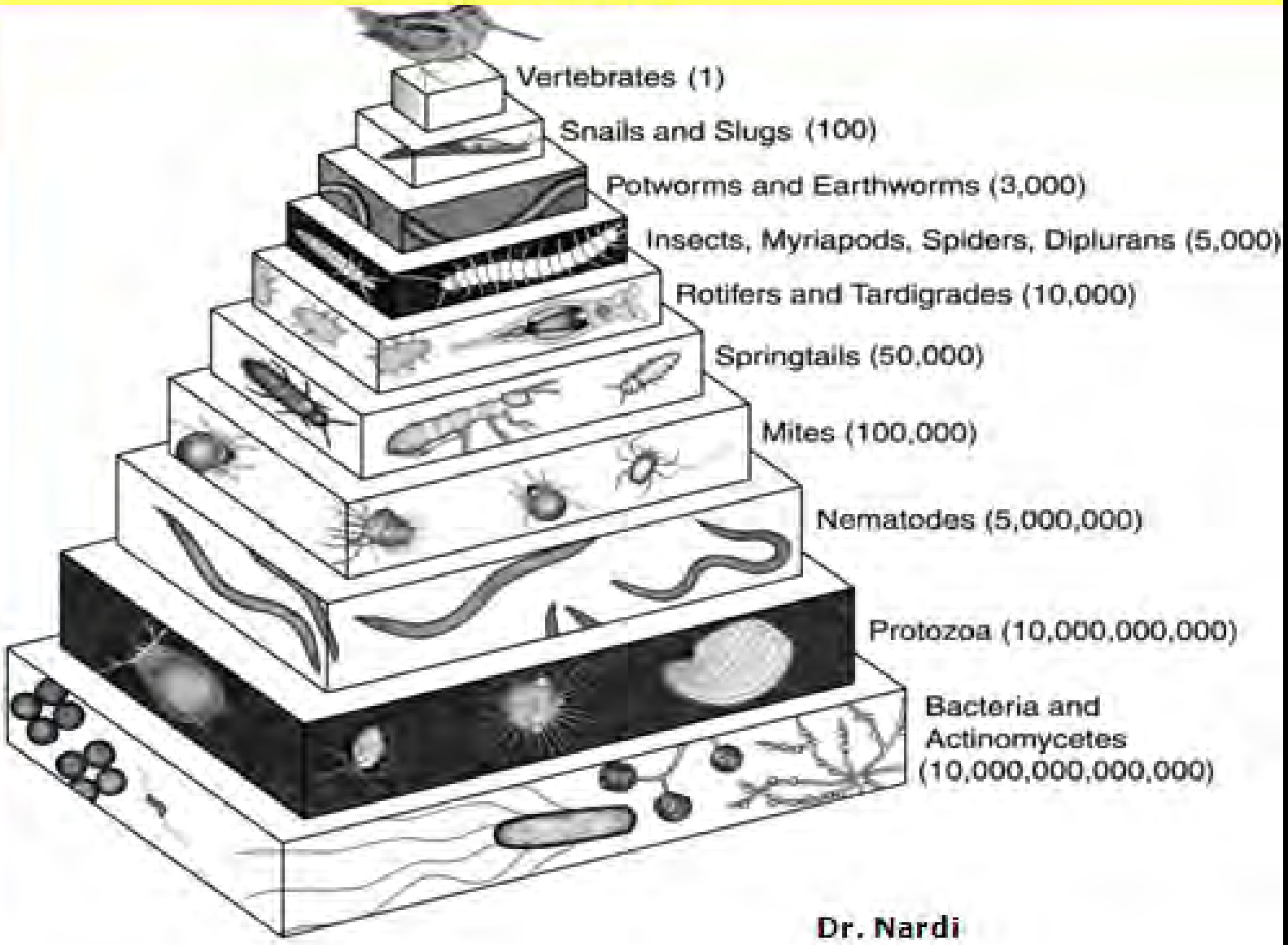
A healthy root system = A healthy surface soil.

Creating a Soil Habitat is the first step to managing soil biota for long-term soil quality, soil health, and productivity.

Soil Food Web
(Soil Livestock)

Photos: Soil Biology Primer

Every trophic level must function for the soil food web to function!



Dr. Nardi

Rotted Fence Post Principle

Zone of greatest microbial activity.

Decay of wood is greatest a few inches below the soil surface, where oxygen and moisture are in plentiful supply and create a zone of maximum biological activity.

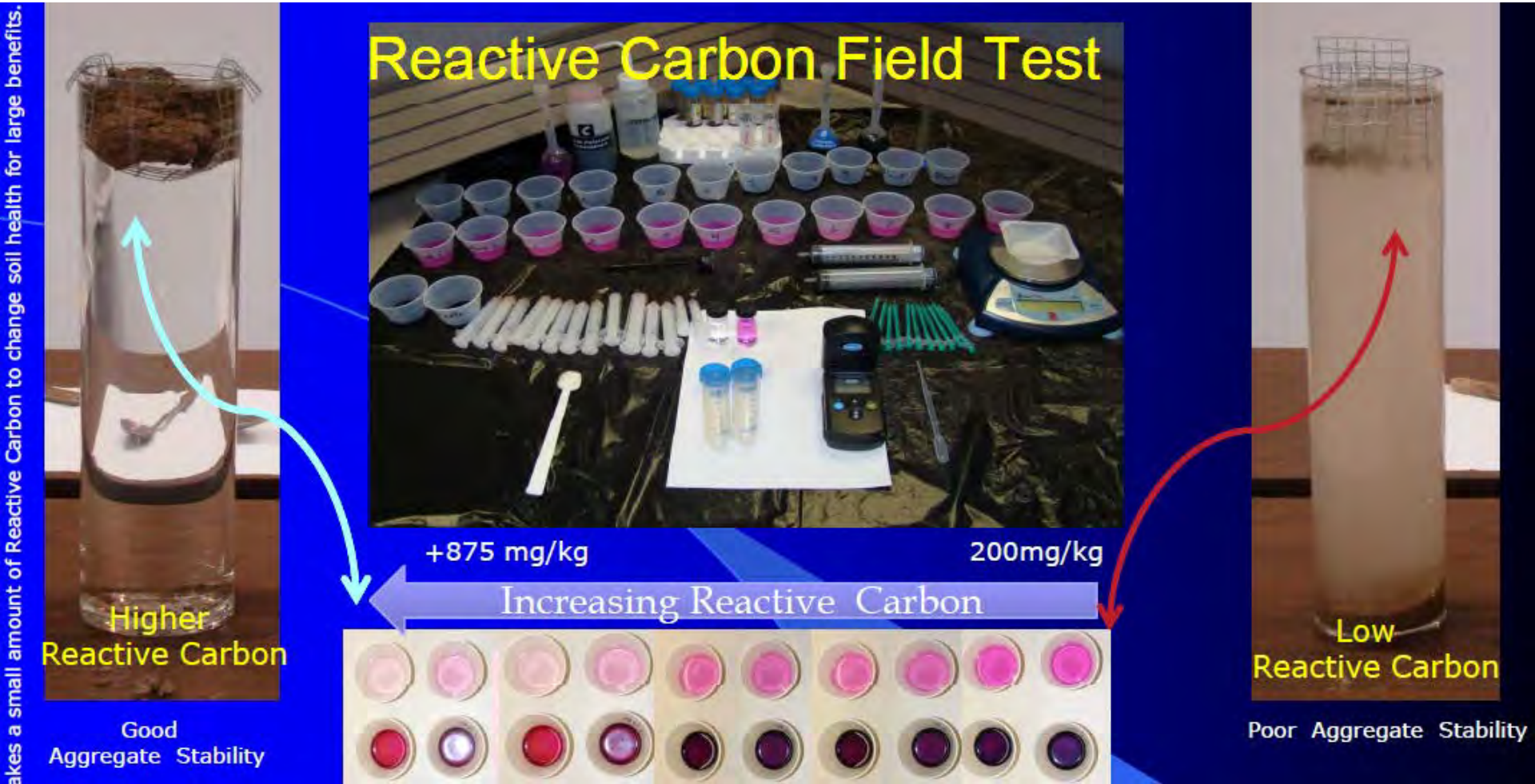
Most soil microorganisms are aerobic and use oxygen as the electron acceptor in their metabolism.

The zone of greatest microbial activity usually occurs just a few inches below the soil surface where optimal temperature, moisture, oxygen and nutrient conditions exist.

Vetch growing in Bermuda grass (small plot demonstration).

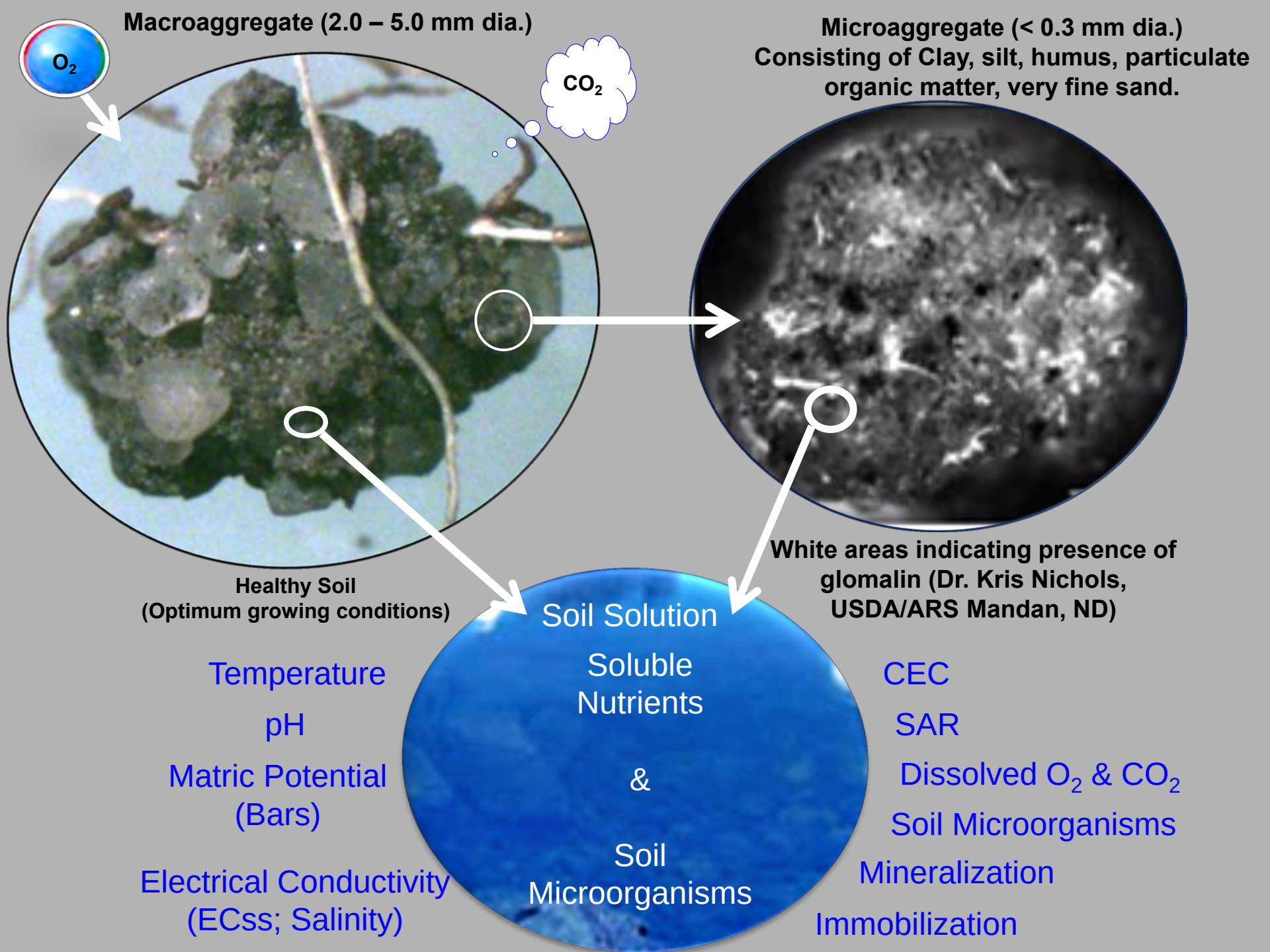
Clover growing in Bermuda grass (small plot demo).

Reactive Carbon and Aggregate Stability

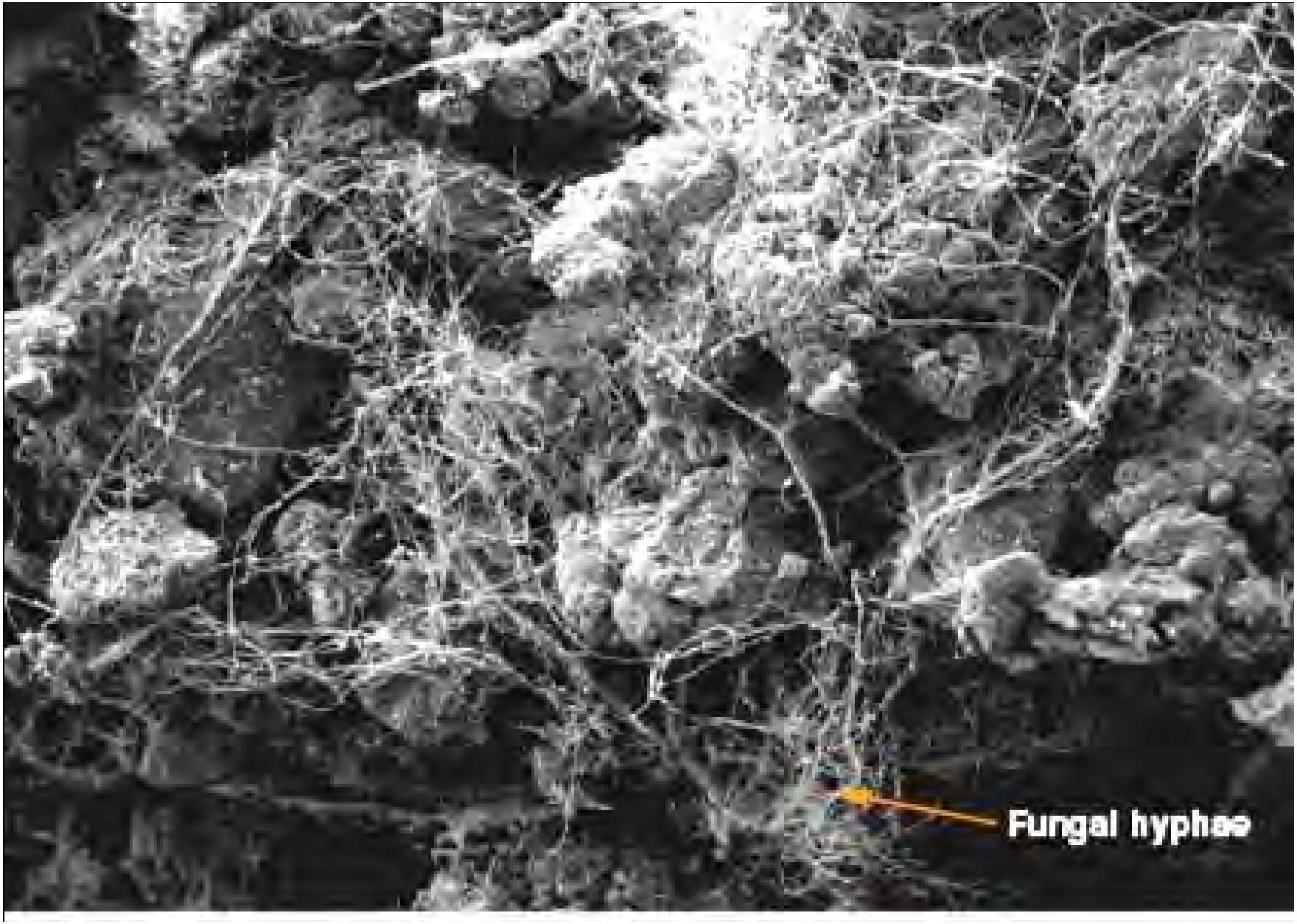


Soil Health: What is it?

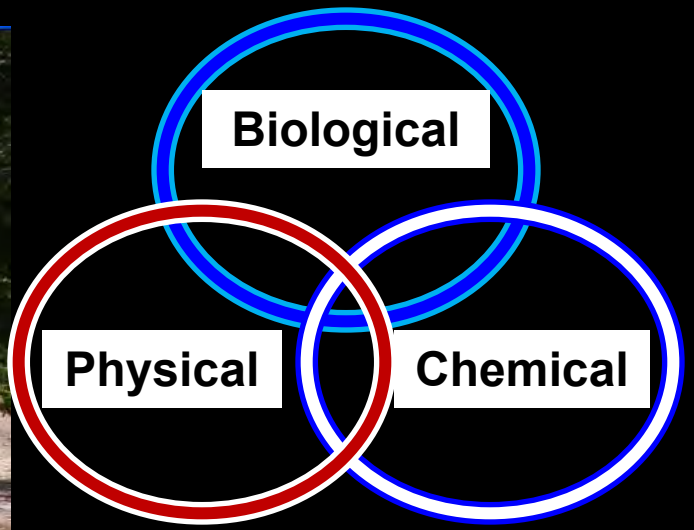
- Productive Soils
- Good Tilth/Structure
- High Organic Matter
- Earthworms
- Water-Stable Aggregates


Macroaggregate (2.0 – 5.0 mm dia.)
O_2
CO_2
Microaggregate (< 0.3 mm dia.)
Consisting of Clay, silt, humus, particulate organic matter, very fine sand.
Healthy Soil
(Optimum growing conditions)
White areas indicating presence of glomalin (Dr. Kris Nichols, USDA/ARS Mandan, ND)
Soil Solution
Soluble Nutrients
&
Soil Microorganisms
Temperature
pH
Matric Potential (Bars)
Electrical Conductivity (ECss; Salinity)
CEC
SAR
Dissolved O_2 & CO_2
Soil Microorganisms
Mineralization
Immobilization

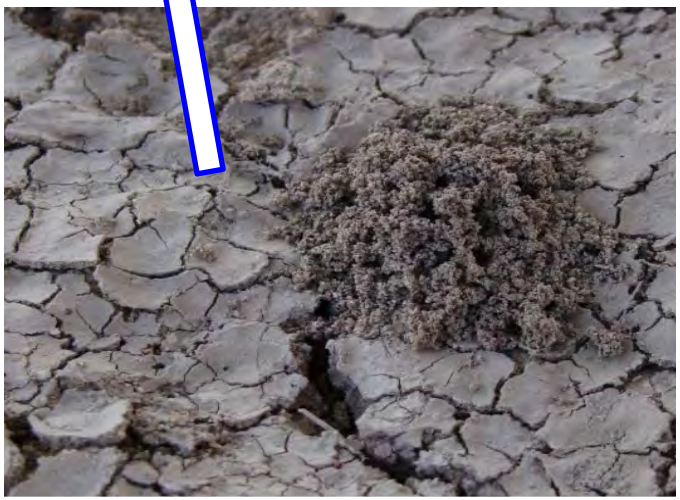
Fungal hyphae binding soil particles together into aggregates.
Arbuscular Mycorrhizal fungi produces Glomalin that glues soil particles together.

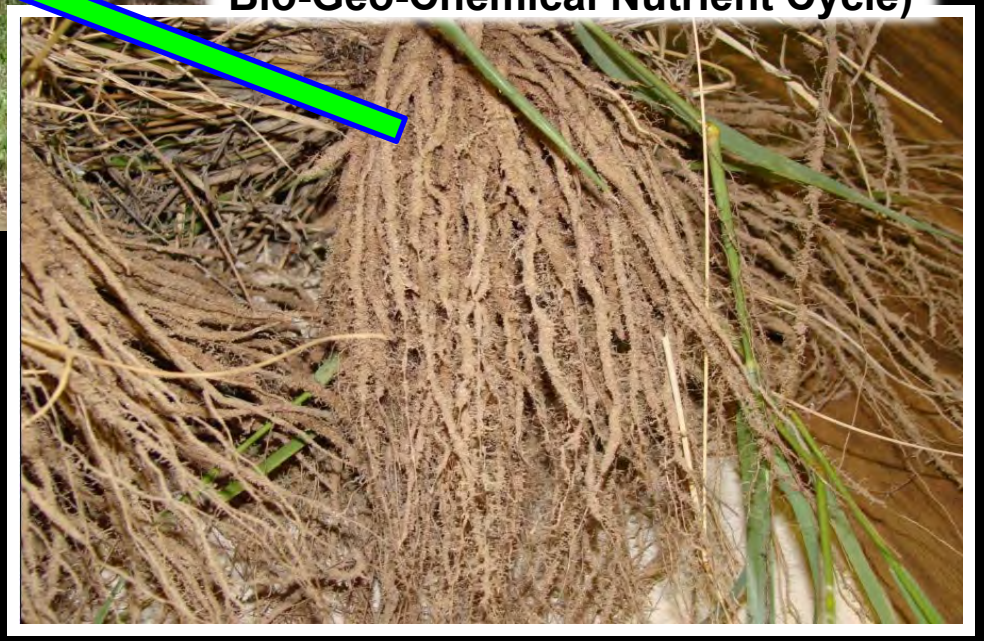


Soil Health Management System (Managing SOM)

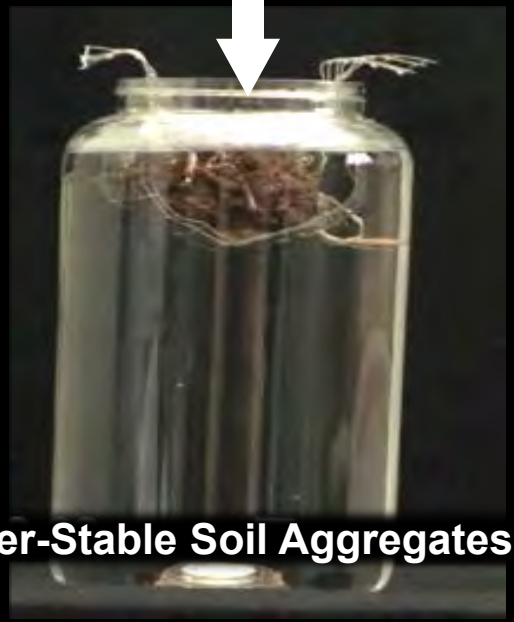


(Emphasis on: Carbon, Carbon and Carbon in understanding the Bio-Geo-Chemical Nutrient Cycle)





TILLAGE AND ITS IMPACT ON THE BIO-GEO-CHEMICAL NUTRIENT CYCLE



Water-Stable Soil Aggregates

Slake Test

Poor aggregate stability

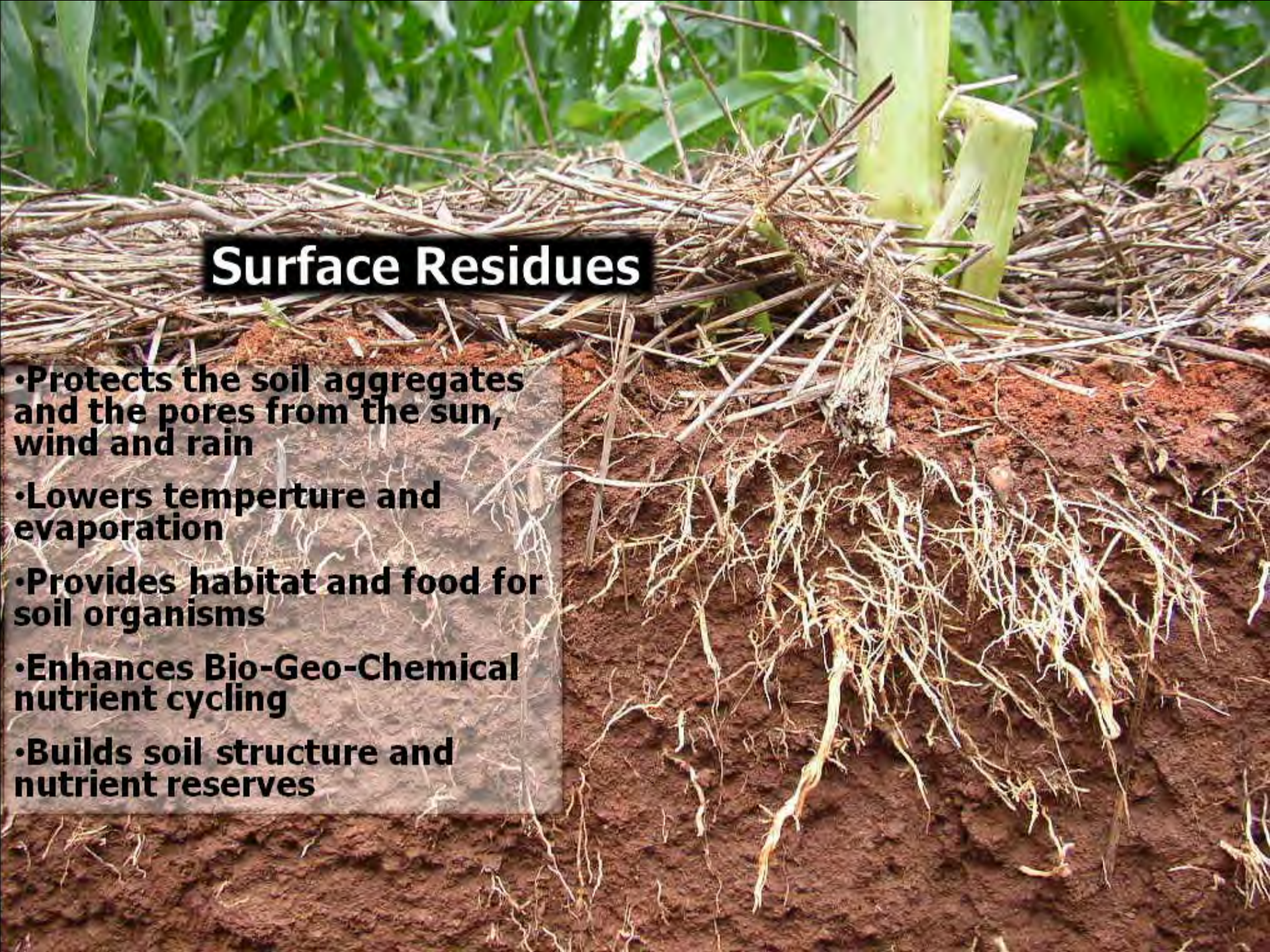
Evolution of a continuous No-till system

Initial phase	Transition phase	Consolidation phase	Maintenance phase
• Rebuild Aggregates • Low OM • Low crop residues • Re-establish microbial biomass • > N immobilization	• decrease soil density • Start increasing of crop residue • Start increasing in OM • Start increasing P • Immobilization N ≥ Mineralization	• High crop residues • High C • > CEC • > H_2O AWH • Immobilization N < Mineralization • > Nutrient Cycling	• High accumulation of crop residue • Continuous N and C Flux • Very high C • > H_2O AWH • > High Nutrient Cycling • Less N and P use
0-5 14%	5-10 34%	10-20 43%	> 20 8%

Time (years)

(Sá, 2004)

Rain Simulator (Infiltration Demonstration)


Surface Residues
•Protects the soil aggregates and the pores from the sun, wind and rain
•Lowers temperture and evaporation
•Provides habitat and food for soil organisms
•Enhances Bio-Geo-Chemical nutrient cycling
•Builds soil structure and nutrient reserves

When soil temperature reaches…

140 F Soil bacteria die

130 F 100% moisture is lost through evaporation and transpiration

113 F

Some bacteria species start dying

100 F 15% of moisture is used for growth
85% moisture lost through evaporation and transpiration

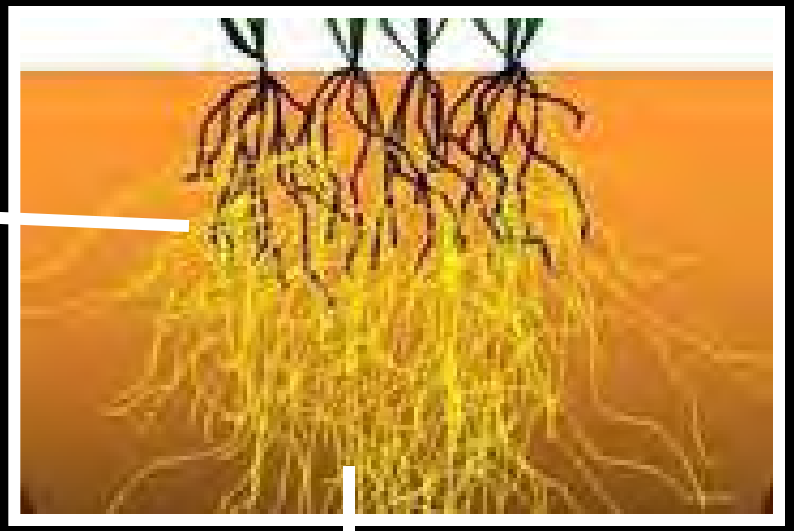
95 F

70 F 100% moisture is used for growth

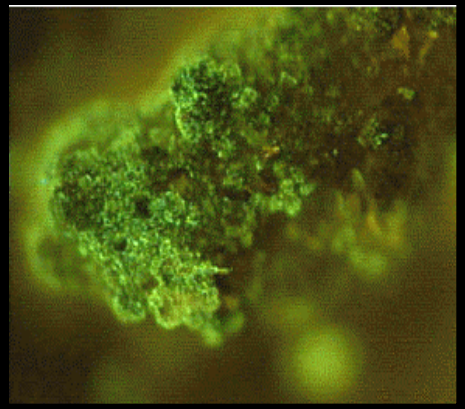
J.J. McEntire, WUC, USDA SCS, Kerrville TX, 3-58 4-R-12198, 1956

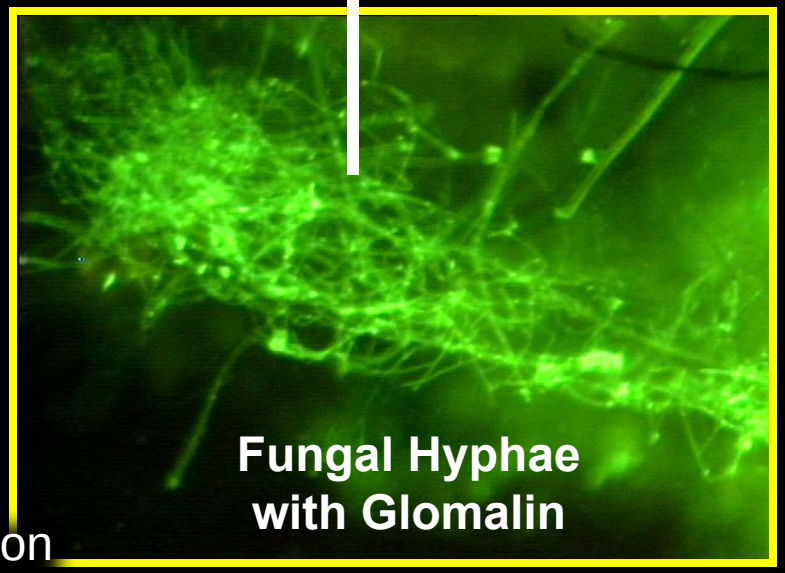
<u>EARTHWORMS:</u> DON’T DISTURB, SOIL ENGINEERS AT WORK; THEY ARE BUILDING SOIL STRUCTURE AND RECYCLING NUTRIENTS.

Rhizosphere
(roots with mycorrhizal fungi)



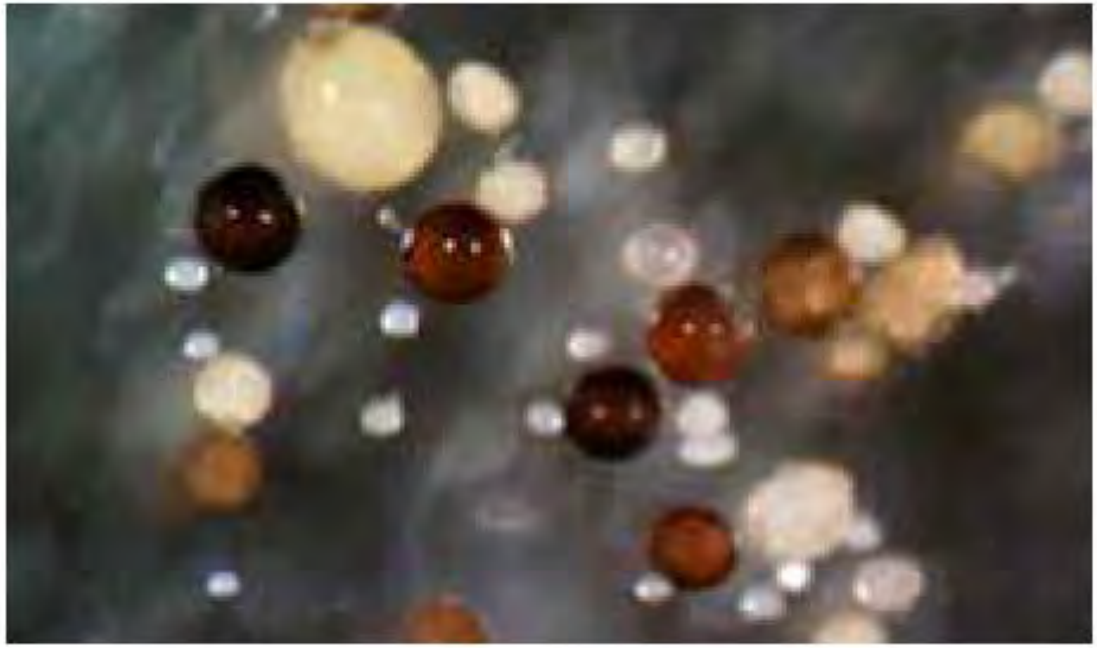
Soil aggregates coated with glomalin





Glomalin is a stable glycoprotein, that stores carbon in the soil as a glue and protects the soil biota.

▶**Above:** USDA-ARS research microbiologist Wendy Taheri found that arbuscular mycorrhizal spores were sparse from a tilled farm field (top), but abundant in an undisturbed prairie soil.



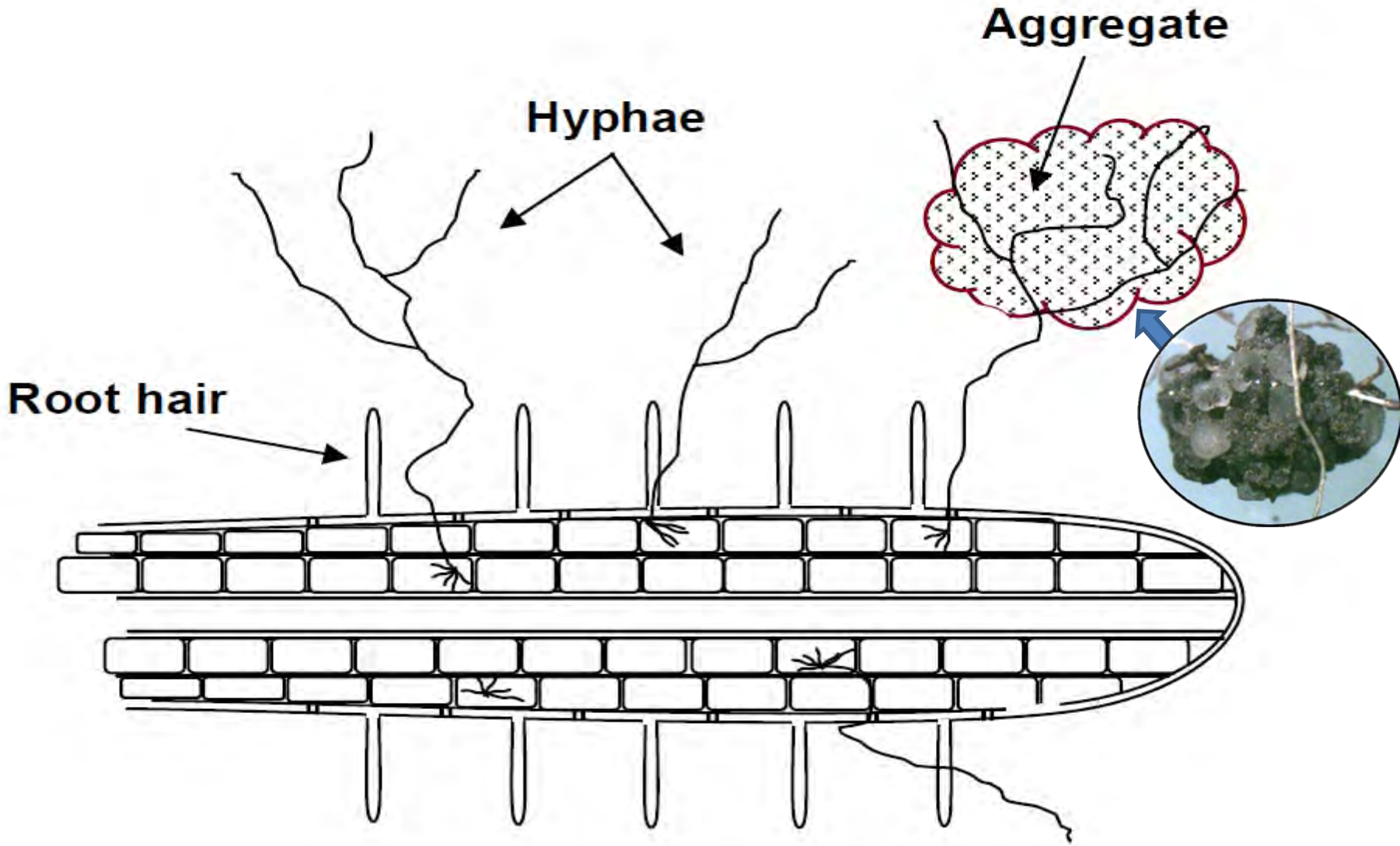
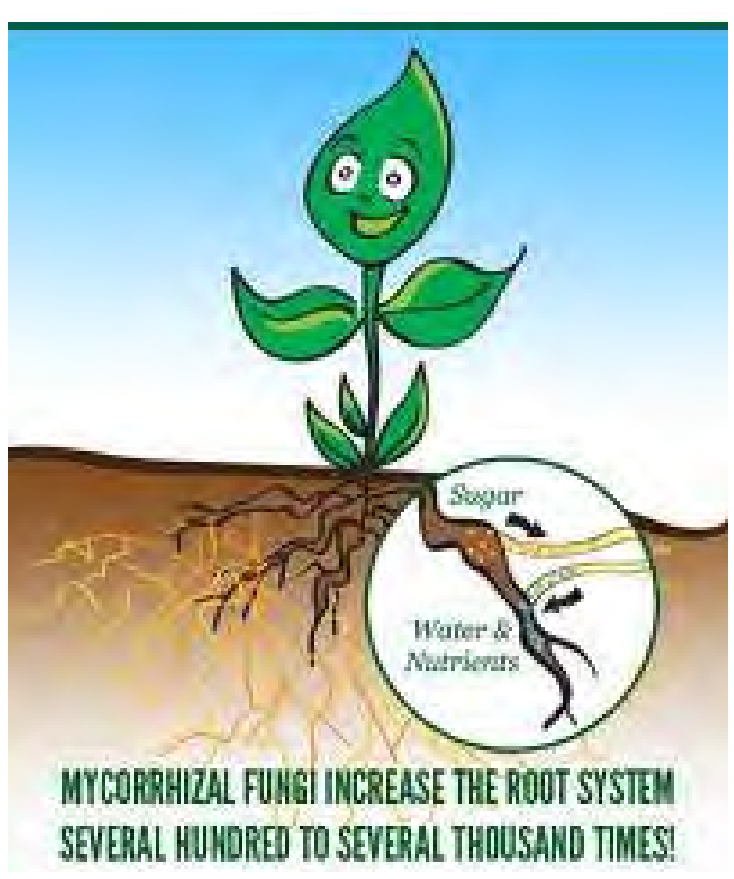
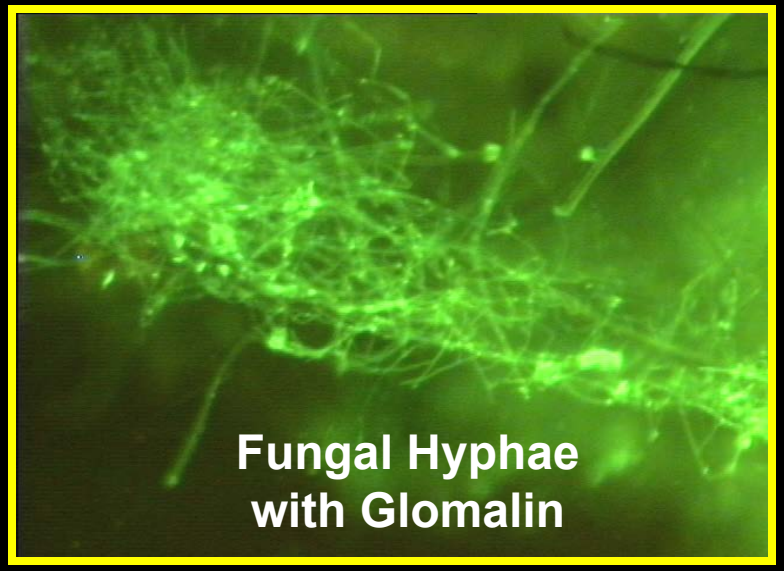


Fig. 1. Hyphae of arbuscular mycorrhizal fungi grow beyond nutrient depleted zones found around roots and root hairs. Hyphae form a frame for soil particles to collect into aggregates which are coated with glomalin.


Sugar
Water &
Nutrients
MYCORRHIZAL FUNGI INCREASE THE ROOT SYSTEM
SEVERAL HUNDRED TO SEVERAL THOUSAND TIMES!


Fungal Hyphae
with Glomalin

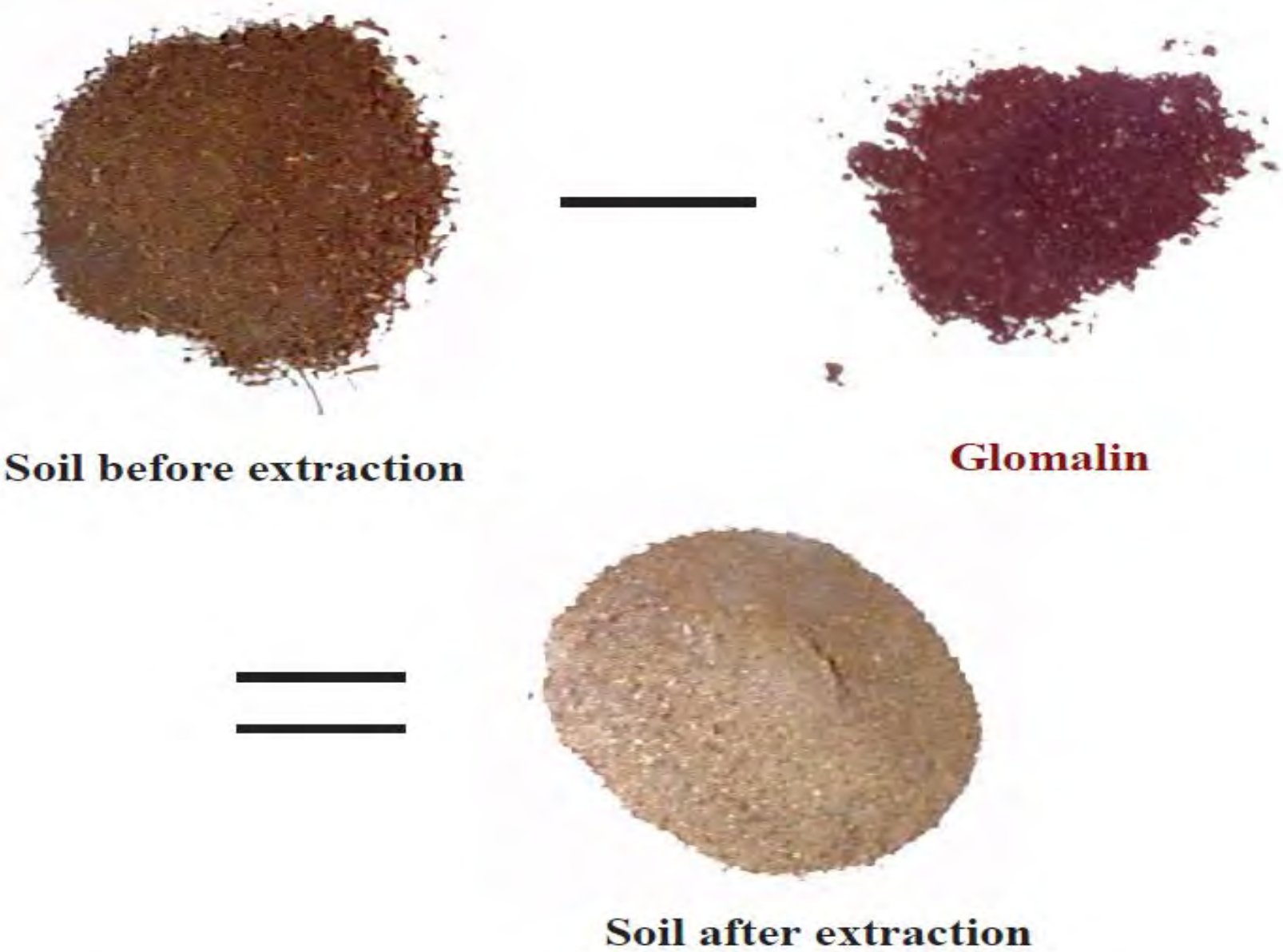


Fig. 2. Glomalin is extracted from soil with high heat. After removal of glomalin, soil is transformed from a rich brown color to a grey mineral color.

What holds the Porosphere together?

Repair mode | **Maintenance mode**

Conventional tilled ⟷ **No-till** **Grass systems**

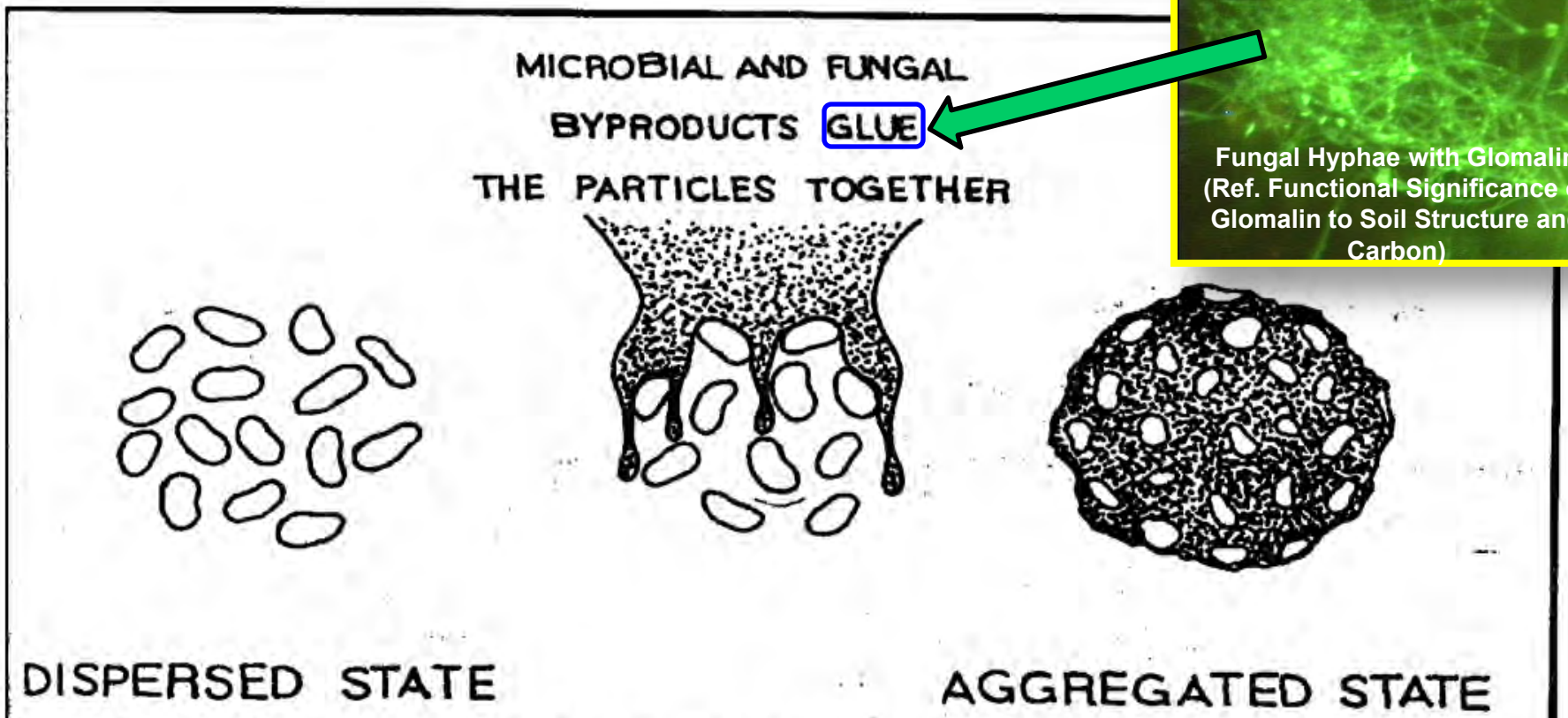
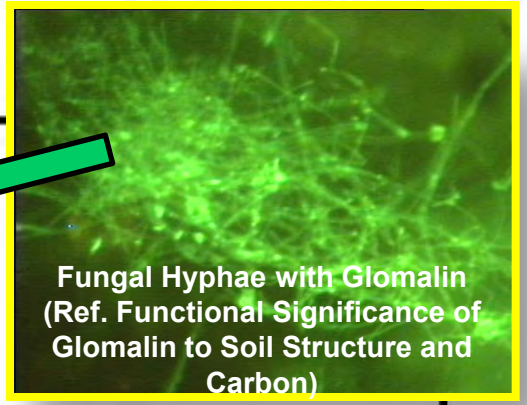
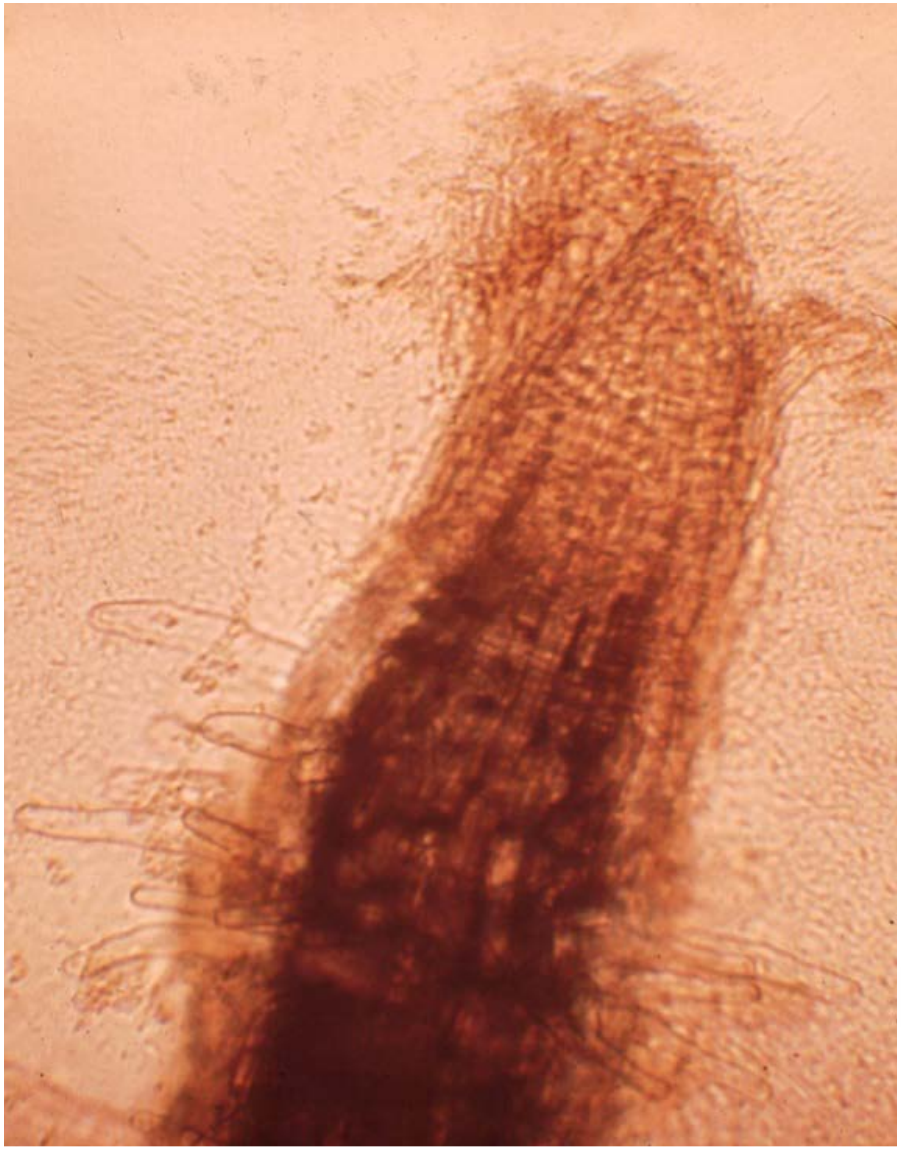


Figure 2 Microbial byproducts glue soil particles into water-stable aggregates.



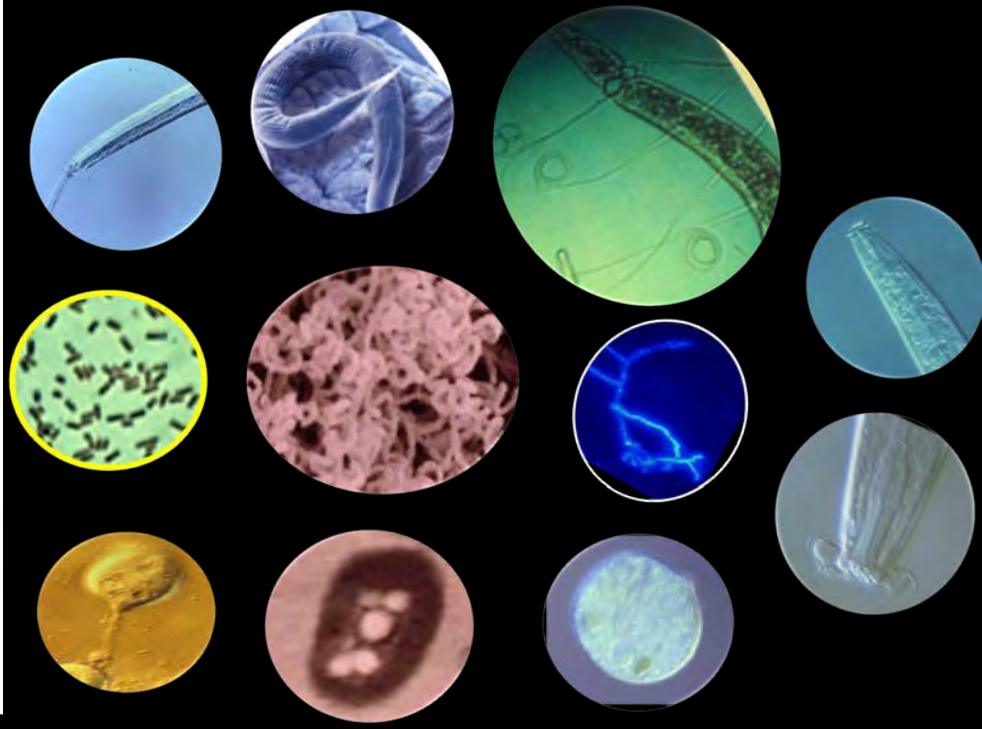
From ATTRA - Soil Quality Publication

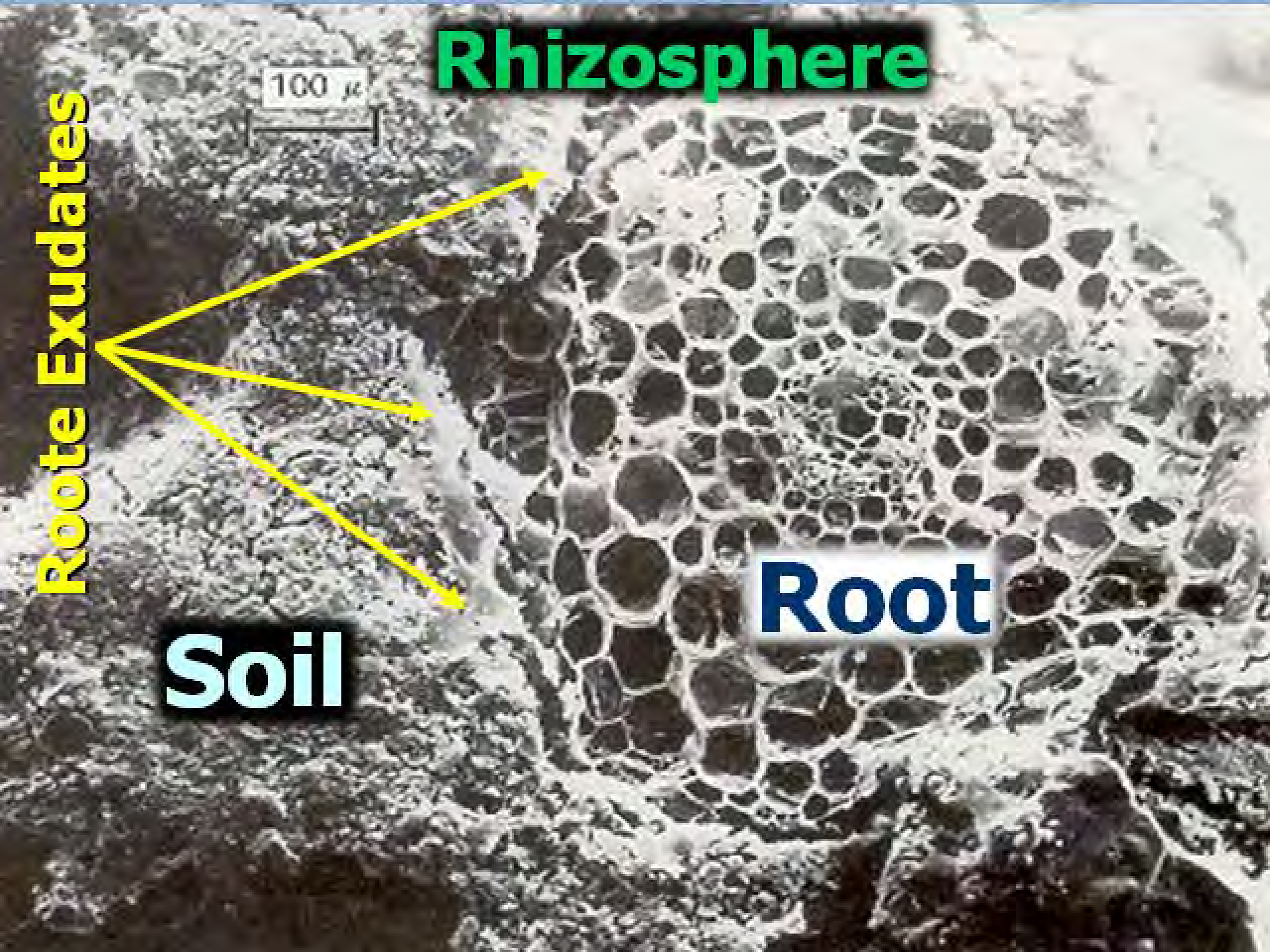
Rhizosphere (Root Exudates): Where Roots Meet the Soil



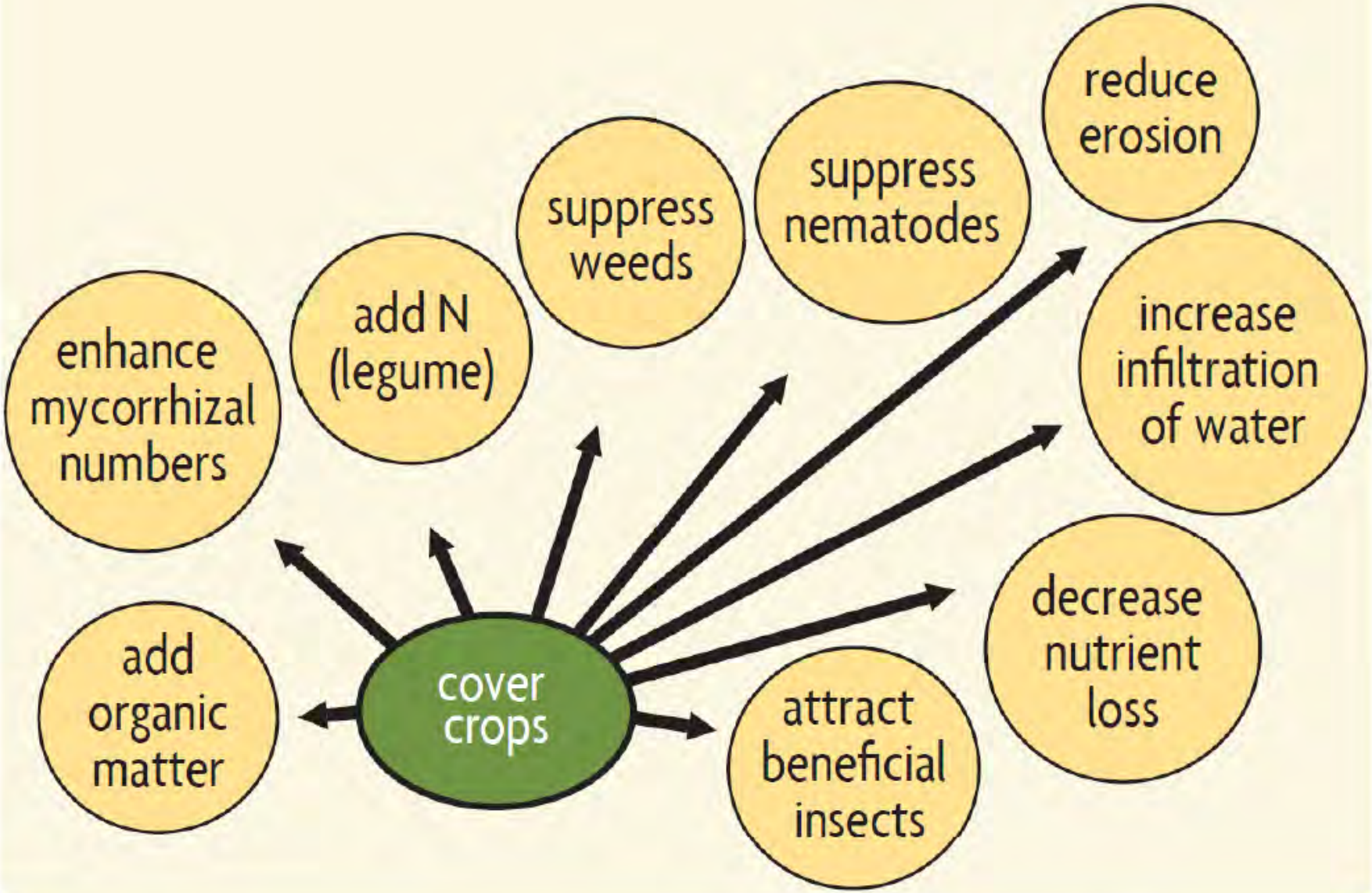
Zone of Concentrated Biological Activity

- Bacteria
- Fungi
- Protozoa
- Nematodes




Rhizosphere
100 μ
Roote Exudates
Root
Soil

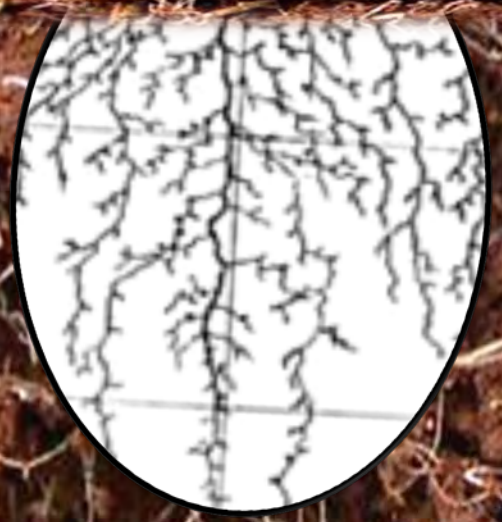
New Zealand White Clover
at the Plant Material Center,
Los Lunas, NM



Magdoff and Van Es, 2003

Primary Producers

Building Soil Organic Matter (SOM)



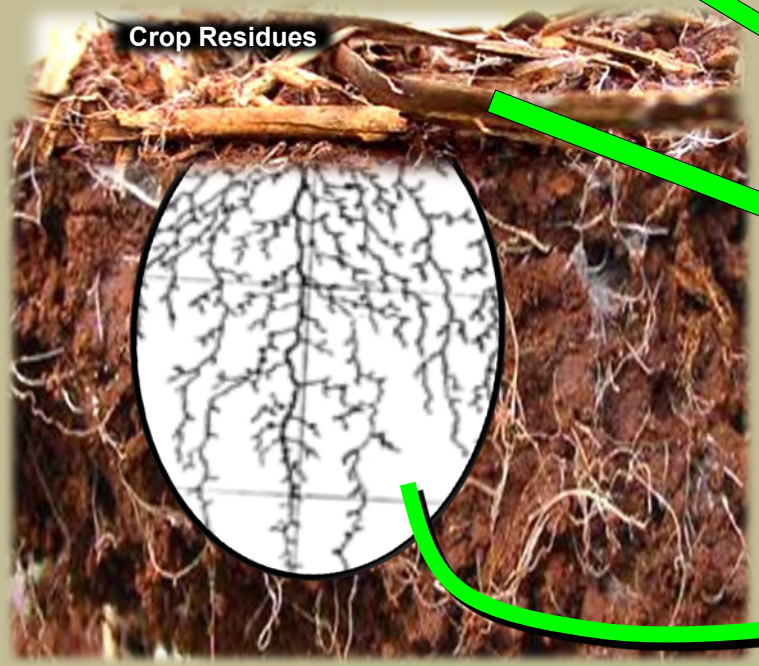
1) Healthy Roots: Produce large quantities of Root Exudates and Glomalin (produced by Mycorrhizal Fungi) &
2) And proper management of Crop Residues (above and below)

Readily Decomposable

Soil Food Web

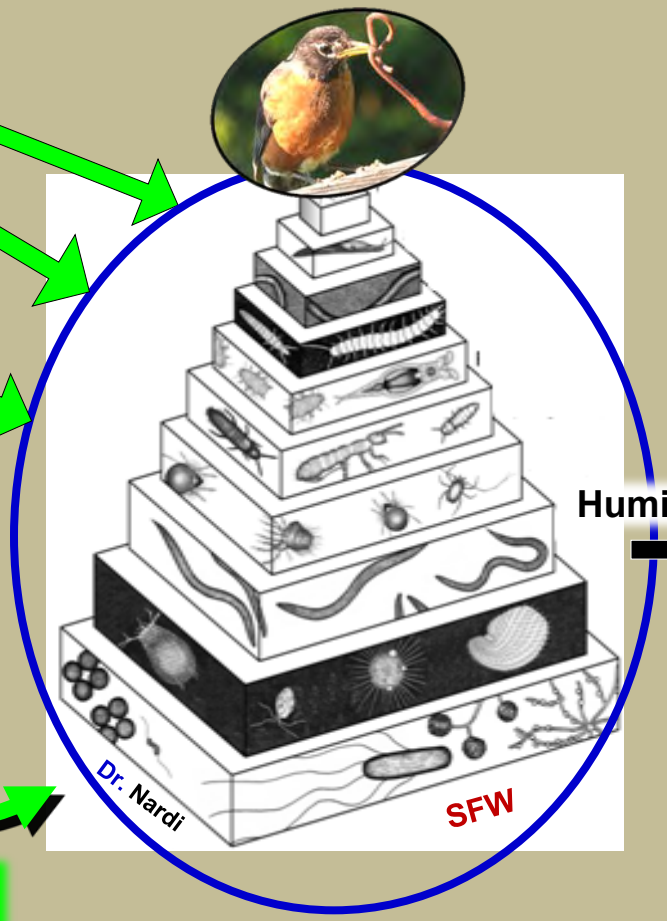
Every trophic level must function for the Soil Food Web (SFW) to function.

(Predator prey relationships)



Glomalin & Root Exudates

(Liquid Organic Carbon)



Humification

Soil Humus

<u>Humification</u>: the process involved in the decomposition of organic matter and leading to the formation of humus.

The difficulty of building SOM, is that about two-thirds of the readily decomposable organic matter returned to the soil is oxidized to CO_2.

Nutrient Cycling

<u>Mineralization:</u> the conversion of an element from an organic form to an inorganic state as a result of microbial decomposition.

<u>Immobilization</u>: the conversion of an element from the inorganic to the organic form in microbial tissues or in plant tissues.

The Difficulty of Building Soil Organic Matter

CO_2

60- 80 g

Oxidized

Organic residues:

100 grams

1 year after soil incorporation

3- 8 g

Biomass

(soil organisms)

3- 8 g

Nonhumic compounds

(polysaccharides, Polyuronides, acids. Etc (Active pool)

10- 30 g

Complex humic compounds

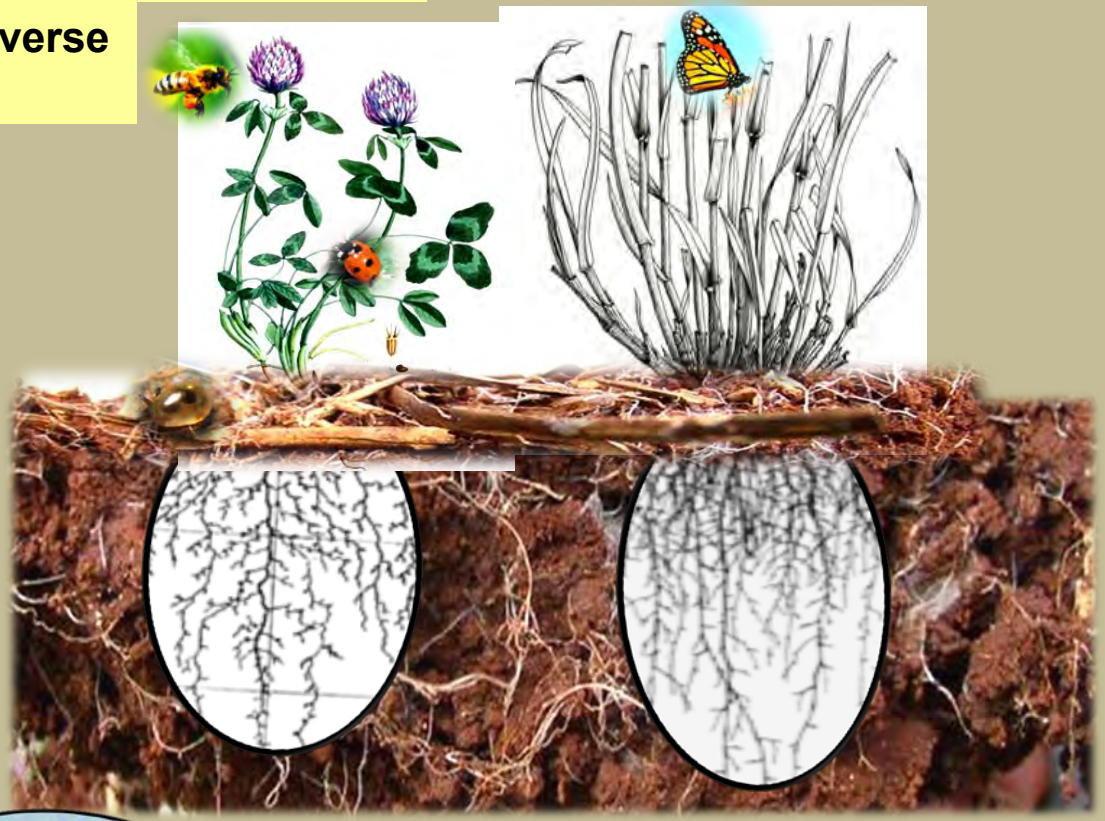
(Non-active pool)

Humus 15 -35 g

The Nature and Properties of Soils (13 Edition)

Building Soil Organic Matter (SOM)

To maintain a diverse Soil Food Web



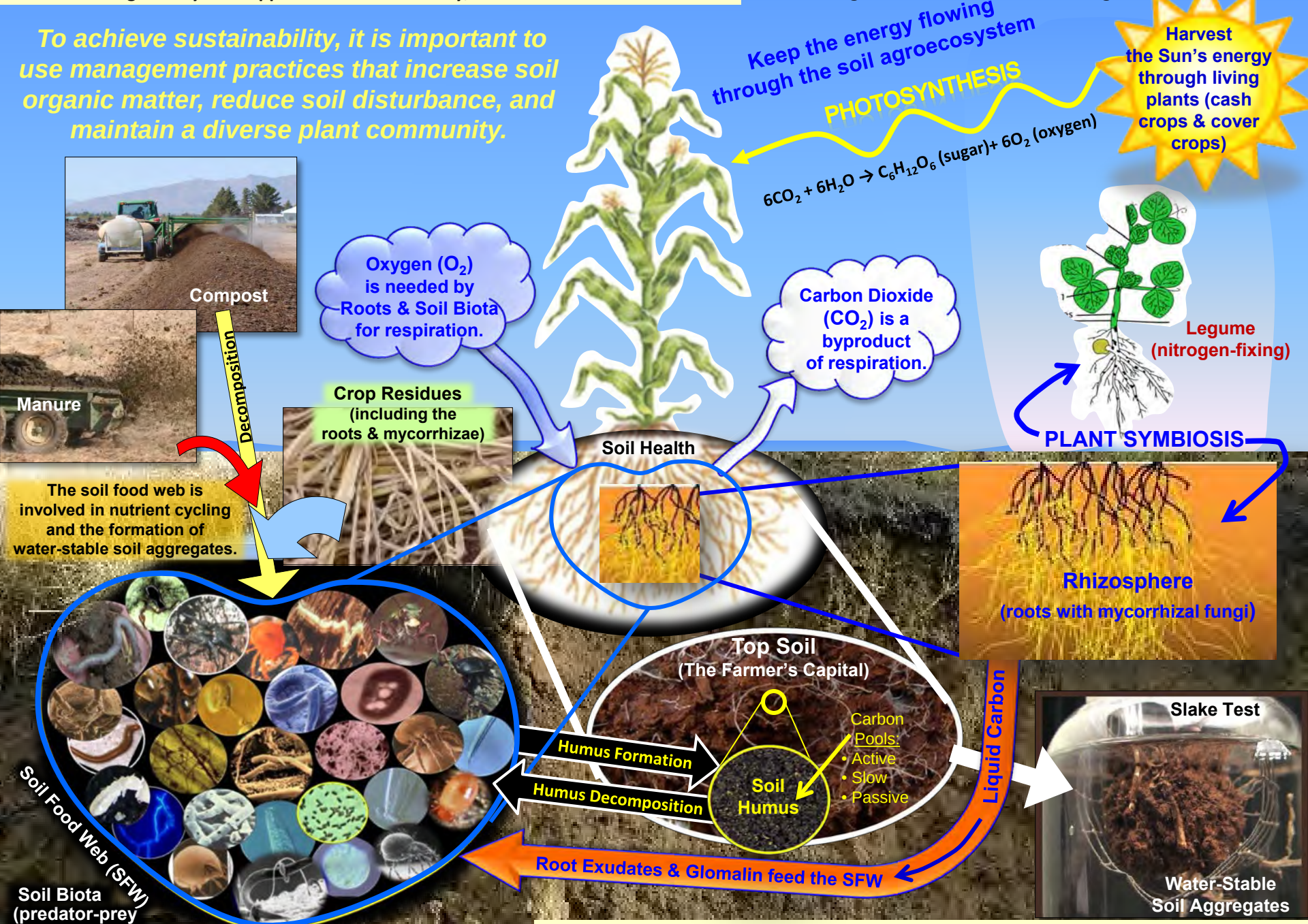
GOALS for Building Healthy Soil:

- Crop Diversity
- Living Roots throughout the year
- Cover the soil
- Less Soil disturbance
- Livestock integration where applicable

SOM Builds Healthy Soil

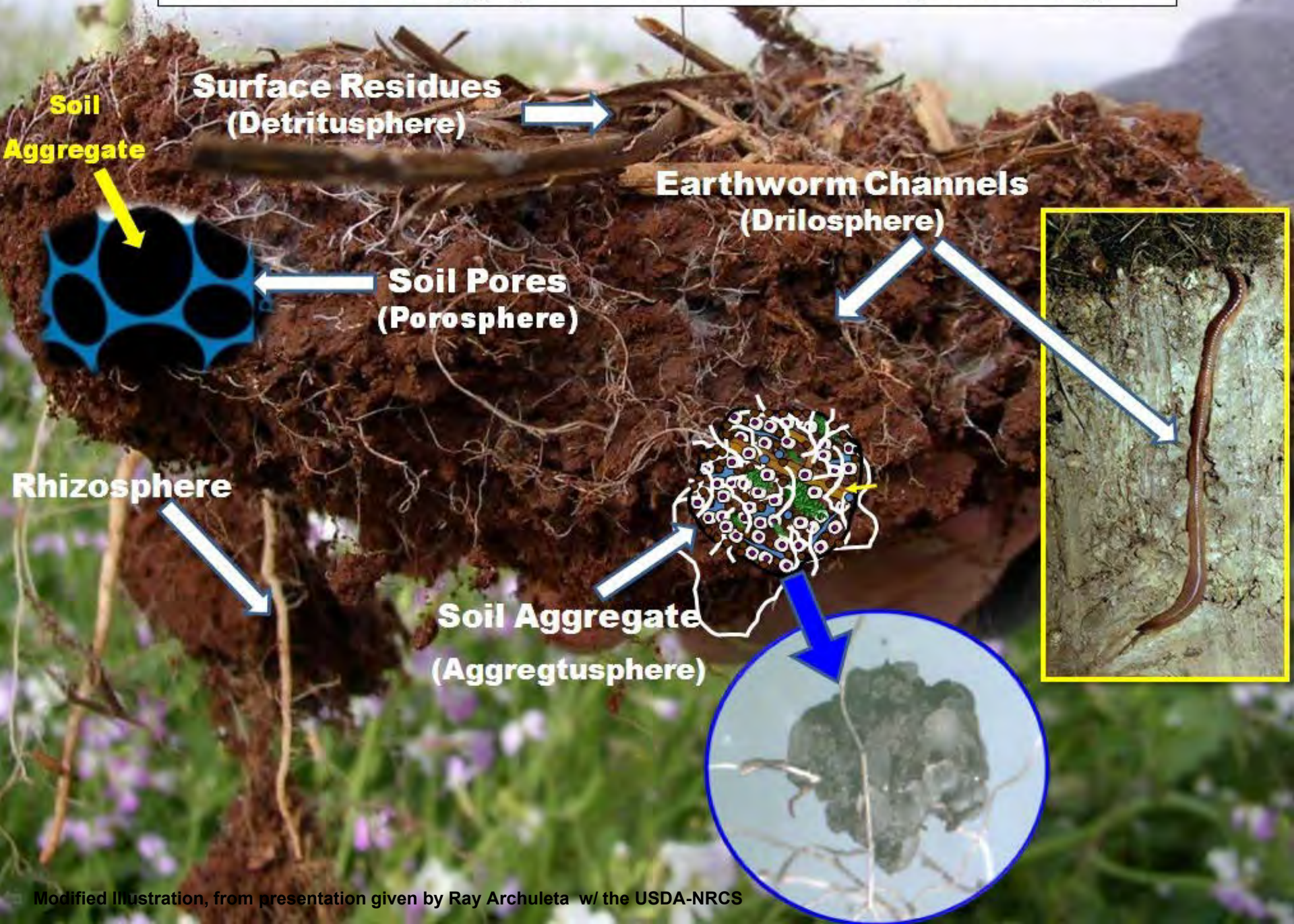
Water-Stable Soil Aggregates

Ref.: Soil Organic Matter in Sustainable Agriculture



Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

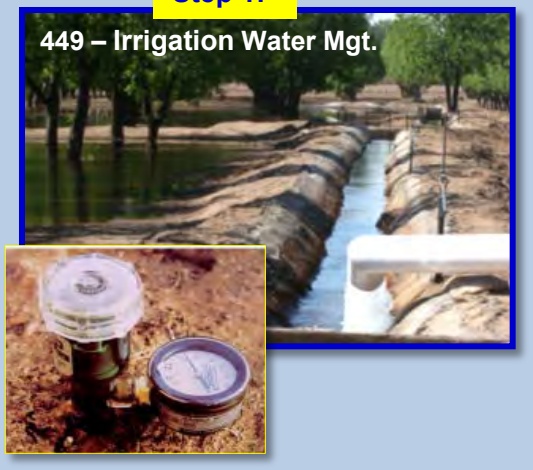
Water-Stable Soil Aggregates: Essential for a healthy functioning soil



Modified Illustration, from presentation given by Ray Archuleta w/ the USDA-NRCS

Plan, Design, Implement & Monitor/Adjust a Dynamic Soil Health Management System

Step 1:



Step 2:

Step 3:

Step 4:

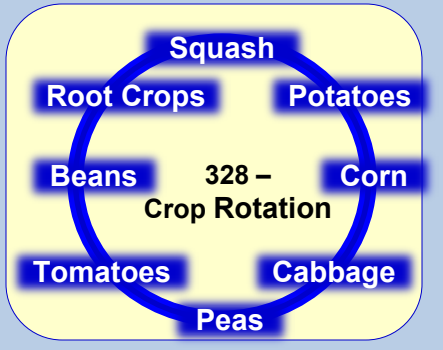
590 – Nutrient Mgt.
& Soil Health Assessment

Step 5:

340 – Cover Crop

Step 6:

Step 7:



Step 8:

AgSource Harris Laboratories
A Division of Cooperative Resources International

300 Speedway Circle, Suite 2
Lincoln, NE 68502

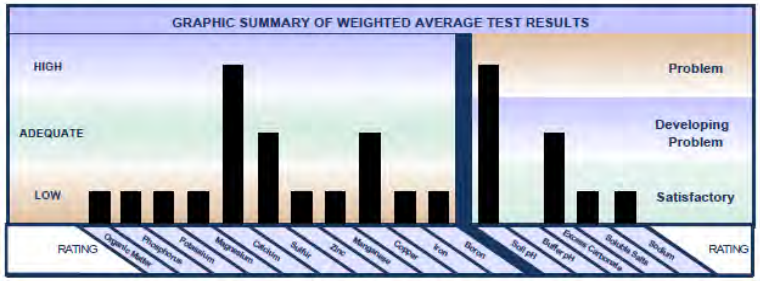
Tel: 402-476-0300
Fax: 402-476-0302

024123

Submitted By 7983610
Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
El Paso, TX 79927

Submitted For
TEXAS AGRILIFE

Date Reported	Laboratory Turnaround	Samples Will Be Stored Until	Laboratory Sample Number
09-Aug-2010	3 Days	21-Aug-2010	AC30486 - AC30491



SUMMARY OF SOIL FERTILITY AND PLANT NUTRIENT GUIDELINES

Sample Number	Crop Yield or Turf/Ornamental Code	Lime Gypsum Sulfur	PLANT FOOD NEED IN: Lbs/Acre N	P_2O_5	K_2O	MgO	S	Zn	Mn	Cu	Fe	B
KI 1E	Pecans 1000 LB	None 0	55.0	20.0	0	8.3	0	3.5	0	0	6.5	1.0
KI 2E	Pecans 1000 LB	None 0	55.0	20.0	10.0	14.0	0	3.8	0	0	6.3	1.0
KI 3E	Pecans 1000 LB	None 0	60.0	15.0	35.0	15.3	0	4.0	0	0	5.3	1.3
KI 1N	Pecans 1000 LB	None 0	45.0	20.0	0	0	0	1.0	0	0	0	0
KI 2N	Pecans 1000 LB	None 0	55.0	30.0	0	5.0	0	3.5	20.0	0	6.8	1.0
KI 3N	Pecans 1000 LB	None 0	60.0	30.0	65.0	13.8	0	4.3	0	0	5.8	1.3

Harris Laboratories
A Division of AgSource Cooperative Services

300 Speedway Circle, Suite 2
Lincoln, NE 68502

Tel: (402) 476-0300
Fax: (402) 476-0302

WATER ANALYSIS

Submitted For
TEXAS AGRILIFE

SAMPLE MARKED
RIO GRANDE RIVER

LABORATORY NUMBER
AC30689

DATE RECEIVED
06-Aug-2010

DATE REPORTED
09-Aug-2010

Submitted By
Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
PO Box 2
El Paso, TX 79927

ANALYSIS OF CHEMICAL PROPERTIES		YOUR RESULTS: UNIT OF MEASURE	RESULT	LBS/ ACRE FOOT	RATING OF YOUR RESULTS: SATISFACTORY	POSSIBLE PROBLEM	PROBABLE PROBLEM
WATER CHARACTERISTICS	pH	--	7.90	--			
	Hardness	--	180.80	--			
	Bicarbonate	ppm	176.88	477.86			
	Carbonate	ppm	2.40	6.53			
IMPACT ON GENERAL PLANT GROWTH	Electrical Conductivity (ECw)	mmhos/cm	0.81	--			
	Total Soluble Salts	ppm	518.40	1410.05			
IMPACT FROM ROOT CONTACT	Sodium	meq/l	2.37	--			
	Chloride	ppm	71.96	195.73			
	Boron	ppm	0.12	0.33			
IMPACT FROM FOLIAGE CONTACT	Sodium	ppm	54.41	148.00			
	Chloride	ppm	71.96	195.73			
IMPACT ON SOIL STRUCTURE	Sodium Absorption Ratio Adj	meq/l	3.28	--			
	Electrical Conductivity (ECw)	mmhos/cm	0.81	--			
	Total Soluble Salts	ppm	518.40	1410.05			

To maintain good soil structure in arid regions, irrigation water should have the capacity to replace the soluble salts being dissolved. If the salts being dissolved are not replaced, a decrease in permeability may occur.

No anticipated difficulty with most crops. | Some difficulty for sensitive & moderately sensitive crops. | Significant difficulty for most crops.

ANALYSIS OF NUTRIENTS

PLANT NUTRIENTS AS NORMALLY REPORTED IN WATER ANALYSIS	RESULTS AS PPM	NUTRIENTS CONVERTED TO BASIC FERTILIZER MATERIAL FORMS	RESULTS LB/ACRE FOOT	MEQ / LITER		
NITRATE (NO3-N)	1.12	NITROGEN (N)	3.06	CATIONS	K+	0.21
PHOSPHATE (PO4)	0.36	PHOSPHATE (P2O5)	0.73		Na+	2.37
POTASSIUM (K)	8.23	POTASH (K2O)	28.87		Ca++	2.72
MAGNESIUM (Mg)	18.44	MAGNESIUM OXIDE (MgO)	80.48		Mg++	1.12
CALCIUM (Ca)	54.32	CALCIUM (Ca)	147.75	ANIONS	Cl-	2.03
SULFATE (SO4)	136.23	SULFUR (S)	121.71		SO4--	2.82
MANGANESE (Mn)	0.02	MANGANESE (Mn)	0.06		HCO3-	2.88
IRON (Fe)	0.86	IRON (Fe)	2.31		CO3--	0.08
BORON (B)	0.12	BORON (B)	0.33		PO4---	0.0
					NO3-	0.08

Harris Laboratories
A Division of AgSource Cooperative Services

300 Speedway Circle, Suite 2
Lincoln, NE 68501

Tel: 402-476-0300
Fax: 402-476-0301

PLANT ANALYSIS

Submitted By:
Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
PO Box 2
El Paso, TX 79927

Submitted For:
TEXAS AGRILIFE

Plant Information Sheet No.
024140

Laboratory Sample No.
AC30644

Date Reported: 9-Aug-10
Sample Marked: KI 1L

Laboratory Turnaround: 3 Days
Crop: PECANS

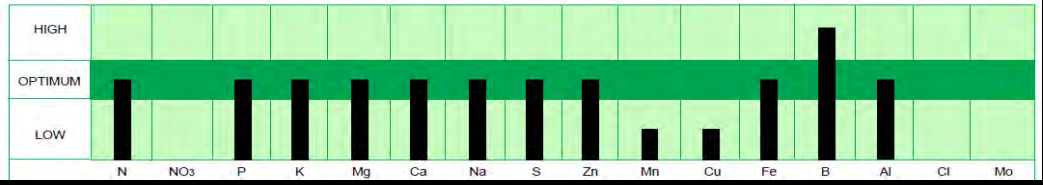
Samples Will Be Stored Until: 21-Aug-10
Plant Part: LEAF

Results of Laboratory Analysis

Laboratory Analysis	2.66		0.12	0.95	0.31	1.21	0.02	0.22	58.22	58.1	5.8	135.0	105.4	101.4		
	% Nitrogen	ppm Nitrate	% Phosphorus	% Potassium	% Magnesium	% Calcium	% Sodium	% Sulfur	ppm Zinc	ppm Manganese	ppm Copper	ppm Iron	ppm Boron	ppm Aluminum	ppm Chloride	ppm Molybdenum

Graphic Rating of Results Compared to Normal Ranges

Normal Ranges	2.49 to 2.8	to	0.11 to 0.3	0.74 to 1.25	0.29 to 0.6	0.89 to 1.5	0 to 0.1	0.19 to 0.4	49 to 100	99 to 800	9 to 30	49 to 300	29 to 45	0 to 2000	to	to



Soils, Water & Tissue Tests. Total Cost: $120 to $175

Select Plants adapted to your Climate (i.e., Temperature & Precipitation)

Net Irrigation Requirement = 48" for Pecans with mature cover

Know your water quality (Salinity, pH, SAR) & quantity (acre-feet/ac.) available

Harris Laboratories
A Division of AgSource Cooperative Services

300 Speedway Circle, Suite 2
Lincoln, NE 68502

Tel: (402) 476-0300
Fax: (402) 476-0302

WATER ANALYSIS

Submitted For
TEXAS AGRILIFE

Submitted By
Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
PO Box 2
El Paso, TX 79927

SAMPLE MARKED
RIO GRANDE RIVER

LABORATORY NUMBER
AC30689

DATE RECEIVED
06-Aug-2010

DATE REPORTED
09-Aug-2010

ANALYSIS OF CHEMICAL PROPERTIES

		YOUR RESULTS			RATING OF YOUR RESULTS
		UNIT OF MEASURE	RESULT	LBS/ ACRE FOOT	SATISFACTORY / POSSIBLE PROBLEM / PROBABLE PROBLEM
WATER CHARACTERISTICS	pH	--	7.90	--	
	Hardness	--	190.80	--	
	Bicarbonate	ppm	175.68	477.86	
	Carbonate	ppm	2.40	6.53	
IMPACT ON GENERAL PLANT GROWTH	Electrical Conductivity (ECw)	mmhos/cm	0.81	--	
	Total Soluble Salts	ppm	518.40	1410.05	
IMPACT FROM ROOT CONTACT	Sodium	meq/l	2.37	--	
	Chloride	ppm	71.86	195.73	
	Boron	ppm	0.12	0.33	
IMPACT FROM FOLIAGE CONTACT	Sodium	ppm	54.41	148.00	
	Chloride	ppm	71.86	195.73	
IMPACT ON SOIL STRUCTURE	Sodium Absorption Ratio Adj	meq/l	3.28	--	
	Electrical Conductivity (ECw)	mmhos/cm	0.81	--	
	Total Soluble Salts	ppm	518.40	1410.05	

To maintain good soil structure in arid regions, irrigation water should have the capacity to replace the soluble salts being dissolved. If the salts being dissolved are not replaced, a decrease in permeability may occur.

No anticipated difficulty with most crops. | Some difficulty for sensitive & moderately sensitive crops. | Significant difficulty for most crops.

ANALYSIS OF NUTRIENTS

PLANT NUTRIENTS AS NORMALLY REPORTED IN WATER ANALYSIS	RESULTS AS PPM	NUTRIENTS CONVERTED TO BASIC FERTILIZER MATERIAL FORMS	RESULTS LB/ACRE FOOT
NITRATE (NO_3-N)	1.12	NITROGEN (N)	3.06
PHOSPHATE (PO_4)	0.38	PHOSPHATE (P_2O_5)	0.73
POTASSIUM (K)	8.23	POTASH (K_2O)	28.87
MAGNESIUM (Mg)	13.44	MAGNESIUM OXIDE (MgO)	80.48
CALCIUM (Ca)	54.32	CALCIUM (Ca)	147.75
SULFATE (SO_4)	136.23	SULFUR (S)	121.71
MANGANESE (Mn)	0.02	MANGANESE (Mn)	0.06
IRON (Fe)	0.86	IRON (Fe)	2.31
BORON (B)	0.12	BORON (B)	0.33

MEQ / LITER		
CATIONS	K^+	0.21
	Na^+	2.37
	Ca^{++}	2.72
	Mg^{++}	1.12
ANIONS	Cl^-	2.03
	SO_4^{--}	2.82
	HCO_3^-	2.88
	CO_3^{--}	0.08
	PO_4^{---}	0.0
	NO_3^-	0.08

SOLUBLE SALTS

(Irrigation Water Quality example)

Dominant Cations (Ions with a positive charge)

Calcium	Ca^{++}	80 ppm
Sodium	Na^{+}	115 ppm
Magnesium	Mg^{++}	14 ppm
Potassium	K^{+}	8 ppm

Dominant Anions (Ions with a negative charge)

Sulfate	$SO4^{--}$	192 ppm
Chloride	Cl^{-}	92 ppm
Bicarbonate	$HCO3^{-}$	183 ppm
Carbonate	$CO3^{--}$	6 ppm

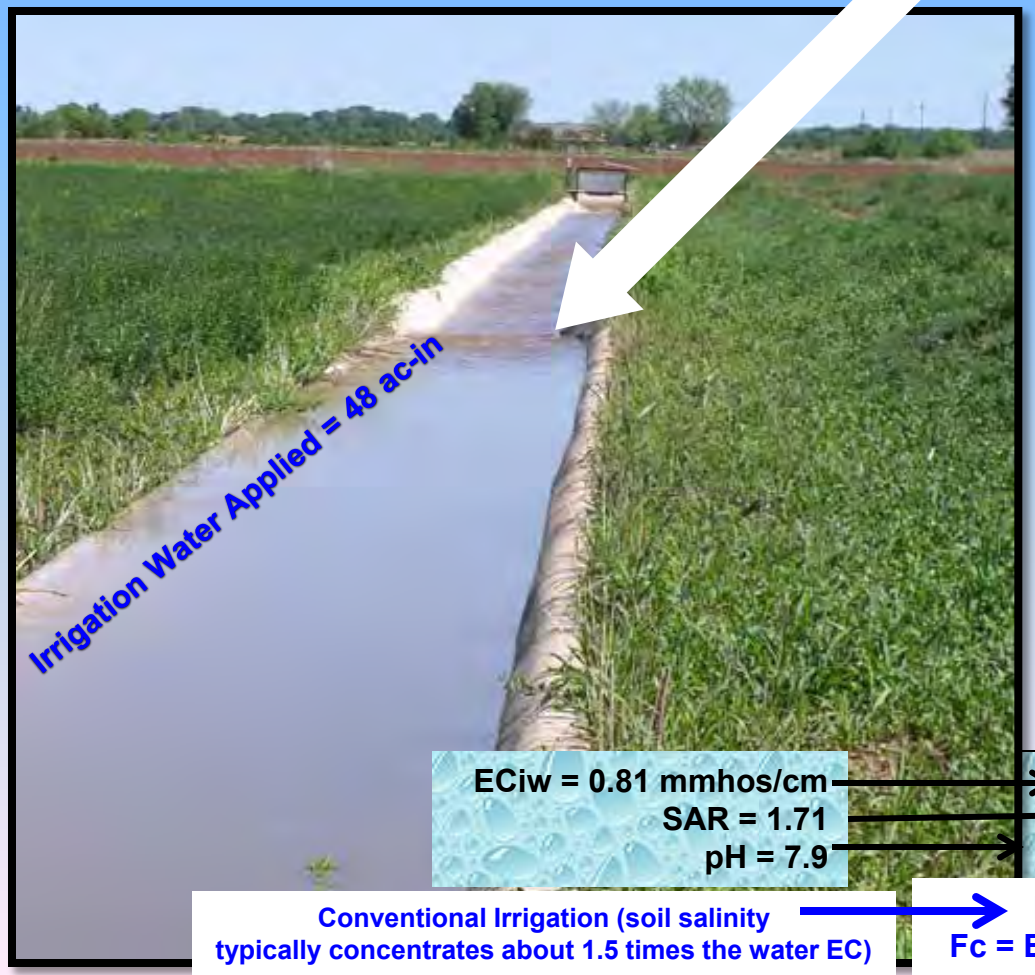
Total ppm: 217 ppm (cations) + 473 ppm (anions) = 690 ppm = 690 mg/l (Soluble Salts)

TDS (ppm) = EC (dS/m) x 640, for EC between 0.1 and 5.0 dS/m
TDS (ppm) = EC (dS/m) x 800, for EC > 5.0 dS/m

- TDS = Total Dissolved Solids
- ppm = parts per million; mg/l = milligrams/liter (ppm = mg/l)
- EC = Electrical Conductivity

690 ÷ 640 ≈ 1.08 dS/m (EC)
(dS/m = mmhos/cm = mS/cm)
dS/m = deciSiemens/meter
mmhos/cm =milliMhos/centimeter
mS/cm = milliSiemens/centimeter
2.72 x ppm = lbs. of salts/ac-ft
(2.72 x 690 ppm = 1,877 lbs/ac-ft)

Irrigation Water Analysis for Pecan



Water Quality Analysis
Pounds per Acre:

- Nitrate-N = 12.2
- Potassium = 89.5
- Sulfate-S = 490.0
- Calcium = 591.0
- Magnesium = 146.2
- Sodium = 592.0
- Chloride = 783.0
- Bicarbonate = 1,911.4
- Carbonate = 26.1
- Iron = 9.3
- Mn = 0.22
- B = 1.31

Total Salts = 5,640.2

ECiw = 0.81 mmhos/cm
SAR = 1.71
pH = 7.9

ECe = 0.36 mmhos/cm (No problem with Salts)
Sodium is 2.6% of total CEC (Satisfactory)
pH = 8.7 (Problem with pH; i.e. nutrient availability)

Conventional Irrigation (soil salinity typically concentrates about 1.5 times the water EC)

Leaching Fraction (LF) = $0.3086/Fc^{1.702}$ (LF = 7.2%)
Fc = ECe(ct)/ECiw (i.e., ECe(ct) = 1.9 & ECiw = 0.81); Fc = 2.35

4	Nutrients ON = Organic Nitrogen mineralized	Irrigation Water Analysis (ppm x 0.227 x 48" = lb./ac.) ppm or mg/l	Pounds per Acre	Soil Analysis 0-6" depth Bulk Density = 1.4 g/cm³ ppm x 1.90 = lb/ac (6" depth) ppm or mg/Kg	Low Adequate High	Nutrient Inputs (recommendations) Lbs./ac. (based on 1000 lb./ac. yield)	Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur % or ppm & Rating (Low - High) O = Optimum	Sufficiency Range (leaf: midshoot leaflets)	Should I Apply Nutrients? - Yes (Y) No (N) - Maintenance (M) - Not Sure (?) - Other (O)	Conservation Practices to consider for achieving sustainability
5	Organic Matter									
6	N mineralized									
7	Nitrate-Nitrogen	1.12	12.2							
8	Phosphorus									
9	Potassium	8.23	89.5							
10	Sulfate-Sulfur	45.03	490.0							
11	Calcium	54.32	591.0							
12	Magnesium	13.44	146.2							
13	Zinc									
14	Iron	0.85	9.3							
15	Manganese	0.02	0.22							
16	Copper									
17	Boron	0.12	1.31							
18	Molybdenum									
19	Sodium	54.41	592.0							
20	Chloride	71.96	783.0							
21	Bicarbonate	175.68	1,911.4							
22	Carbonate	2.40	26.1							

Calculations and Conversions: (48 ac-in of irrigation water applied/ac/yr)

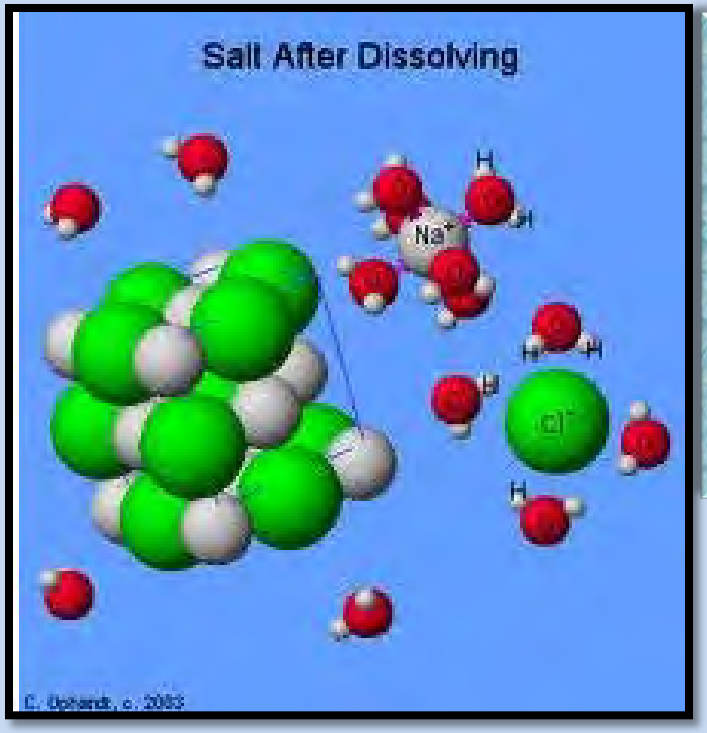
Water = 1.0 g/cm³
Cubic Foot = 28,316.85 cm³
28,316.85 g of Water/Cubic Foot
28,316.85 g x 1.0 lb./454.0 g = 62.37 lbs. of Water/ft³
62.37 lbs./ft³ x 43,560 ft3 = 2,716,837.2 lbs./ac-ft
2,716,837.2 ≈ 2.72 million lbs. of water/ac-ft
1.0"/12.0" = 0.0833
0.0833 x 2.72 = 0.227 (≈ 227,000 lbs. of Water/ac-in)
Example: Calcium54.32 ppm x 0.227 x 48" = 591.87 lbs.
Example: Calcium 54.32 ppm x 2.72 x 4' = 591.0 lbs.

ppm = mg/l
TDS (ppm) = EC (mmhos/cm) x 640,
for EC between 0.1 and 5.0 mmhos/cm
Example: 0.81 mmhos/cm x 640 = 518.4 mg/l

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

- Electrical Conductivity of Irrigation Water (ECiw) = 0.81mmhos/cm
- Sodium Adsorption Ratio (SAR) from water test = 1.71 & pH = 7.9
- Irrigation Water Quality infiltration assessment (degree of restriction on use is none). Total Dissolved Solids = 518.40 mg/l
- Soluble salts applied = 5,640.2 lb./ac./yr.
- Soluble Salts = 0.36 mmhos/cm (Satisfactory)
- Soil pH = 8.7 (Problem. e.g., nutrient availability)
- Sodium is 2.6% of Total Cation Exchange Capacity (Satisfactory)
- Refer to Crop Salt Tolerance Table (Section 2) to evaluate for potential yield reduction (No yield reductions due to existing salinity levels)

Irrigation water quality guidelines				
Potential irrigation water quality problem	Parameter	Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity (affects crop water availability)	ECiw (mmho/cm)	< 0.7	0.7 – 3.0	>3.0
	or TDS (mg/l)	< 450	450 – 2,000	> 2,000
Infiltration (affects water infiltration rate, evaluated by using ECiw and SAR together)	SAR	ECiw (mmho/cm)		
	0 – 3	> 0.7	0.7 – 0.2	< 0.2
	3 – 6	> 1.2	1.2 – 0.3	< 0.3
	6 – 12	> 1.9	1.9 – 0.5	< 0.5
	12 - 20	> 2.9	2.9 – 1.3	< 1.3
	20 - 40	> 5.0	5.0 – 2.9	< 2.9
Specific ion toxicity (affects sensitive crops)				
(Na^+) surface irrigation	SARadj	< 3	3 - 9	> 9
sprinkler irrigation	meq/l	< 3	> 3	
(Cl^-) surface irrigation	meq/l	< 4	4 – 10	> 10
sprinkler irrigation	meq/l	< 3	> 3	
Boron (B)	ppm/l	< 0.7	0.7 – 3.0	> 3.0
(HCO_3^-) Bicarbonate (overhead sprinkler only)	meq/l	< 1.5	1.5 – 8.5	> 8.5



Dominant Soluble Ions:

Calcium (Ca_2^{++})
Magnesium (Mg_2^{++})
Sodium (Na^+)
Potassium (K^+)
Chloride (Cl^-)
Sulfate (SO_4^{--})
Bicarbonate (HCO_3^-)

Excessive Soluble Salts

EC (TDS) pocket meter

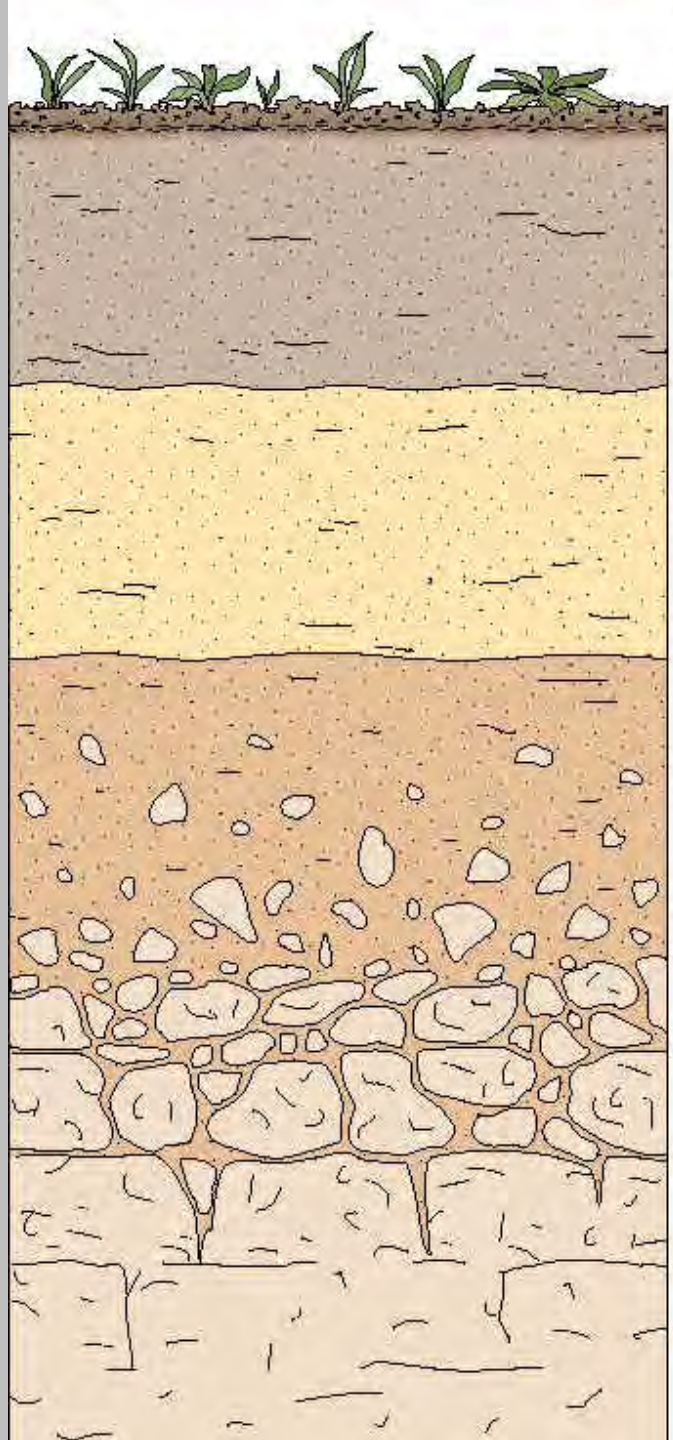
Osmotic potential, bars ≈ -0.36 (EC)

Where,
EC = the electrical conductivity of the soil water (dS/m)
-0.36 = the constant that relates EC to osmotic potential in bars. The negative factor indicates that osmotic pressure exerts a suction force on the root.
(ASCE, 1996 and USDA Handbook 60)

Crop (name)	Yield loss 0%		Yield loss 10%		Yield loss 25%		Yield loss 50%		Maximum
	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[3]
Alfalfa	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	15.5
Almond	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.7	7.0
Apple	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Apricot	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	6.0
Barley	8.0	5.3	10.0	6.7	13.0	8.7	18.0	12.0	28.0
Beans	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.5
Beets	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15.0
Bermuda Grass	6.9	4.6	8.5	5.7	10.8	7.2	14.7	9.8	22.5
Blackberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Boysenberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Broccoli	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	13.5
Cabbage	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12.0
Cantaloupe	2.2	1.5	3.6	2.4	5.7	3.8	9.1	6.1	16.0
Carrot	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.1	8.0
Clover	1.5	1,0	2.3	1.6	3.6	2.4	5.7	3.8	10.0
Corn, Grain & Silage	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Corn Silage	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15.5
Corn, Sweet	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Cotton	7.7	5.1	9.6	6.4	13.0	8.4	17.0	12.0	27.0
Cucumber	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10.0
Fescue, Tall	3.9	2.6	5.8	3.9	8.6	5.7	13.3	8.9	23.0
Grape	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12.0
Lettuce	1.3	0.9	2.1	1.4	3.2	2.1	5.2	3.4	9.0
Love Grass	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14.0
Meadow Foxtail	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.6	12.0
Onion	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.5
Orchard Grass	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	17.5
Peach	1.7	1.0	2.2	1.4	2.9	1.9	4.1	2.7	6.5
Pear	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Pecan[4]	1.9	1.3**	2.4*	1.6**	3.2*	2.4**	4.6	3.0**	8.0*
Pepper	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.5

Dr. Jamie Iglesias, with Texas Agrilife Center, discussing soil profile characteristics, drainage, water & salinity management, and water table.

Measure the Depth of Soil



Soil horizons

O Humus

A Zone of leaching of soluble salts (topsoil)

B Zone of accumulation of salts (subsoil)

C Weathered parent material (bedrock)

Gradational contact

Fresh parent material (bedrock)

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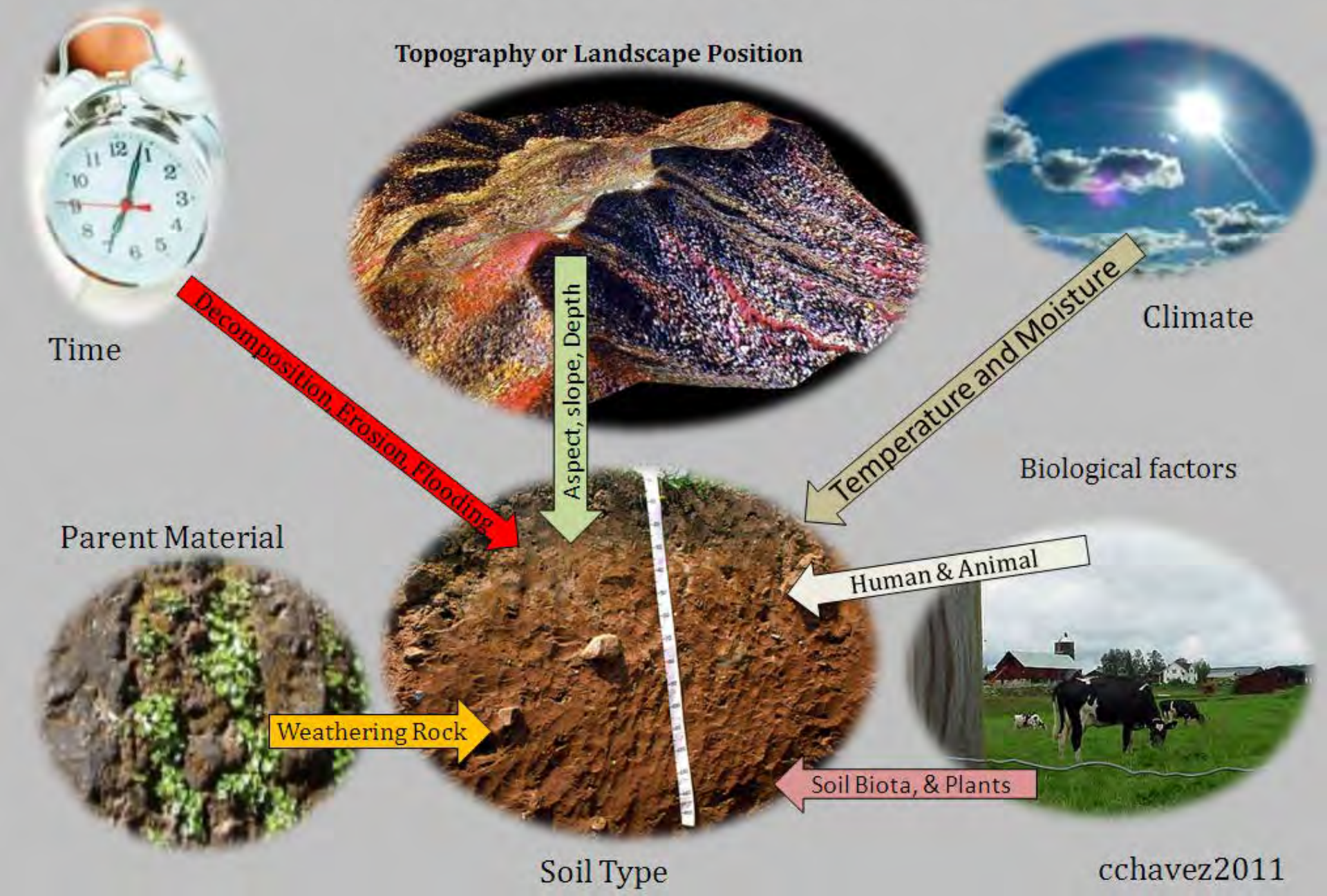
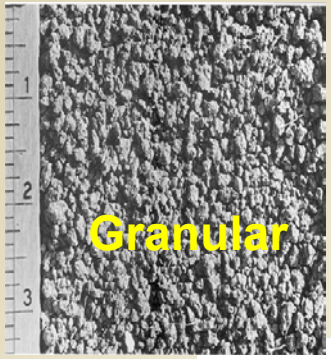
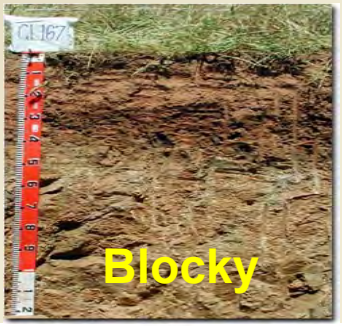
0” – 10 Very Shallow
10” – 20” Shallow
20” - 40” Mod Deep
40” - 60” Deep
>60 “ Very Deep

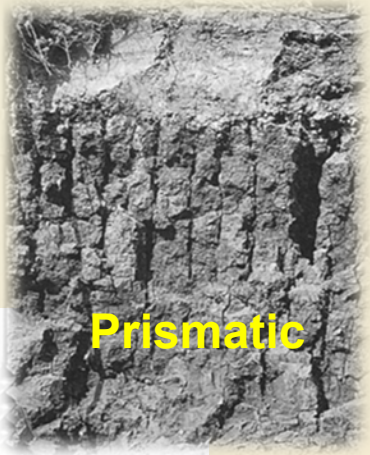
5 - Soil Forming Factors

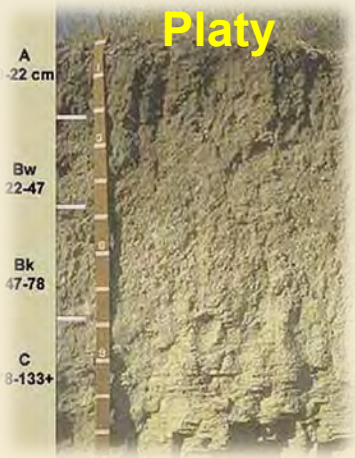


Know Your Soils and their Productivity Potential

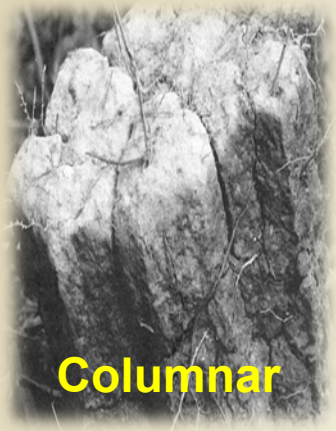


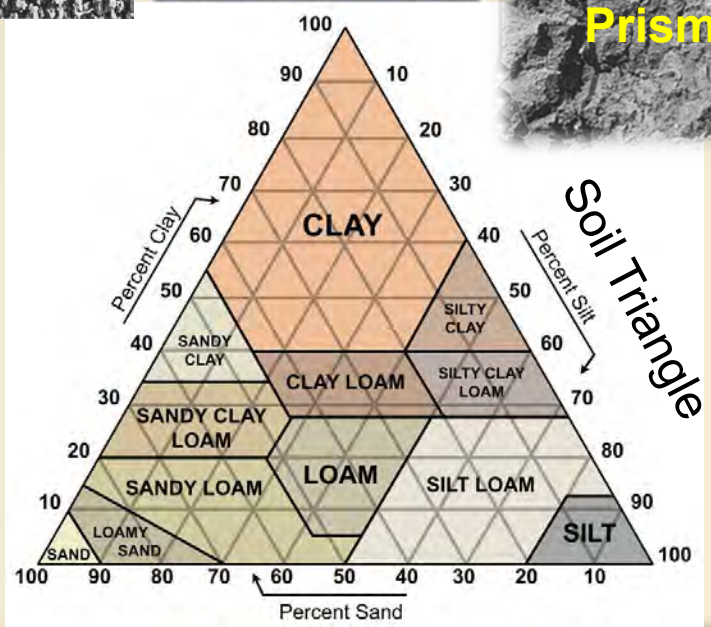




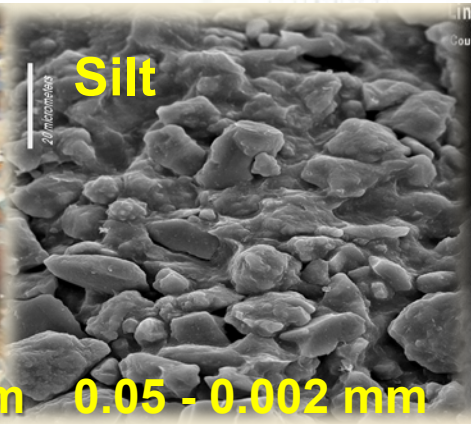


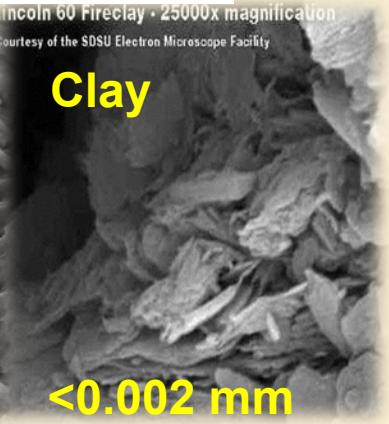
Soil Structure





Soil Particles



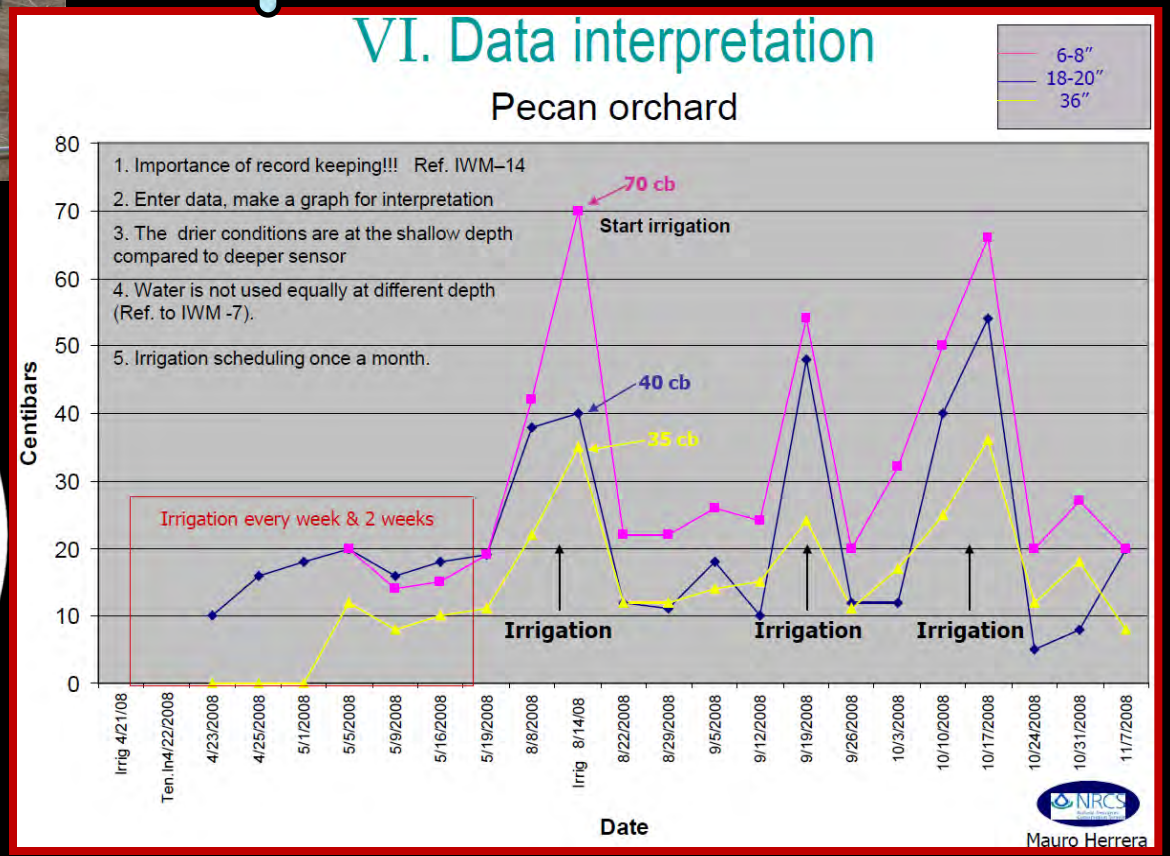


Soil Texture	% Sand	% Silt	% Clay	CEC Range (meq/100g)	Bulk Density (g/cm³)	Soil weight (Million lbs. per ac-ft)	Soil Solids		Unavail-able Water		Available Water	
							% Vol.	in/ft	% Vol.	in/ft	% Vol.	in/ft
Sands	86 - 98	2 - 14	2 - 8	2 – 6	1.65	4.48	62.3	7.47	2.5	0.3	4.17	0.5
Loamy Sands	72 - 88	2 - 28	2 - 14		1.6	4.35	60.4	7.25	7.0	0.84	8.33	1.0
Fine Sands	86 - 98	2 - 14	2 - 8		1.65	4.48	61.5	7.38	10.2	1.22	10.4	1.25
V. F. Sands	86 - 98	2 - 14	2 - 8		1.65	4.48						
Loamy F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35						
Loamy V. F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35						
Sandy Loam	46 - 84	2 - 48	2- 18	3 – 8	1.56	4.24	58.8	7.06	12.3	1.48	12.5	1.5
Fine Sandy Loam	46 - 84	2 - 48	2 - 18		1.56	4.24						
V. F. Sandy Loam	46 - 84	2 - 48	2 - 18		1.53	4.16	55.4	6.65	16.2	1.94	16.7	2.0
Loam	26 - 50	30 - 48	10 - 26	7 – 15	1.42	3.86						
Silt Loam	2 - 48	52 - 78	2 - 26	10 –19	1.46	3.97						
Silt	2 - 18	82 - 98	2 - 10		1.47	3.99						
Sandy Clay Loam	46 - 78	2 - 26	22 - 36		1.4	3.8	50.2	6.02	20.0	2.4	18.3	2.2
Silty Clay Loam	2 - 18	42 - 70	28 - 38		1.27	3.45						
Clay Loam	22- 44	18 - 50	28 - 38		1.32	3.59						
Sandy Clay	46 - 62	2 - 16	38 - 54		1.33	3.61	47.9	5.75	21.5	2.58	16.7	2.0
Silty Clay	2 - 18	42 - 58	42 - 58		1.23	3.34						
Clay	2 - 44	2 - 38	42 - 98	15 - 30	1.25	3.4						

IRRIGATION WATER MGT.

IRRIGATION WATER MGT.

NOTE: Lower soil temperatures provide an optimal environment for soil biota and crop roots (i.e. increased nutrient cycling and water use efficiency)



464 – Irrigation Land Leveling

Head Gate

ACEQUIA

Surface Drip Irrigation

High Flow Turnout

Laser Leveled Field
(Uniform water distribution)

Gated Aluminum Pipe

Irrigation Pipe

SIPHON TUBES

Concrete Lined Ditch

Irrigation Pipe and Valves

High Flow Turnouts

Center Pivot

Subsurface Drip Irrigation

Surface Drip Irrigation

Micro Sprinkler Irrigation

Side Roll

Concrete Lined Ditch

Aluminum Gated Pipe

Use <↑>, <↓> arrow, <Pg up>, <Pg dn> keys to move in window

GRADED BORDER ANALYSIS

Date: 07/17/09

Job name: Alfalfa field irrigated with Hi-Flow Turnout

Location: Los Lunas

By: Conservation Planner

Office: Los Lunas, NM

Roughness coefficient (n) = 0.150

Slope (S) = 0.0001 ft/ft

Net application (Fn) = 2.00 inches

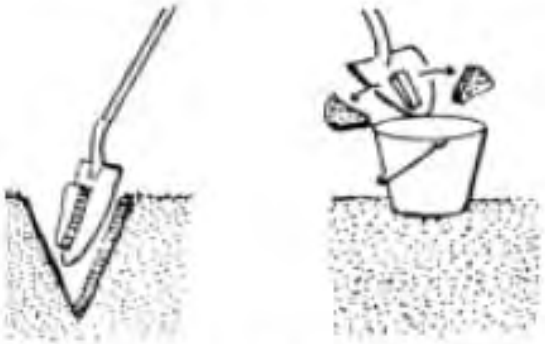
Flow per border (Q) = 7.00 cfs

Intake family (If) = 0.30

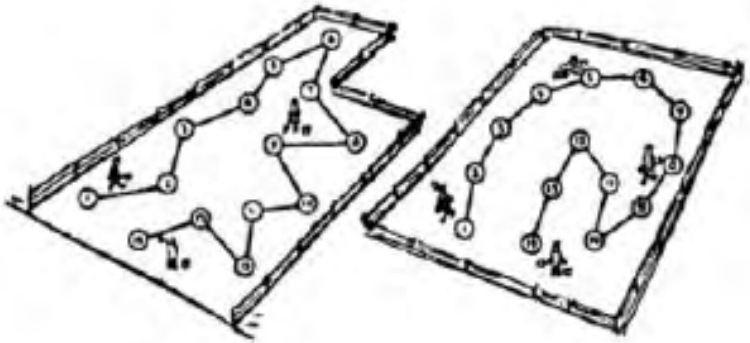
Border width (W) = 375 ft

Border length (L) = 650 ft

Inflow Time	Unit Flow (cfs/ft)	Gross Application (in)	Deep Percolation (in)	Runoff (in)	Application Efficiency (percent)
1 hr, 0 min	Application depth is less than 80% of net requirements				
1 hr,30 min	Application depth is less than 80% of net requirements				
2 hr, 0 min	**0.019**	**2.48**	**0.00**	**0.68**	**72.6**
2 hr,30 min	0.019	3.10	0.09	1.02	64.5
3 hr, 0 min	0.019	3.72	0.30	1.43	53.7



All tools and containers free from rust!



Be representative! Mix well.

Air dry 2 cups (no rocks)!

COLLECT 15-20 SOIL SUBSAMPLES PER FIELD

AgSource
Harris Laboratories
A Division of Cooperative Resources International

300 Speedway Circle, Suite 2
Lincoln, NE 68502

Tel: 402-476-0300
Fax: 402-476-0302

024123

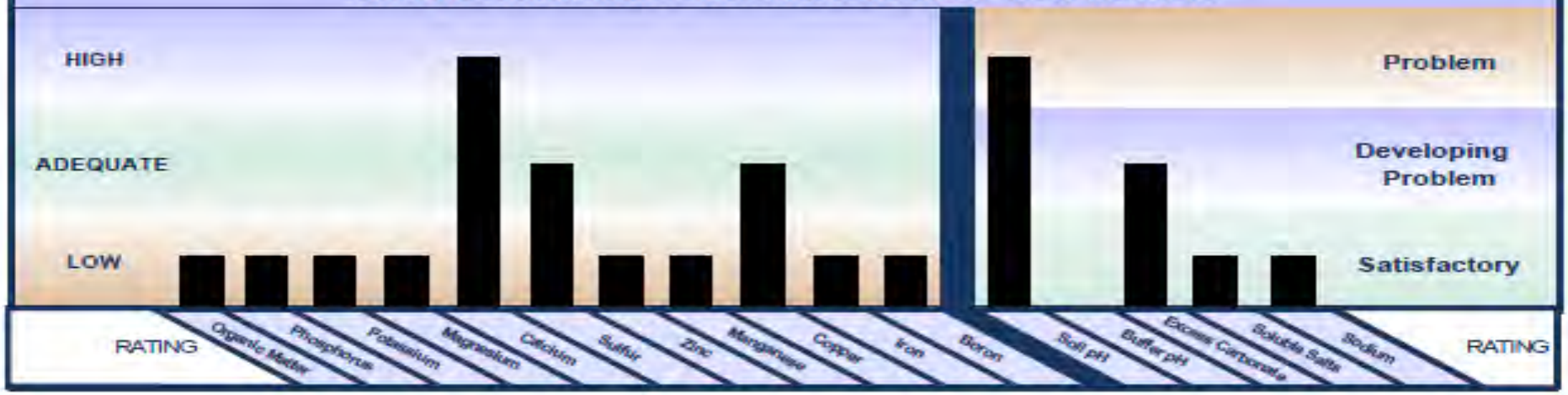
Submitted By 7983610
Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
El Paso, TX 79927

Submitted For
TEXAS AGRILIFE

SOILS TEST RESULTS

Date Reported	Laboratory Turnaround	Samples Will Be Stored Until	Laboratory Sample Number
09-Aug-2010	3 Days	21-Aug-2010	AC30486 - AC30491

GRAPHIC SUMMARY OF WEIGHTED AVERAGE TEST RESULTS



SUMMARY OF SOIL FERTILITY AND PLANT NUTRIENT GUIDELINES

Sample Number	Crop Yield or Turf/Ornamental Code	Lime Gypsum Sulfur	PLANT FOOD NEED IN: Lbs/Acre N	P_2O_5	K_2O	MgO	S	Zn	Mn	Cu	Fe	B
KI 1E	Pecans 1000 LB	None 0	55.0	20.0	0	8.3	0	3.5	0	0	6.5	1.0
KI 2E	Pecans 1000 LB	None 0	55.0	20.0	10.0	14.0	0	3.8	0	0	6.3	1.0
KI 3E	Pecans 1000 LB	None 0	60.0	15.0	35.0	15.3	0	4.0	0	0	5.3	1.3
KI 1N	Pecans 1000 LB	None 0	45.0	20.0	0	0	0	1.0	0	0	0	0
KI 2N	Pecans 1000 LB	None 0	55.0	30.0	0	5.0	0	3.5	20.0	0	6.8	1.0
KI 3N	Pecans 1000 LB	None 0	60.0	30.0	65.0	13.8	0	4.3	0	0	5.8	1.3

4	Nutrients ON = Organic Nitrogen mineralized	Irrigation Water Analysis (ppm x 0.227 x 48" = lb./ac.)		Soil Analysis 0-6" depth Bulk Density = 1.4 g/cm³ ppm x 1.90 = lb/ac (6" depth)		Nutrient Inputs (recommendations)	Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur		Should I Apply Nutrients? - Yes (Y) No (N) - Maintenance (M)	Conservation Practices to consider for achieving sustainability
		ppm or mg/l	Pounds per Acre	ppm or mg/Kg	Low Adequate High	Lbs./ac. (based on	% or ppm & Rating	Sufficiency Range		
5	Organic Matter			0.6%	11,400 Low					
6	N mineralized			ON	12.0 Low					
7	Nitrate-Nitrogen			4.5	8.55 lbs./ac					
8	Phosphorus			5.0	Low					
9	Potassium			122.0	Low					
10	Sulfate-Sulfur			20.7	Adequate					
11	Calcium			2,948.0	High					
12	Magnesium			187.0	Low					
13	Zinc			0.4	low					
14	Iron			4.6	low					
15	Manganese			4.2	low					
16	Copper			0.6	adequate					
17	Boron			0.4	low					
18	Molybdenum									
19	Sodium				use SAR					
20	Chloride									
21	Bicarbonate									
22	Carbonate									

Calculations and Conversions(ppm = mg/kg):

Soil Bulk Density of 1.472g/cm³ ≈ 4,000,000 lbs./ac-ft

Cubic Foot = 28,316.85 cm³

28,316.85 cm³ x 1.472g/cm³ = 41,682.4 g of soil/ft³

41,682.4 g x 1.0 lb./454 g = 91.81 lbs. of soil/ft³

91.81 lbs. of soil/ft³ x 43,560 ft³ ≈ 4,000,000.0 lbs./ac-ft

≈ 4,000,000 lbs. of Soil (dry weight)/ac-ft

4,000,000 (conversion factor is 4.0)

Example: Nitrate-Nitrogen 4.5 ppm x 4.0 = 18.0 lbs. of Nitrate-Nitrogen/ac-ft

Example: Nitrate-Nitrogen 4.5 ppm x 2.0 = 9.0 lbs. of Nitrate-Nitrogen/ac (6" depth)

Example: 4,000,000 lbs. of Soil x 0.012 (1.2% Organic Matter) = 48,000 lbs. Organic Matter/ac-ft

48,000 lbs. Organic Matter x 0.05 (5% is Organic N) = 2,400 lbs. of Organic N.

2,400 lbs. of Organic N x 0.025 (about 2.5% is mineralized/yr.) = 60 lbs. of N mineralized/ac/yr

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

- Soluble Salts = 0.36 mmhos/cm (Satisfactory)
- Soil pH = 8.7 (Problem. e.g., nutrient availability)
- Sodium is 2.6% of Total Cation Exchange Capacity (Satisfactory)
- Refer to Crop Salt Tolerance Table (Section 2) to evaluate for potential yield reduction (No yield reductions due to existing salinity levels)

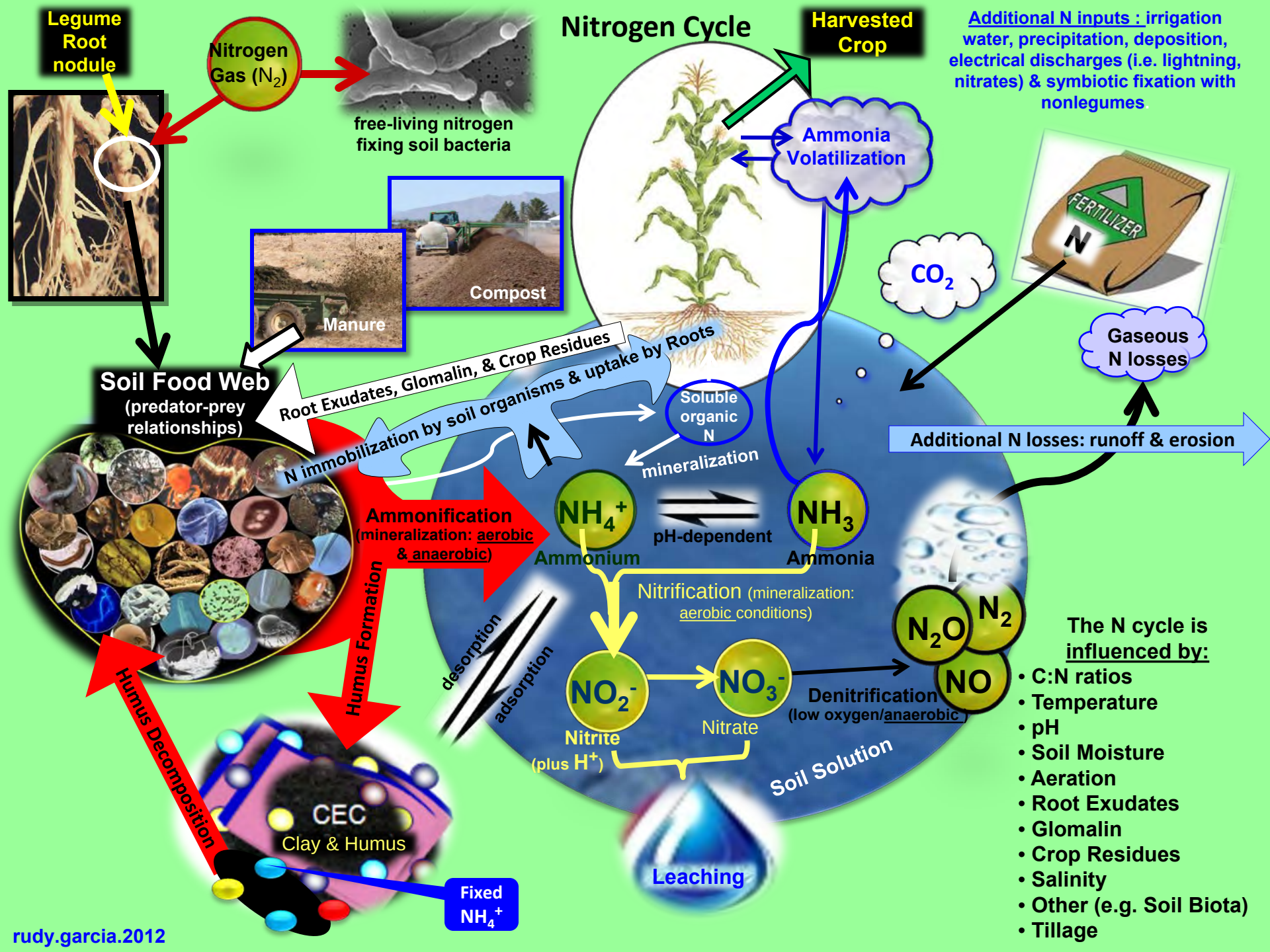
Soil Analysis for Pecan

Yield is about 2,300 lbs./ac. for mature yields

Soil Analysis:

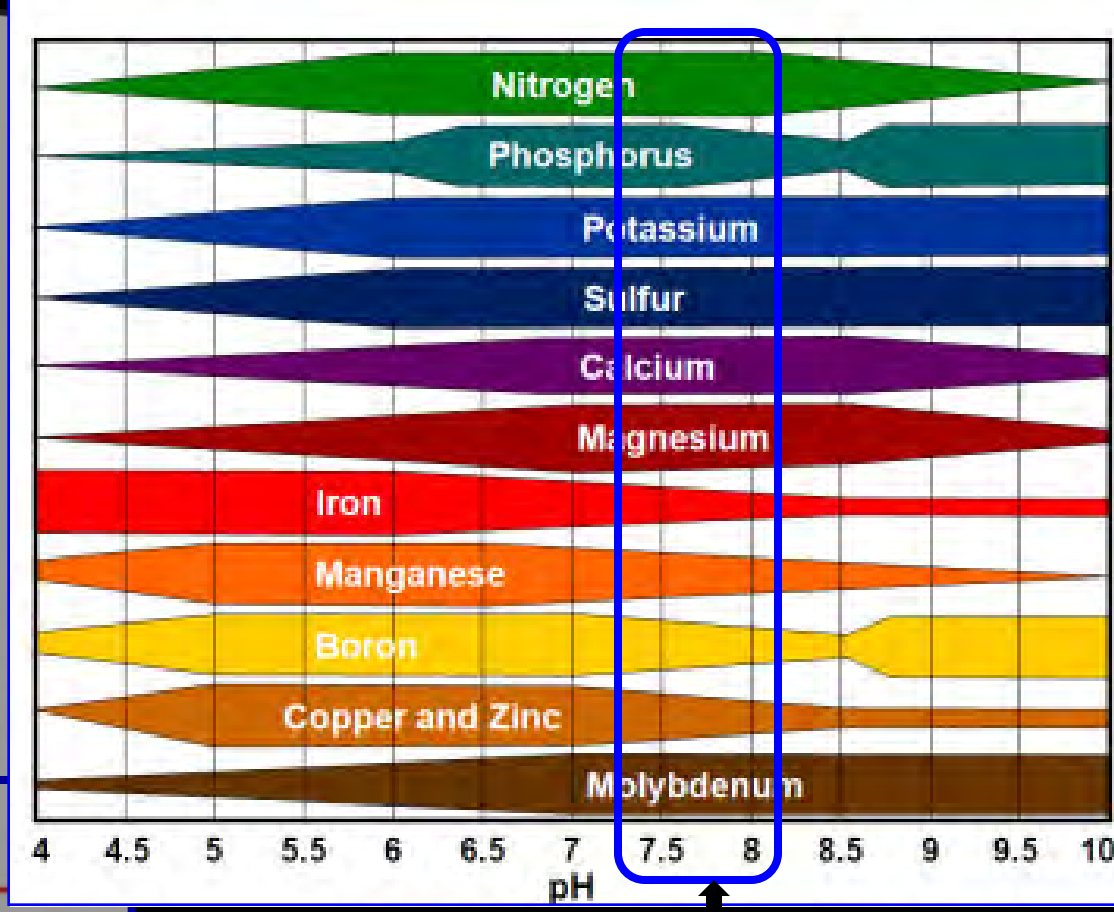
- Organic Matter = 0.6% (Low)
- Nitrogen Mineralized = 12.0 lbs./ac.
- Nitrate-N = 8.55 lbs./ac. (Low)
- Phosphorus = 5.0 ppm (Low)
- Potassium = 122.0 ppm (Low)
- Sulfate-S = 20.7 ppm (Adequate)
- Calcium = 2,948.0 ppm (High)
- Magnesium = 187.0 ppm (Low)
- Zn = 0.4 ppm (Low)
- Iron = 4.6 ppm (Low)
- Mn = 4.2 ppm (Low)
- Cu = 0.6 ppm (Adequate)
- B = 0.4 ppm (Low)
- Sodium = 2.6% of total CEC (good)

ECe = 0.36 mmhos/cm (No problem with Salts)
Sodium is 2.6% of total CEC (Satisfactory)
pH = 8.7 (Potential problem with pH; i.e. nutrient availability)

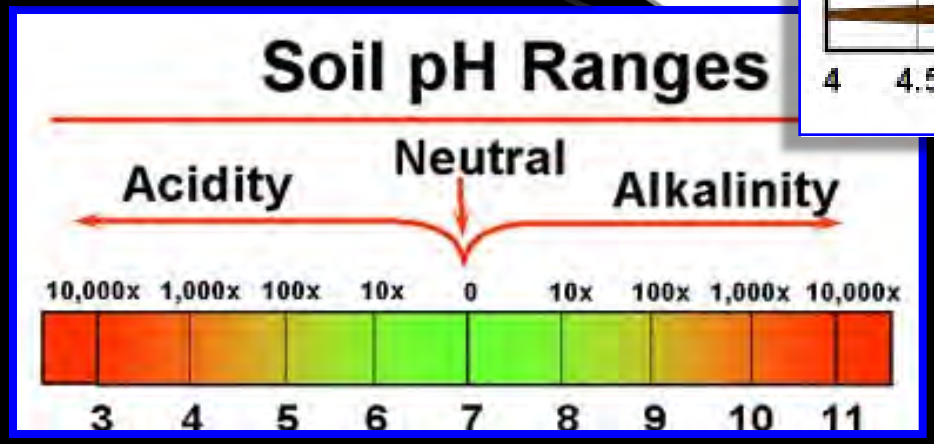

Nitrogen Cycle
Legume Root nodule
Nitrogen Gas (N_2)
free-living nitrogen fixing soil bacteria
Harvested Crop
Additional N inputs : irrigation water, precipitation, deposition, electrical discharges (i.e. lightning, nitrates) & symbiotic fixation with nonlegumes
Ammonia Volatilization
CO_2
FERTILIZER
N
Compost
Manure
Gaseous N losses
Soil Food Web
(predator-prey relationships)
Root Exudates, Glomalin, & Crop Residues
N immobilization by soil organisms & uptake by Roots
Soluble organic N
mineralization
Additional N losses: runoff & erosion
Ammonification
(mineralization: aerobic & anaerobic)
NH_4^+
Ammonium
pH-dependent
NH_3
Ammonia
Nitrification (mineralization: aerobic conditions)
Humus Formation
desorption
adsorption
NO_2^-
Nitrite
(plus H^+)
NO_3^-
Nitrate
Denitrification
(low oxygen/anaerobic)
N_2O
N_2
NO
Soil Solution
Leaching
Humus Decomposition
CEC
Clay & Humus
Fixed NH_4^+
The N cycle is influenced by:
• C:N ratios
• Temperature
• pH
• Soil Moisture
• Aeration
• Root Exudates
• Glomalin
• Crop Residues
• Salinity
• Other (e.g. Soil Biota)
• Tillage
rudy.garcia.2012

Denomination	pH range
Ultra acid	< 3.5
Extreme acid	3.5 - 4.4
Very strong acid	4.5 - 5.0
Strong acid	5.1 - 5.5
Moderate acid	5.6 - 6.0
Slight acid	6.1 - 6.5
Neutral	6.6 - 7.3
Slightly alkaline	7.4 - 7.8
Moderately alkaline	7.9 - 8.4
Strongly alkaline	8.5 - 9.0
Very strongly alkaline	> 9.0

Soil
pH Meter



Calcareous Soils



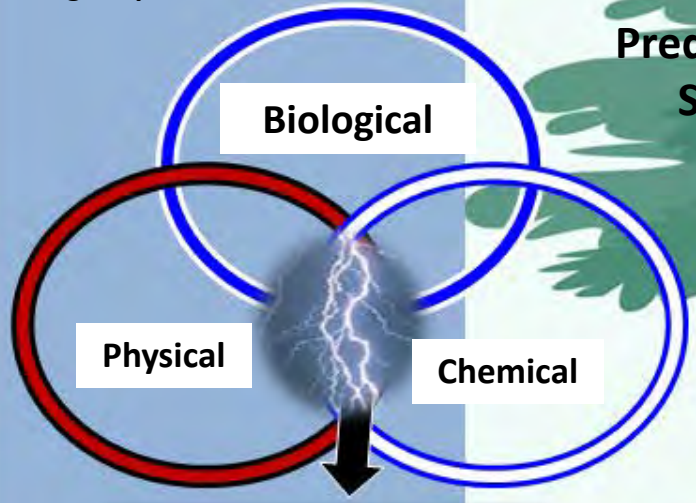
The soil pH is a measure of the acidity or alkalinity in soils. It ranges from 0 to 14, with 7 being neutral. A pH below 7 is acidic and above 7 is alkaline. Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It <u>specifically affects plant nutrient availability by controlling the chemical forms of the nutrient</u>.

pH affects Nutrient solubility
(i.e., chemical forms of the nutrient)

Soil is the Heart of the System

- Connects above and below
- Ultimate recycler of C, N, O, and other nutrients
- Drives physical, chemical, and biological processes , and much more.

Biodiversity with minimal soil disturbance drives soil health (NOTE: the Soil Food Web is sustained by Root Exudates, Glomalin, Crop Residues, Manure, Compost, Predator-Prey relationships , Plant Symbiosis, and Soil Humus).

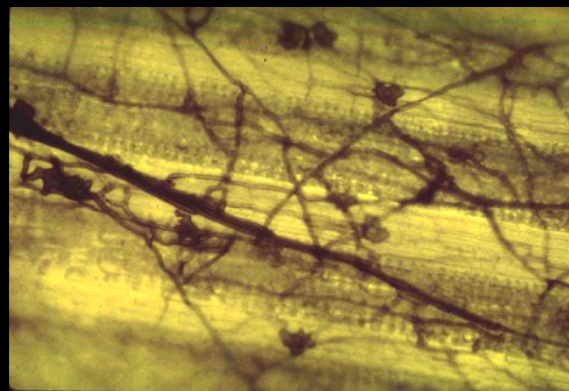


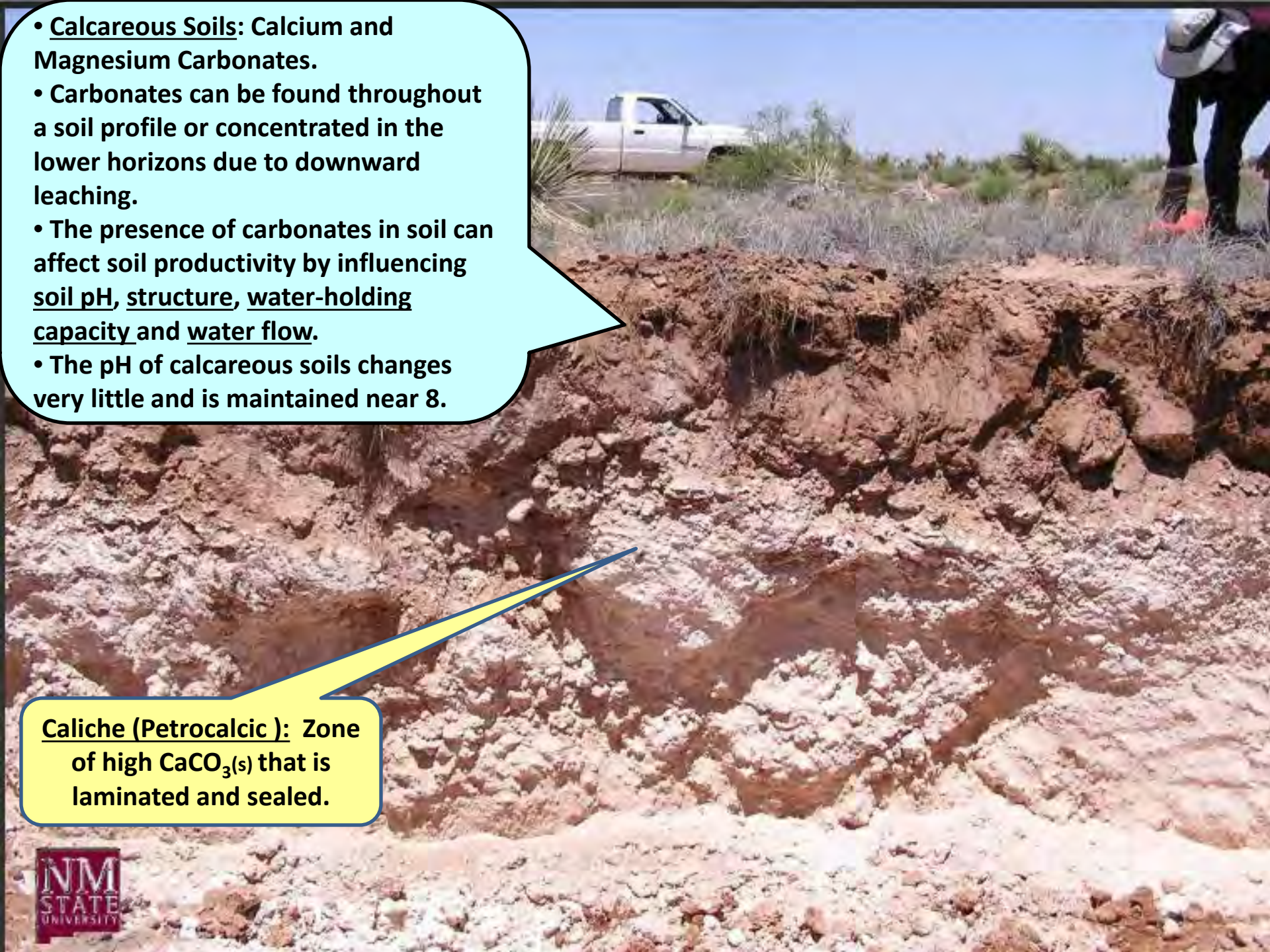
Unleashing Soil Health
(Emphasis: understanding Dynamic Soil Properties)

Fungi and Bacteria (solubilize mineral elements)

- **Various species of <u>fungi</u> can solubilize mineral elements from the mineral soil, not one species can solubilize ALL minerals (Diversity is needed)**

- **Various species of <u>bacteria</u> can solubilize mineral elements from the mineral soil, not one species can solubilize ALL minerals (Diversity is needed)**




• Calcareous Soils: Calcium and Magnesium Carbonates.
• Carbonates can be found throughout a soil profile or concentrated in the lower horizons due to downward leaching.
• The presence of carbonates in soil can affect soil productivity by influencing soil pH, structure, water-holding capacity and water flow.
• The pH of calcareous soils changes very little and is maintained near 8.
Caliche (Petrocalcic): Zone of high $CaCO_{3(s)}$ that is laminated and sealed.
NM STATE UNIVERSITY

Crop Tolerance to Soil Lime

Crop	Relative Tolerance
• Sudangrass	• Low to moderate
• Forage Corn	• Moderate
• Sorghum	• Low to Moderate
• Cotton	• Moderate to High
• Alfalfa (general)	• High
– 801S	
– WL 454HQ.RR	
• Bermudagrass (warm season)	• Medium
• Tall wheatgrass (cool season)	• High
• Wheat (cool season)	• Moderate
• Forage Teff	• Moderate

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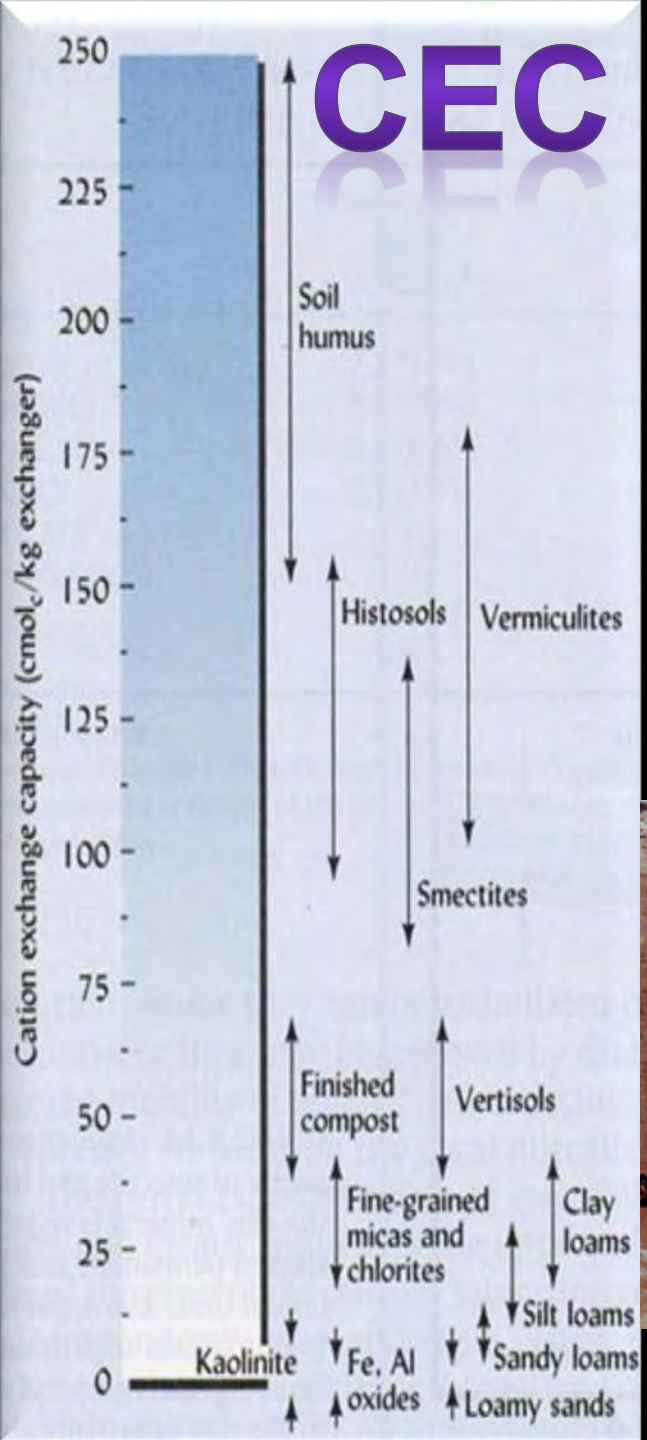
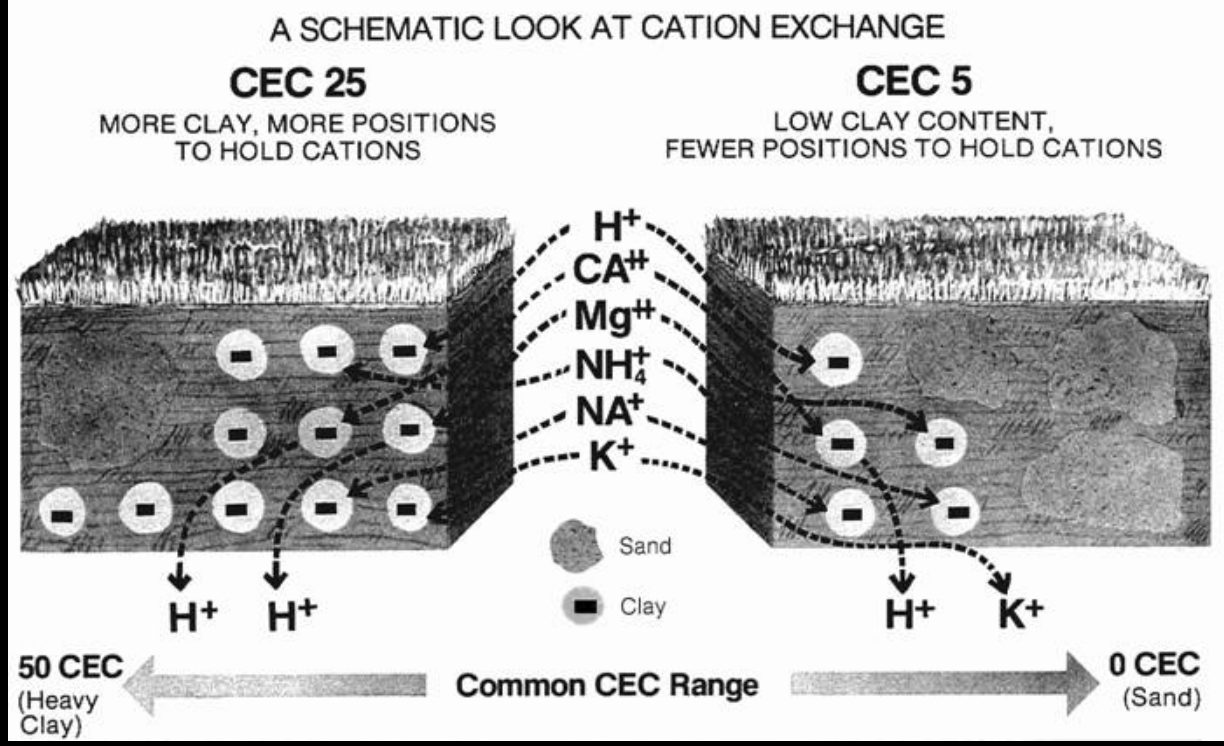
CEC





Soils with CEC 11-50 Range:

- High clay content; Greater capacity to hold nutrients in a given soil depth; high water-holding capacity; physical ramifications of a soil with a high clay content.

Soils with CEC 1-10 Range

- High sand content; Nitrogen and Potassium leaching more likely, low water-holding capacity, physical ramifications of a soil with a high sand content.

Cation Exchange Capacity (CEC): Aridisols CEC: Typical proportions of major adsorbed cations: Ca (65%), Mg (20%), K (10%) and Na (5%) (Table 8.1, Nature & Properties of Soil, 11th Edition)

e.g., Soil CEC = 25 meq/100 g of soil. 65% of CEC is Calcium.

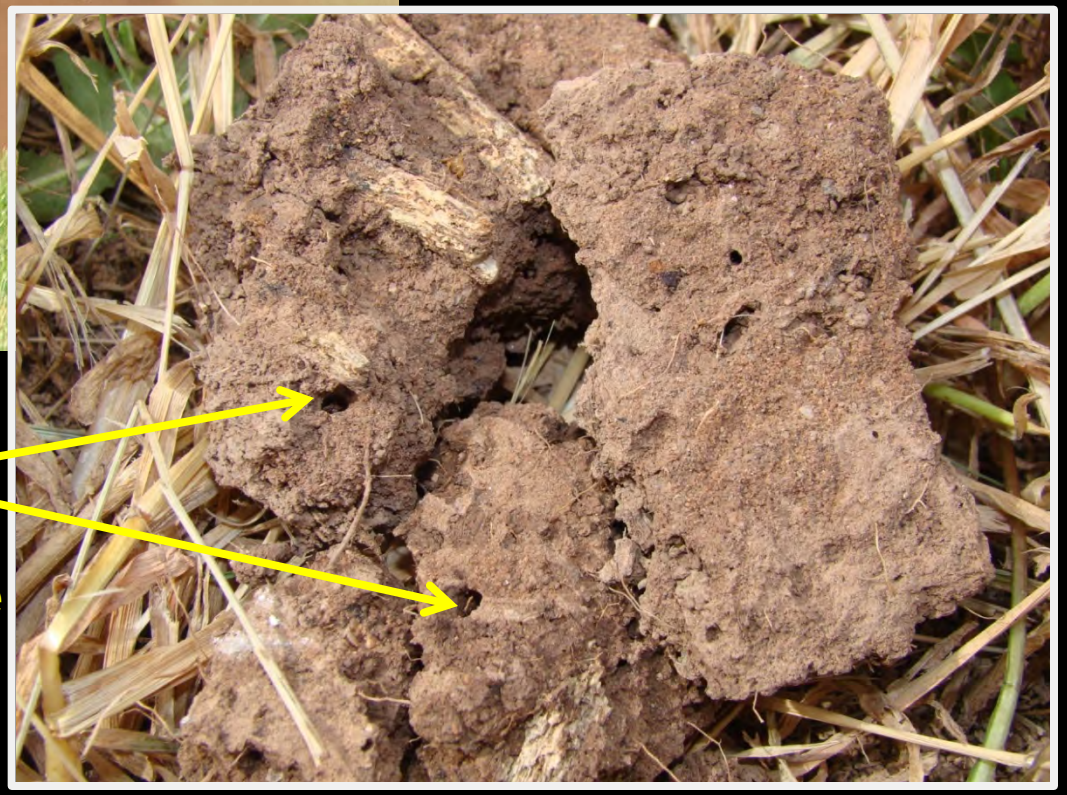
0.65 x 25 = 16.25 meq of Ca/100 g of soil

20.04 mg of Calcium/meq

16.25 meq x 20.04 mg/meq = 325.65 mg of Ca/ 100 g of soil

COMPOSTING

Compost/Manure Management



Earth Worm activity on surface and below

Note that by early spring of 2010, the soil biota had incorporated all the top-dressed composted manure. These soils have 2.5% SOM

Cover Crop Cocktail: Grasses, Legumes and Brassicas

Table:1 carbon to nitrogen ratios of crop residues and other organic materials.

Material	C:N ratio
Rye Straw	82:1
Wheat Straw	80:1
Oat Straw	70:1
Corn Stover	57:1
Rye Cover Crop (anthesis)	37:1
Pea Straw	29:1
Rye Cover Crop (vegetative)	26:1
Mature Alfalfa Hay	25:1
Ideal Microbe Diet	24:1
Rotted Barnyard Manure	20:1
Legume Hay	17:1
Beef Manure	17:1
Young Alfalfa Hay	13:1
Hairy Vetch Cover Crop	11:1
Soil Microorganisms (average)	8:1

(Ref.: Carbon: Nitrogen Ratios in Cropping Systems, by Jon Stika)

Cover Crop Cocktail Mix (grasses, legumes & brassicas), ND

Conclusion

Understanding carbon to nitrogen ratios of crop residues and other material applied to the soil is important to mange soil cover and crop nutrient cycling. Providing quality habitat for soil microorganisms should be the goal of producers interested in improving soil health. Soil is a biological system that functions only as well as the organisms that inhabit it.

PLANTING COVER CROP COCKTAIL MIXES TO IMPROVE SOIL HEALTH (NUTRIENT CYCLING, WATER-STABLE AGGREGATES, HABITAT FOR SOIL MICROORGANISMS)

Inches of Available Water on 5/6/08 Following the 2007 Cover Crop (ND).

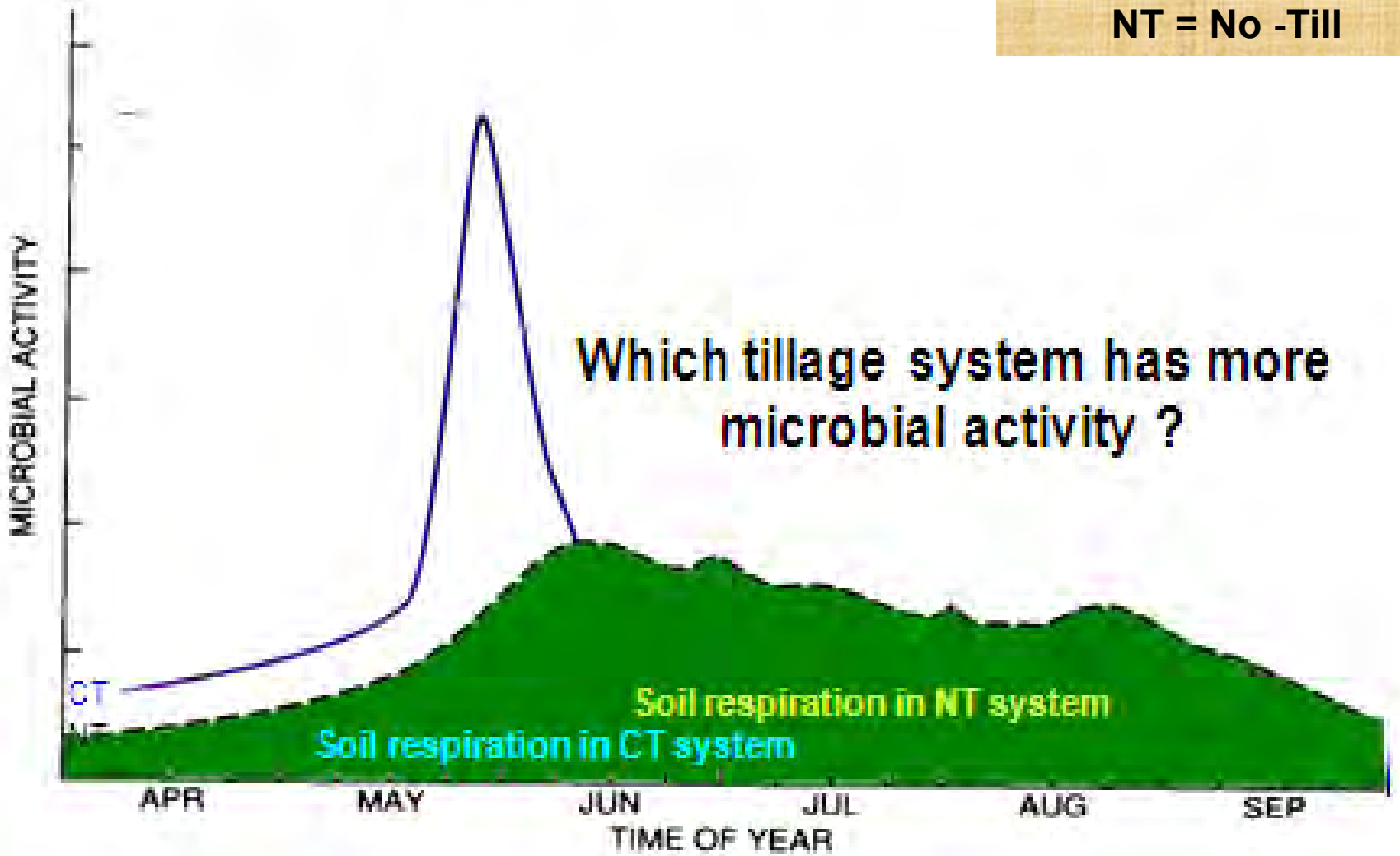
Summary

No Cover Crop	3.11 Inches
Cover Crop	3.07 Inches
Difference	0.04 Inches

324- Deep Tillage with minimal soil disturbance

Effect of tillage on microbial activity

CT = Conventional-Till
NT = No -Till



CROP ROTATION

***This practice means growing various crops on the same piece of land in a planned sequence*. This sequence may involve growing high residue producing crops such as corn or wheat in rotation with low residue producing crops such as vegetables or soybeans. The rotation may also involve growing forage crops in rotation with various field crops. *Crop rotations help break insect, disease and weed cycles*.**

- Sample at Midseason
- Sample midshoot leaflets/leaves
- Sample #: 25 – 60

Harris Laboratories
A Division of AgSource Cooperative Services

300 Speedway Circle, Suite 2
Lincoln, NE 68501

Tel: 402-476-0300
Fax: 402-476-0301

PLANT ANALYSIS

Submitted By:

Texas AgriLife Extension Service
9521 Socorro Road, Suite 82
PO Box 2
El Paso, TX 79927

Submitted For:

TEXAS AGRILIFE

Plant Information Sheet No.

024140

Laboratory Sample No.
AC30644

Date Reported: **9-Aug-10**

Laboratory Turnaround: **3 Days**

Samples Will Be Stored Until: **21-Aug-10**

Sample Marked: **KI 1L**

Crop: **PECANS**

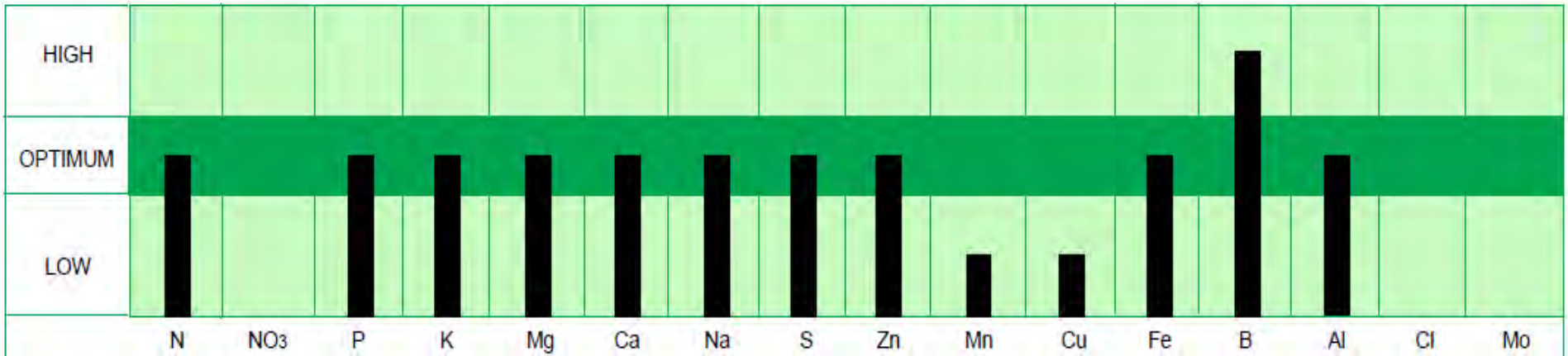
Plant Part: **LEAF**

Results of Laboratory Analysis

Laboratory Analysis	2.66		0.12	0.95	0.31	1.21	0.02	0.22	58.22	58.1	5.8	135.0	105.4	101.4		
	% Nitrogen	ppm Nitrate	% Phosphorus	% Potassium	% Magnesium	% Calcium	% Sodium	% Sulfur	ppm Zinc	ppm Manganese	ppm Copper	ppm Iron	ppm Boron	ppm Aluminum	ppm Chloride	ppm Molybdenum

Graphic Rating of Results Compared to Normal Ranges

Normal Ranges	2.49 to 2.8	to	0.11 to 0.3	0.74 to 1.25	0.29 to 0.6	0.89 to 1.5	0 to 0.1	0.19 to 0.4	49 to 100	99 to 800	9 to 30	49 to 300	29 to 45	0 to 2000	to	to



Pecan Plant Tissue Analysis:

- N = 2.66% Optimum: Sufficiency Range: 2.49 – 2.8%
- P = 0.12% Optimum: Sufficiency Range: 0.11 – 0.3%
- K = 0.95% Optimum: Sufficiency Range: 0.74 - 1.25%
- S = 0.22% Optimum: Sufficiency Range: 0.19 - 0.4%
- Ca = 1.21% Optimum: Sufficiency Range: 0.89 – 1.5%
- Mg = 0.31% Optimum: Sufficiency Range: 0.29 - 0.6%
- Zn = 58.22 ppm Optimum: Sufficiency Range: 49 – 100 ppm
- Fe = 135 ppm Optimum: Sufficiency Range: 49 – 300 ppm
- Mn = 58.1 ppm Low: Sufficiency Range: 99 - 800 ppm
- Cu = 5.8 ppm Low : Sufficiency Range: 9 – 30 ppm
- B = 105.4 ppm High: Sufficiency Range: 29 – 45 ppm
- Na = 0.02% Optimum: Sufficiency Range: 0 – 0.1%

Yield is about 2,300 lbs./ac. for mature trees

4	Nutrients ON = Organic Nitrogen mineralized	Irrigation Water Analysis (ppm x 0.227 x 48" = lb./ac.)		Soil Analysis 0-6" depth Bulk Density = 1.4 g/cm³ ppm x 1.90 = lb/ac (6" depth)		Nutrient Inputs (recommendations)	Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur		Should I Apply Nutrients? - Yes (Y) No (N) - Maintenance (M) - Not Sure (?) - Other (O)	Conservation Practices to consider for achieving sustainability
		ppm or mg/l	Pounds per Acre	ppm or mg/Kg	Low Adequate High	Lbs./ac. (based on 1000 lb./ac. yield)	% or ppm & Rating (Low - High) O = Optimum	Sufficiency Range (leaf: midshoot leaflets)		
5	Organic Matter									♥ Cover Crops
6	N mineralized									
7	Nitrate-Nitrogen						2.66% O	2.49 - 2.8%		♥ Crop Rotations
8	Phosphorus						0.12% O	0.11 - 0.3%		
9	Potassium						0.95% O	0.74 -1.25%		
10	Sulfate-Sulfur						0.22% O	0.19 - 0.4%		♥ Manure or Compost
11	Calcium						1.21% O	0.89 - 1.5%		
12	Magnesium						0.31% O	0.29 - 0.6%		
13	Zinc						58.22 ppm O	49 - 100 ppm		♥ Minimum-Till (No-Till); Residue mgt.
14	Iron						135 ppm O	49 -300 ppm		
15	Manganese						58.1 ppm L	99 -800 ppm		
16	Copper						5.8 ppm L	9 - 30 ppm		♥ IWM
17	Boron						105.4 ppm H	29 - 45 ppm		
18	Molybdenum						not	analyzed		♥ Soil Amendments (e.g. gypsum)
19	Sodium						0.02% O	0 - 0.1		
20	Chloride						not analyzed	> 0.5% excess		
21	Bicarbonate									
22	Carbonate									♥ IPM

Conversions and Calculations (ppm = mg/kg):

Parts Per Million (ppm) = milligram/kilogram (mg/kg)

Example: 10,000 ppm ÷ 1,000,000 ppm = 1.0%
Example: 5,000 ppm ÷ 1,000,000 ppm = 0.5%
Example: 1,000 ppm ÷ 1,000,000 ppm = 0.1%
Example: 500 ppm ÷ 1,000,000 ppm = 0.05%
Example: 100 ppm ÷ 1,000,000 ppm = 0.01%

1.0 gram = 1,000 milligrams
1.0 kilogram = 1,000 grams = 1,000,000 mg

Example: 100 mg/1,000,000 mg = 100 mg/kg
100 mg ÷ 1,000,000 mg = 0.01%
100 ppm ÷ 1,000,000 ppm = 0.01%
ppm = mg/kg

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

Emphasis on Building Healthy Soils to help manage insect, disease and weed pressures.

HABITAT FOR BENEFICIAL INSECTS AND POLLINATORS

IPM includes Prevention, Avoidance, Monitoring & Suppression.

Managing **Diseases** & **Insects**: Crop rotations are the most effective way of reducing many pest populations.

Weed Control: The more diversity in the rotation, the easier it is to control weeds. Cover crops compete with weeds and crop residue serves to suppress establishment of the weeds.

Integrated Nutrient Management

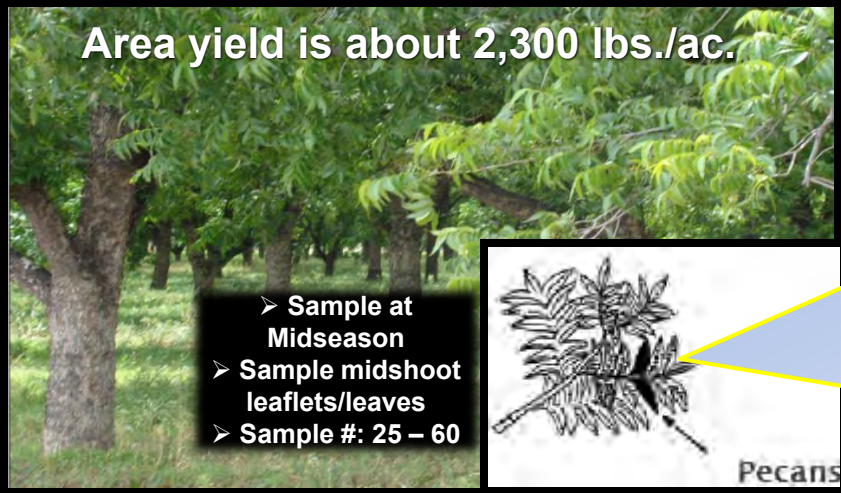
Collecting Leaf Samples from Sorghum Crop for Nutrient Analysis

Collecting Soil Samples for Nutrient Analysis

NRCS Soil Quality Test Kit

NRCS Active Carbon Field Kit

rudy.garcia.2010



Pecan Plant Tissue Analysis:

- N = 2.66% Optimum: Sufficiency Range: 2.49 – 2.8%
- P = 0.12% Optimum: Sufficiency Range: 0.11 – 0.3%
- K = 0.95% Optimum: Sufficiency Range: 0.74 - 1.25%
- S = 0.22% Optimum: Sufficiency Range: 0.19 - 0.4%
- Ca = 1.21% Optimum: Sufficiency Range: 0.89 – 1.5%
- Mg = 0.31% Optimum: Sufficiency Range: 0.29 - 0.6%
- Zn = 58.22 ppm Optimum: Sufficiency Range: 49 – 100 ppm
- Fe = 135 ppm Optimum: Sufficiency Range: 49 – 300 ppm
- Mn = 58.1 ppm Low: Sufficiency Range: 99 - 800 ppm
- Cu = 5.8 ppm Low : Sufficiency Range: 9 – 30 ppm
- B = 105.4 ppm High: Sufficiency Range: 29 – 45 ppm
- Na = 0.02% Optimum: Sufficiency Range: 0 – 0.1%

Soil Probe

Water Quality Analysis

Pounds per Acre:

- Nitrate-N = 12.2
- Potassium = 89.5
- Sulfate-S = 490.0
- Calcium = 591.0
- Magnesium = 146.2
- Sodium = 592.0
- Chloride = 783.0
- Bicarbonate = 1,911.4
- Carbonate = 26.1
- Iron = 9.3
- Mn = 0.22
- B = 1.31

Total Salts = 5,640.2

Soil Analysis:

- Organic Matter = 0.6% (Low)
- Nitrogen Mineralized = 12.0 lbs./ac.
- Nitrate-N = 8.55 lbs./ac. (Low)
- Phosphorus = 5.0 ppm (Low)
- Potassium = 122.0 ppm (Low)
- Sulfate-S = 20.7 ppm (Adequate)
- Calcium = 2,948.0 ppm (High)
- Magnesium = 187.0 ppm (Low)
- Zn = 0.4 ppm (Low)
- Iron = 4.6 ppm (Low)
- Mn = 4.2 ppm (Low)
- Cu = 0.6 ppm (Adequate)
- B = 0.4 ppm (Low)
- Sodium = 2.6% of total CEC (good)

ECiw = 0.81 mmhos/cm → ECe = 0.36 mmhos/cm (No problem with Salts)

SAR = 1.71 → Sodium is 2.6% of total CEC (Satisfactory)

pH = 7.9 → pH = 8.7 (Problem with pH; i.e. nutrient availability)

Conventional Irrigation (soil salinity typically concentrates about 1.5 times the water EC) → Leaching Fraction (LF) = $0.3086/Fc^{1.702}$ (LF = 7.2%)

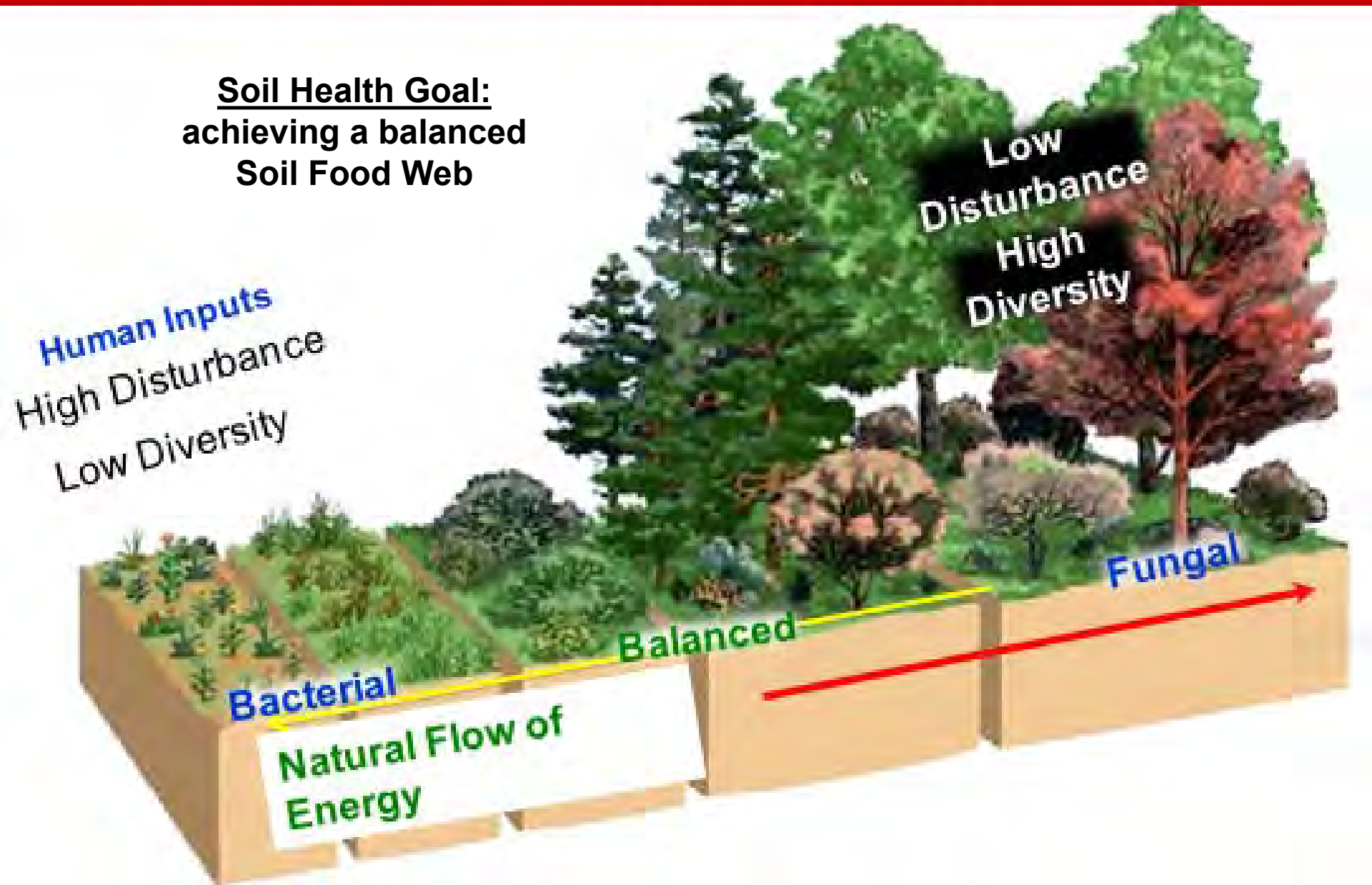
Fc = ECe(ct)/ECiw (i.e., ECe(ct) = 1.9 & ECiw = 0.81); Fc = 2.35

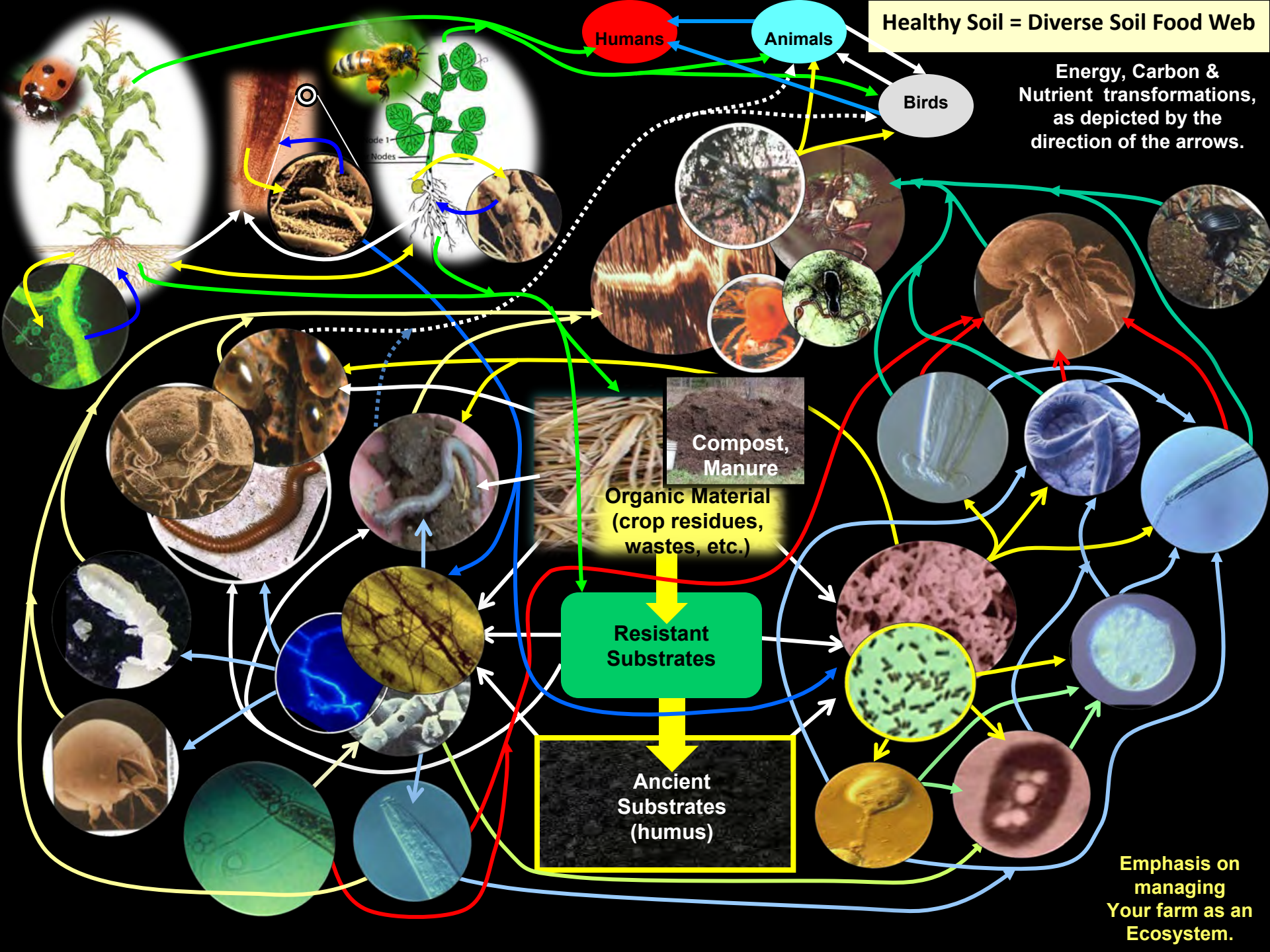
4	Nutrients ON = Organic Nitrogen mineralized	Irrigation Water Analysis (ppm x 0.227 x 48" = lb./ac.)		Soil Analysis 0-6" depth Bulk Density = 1.4 g/cm^3 ppm x 1.90 = lb/ac (6" depth)		Nutrient Inputs (recommendations)	Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur		Should I Apply Nutrients? - Yes (Y) No (N) - Maintenance (M) - Not Sure (?) - Other (O)	Conservation Practices to consider for achieving sustainability
		ppm or mg/l	Pounds per Acre	ppm or mg/Kg	Low Adequate High	Lbs./ac. (based on 1000 lb./ac. yield)	% or ppm & Rating (Low - High) O = Optimum	Sufficiency Range (leaf: midshoot leaflets)		
5	Organic Matter			0.6%	11,400 Low				Manure?	♥ Cover Crops
6	N mineralized			ON	12.0 Low	Manure?			n/a	
7	Nitrate-Nitrogen	1.12	12.2	4.5	8.55 lbs./ac	55.0 N	2.66% O	2.49 - 2.8%	Yes	♥ Crop Rotations
8	Phosphorus			5.0	Low	22.5 P_2O_5	0.12% O	0.11 - 0.3%	Yes	
9	Potassium	8.23	89.5	122.0	Low	18.3 K_2O	0.95% O	0.74 -1.25%	Yes	
10	Sulfate-Sulfur	45.03	490.0	20.7	Adequate	none	0.22% O	0.19 - 0.4%	No	♥ Manure or Compost
11	Calcium	54.32	591.0	2,948.0	High	none	1.21% O	0.89 - 1.5%	No	
12	Magnesium	13.44	146.2	187.0	Low	9.4 MgO	0.31% O	0.29 - 0.6%	Not Sure?	
13	Zinc			0.4	low	3.3	58.22 ppm O	49 - 100 ppm	Yes	♥ Minimum-Till (No-Till); Residue mgt.
14	Iron	0.85	9.3	4.6	low	5.1	135 ppm O	49 -300 ppm	Yes	
15	Manganese	0.02	0.22	4.2	low	3.3	58.1 ppm L	99 -800 ppm	Yes	
16	Copper			0.6	adequate	none	5.8 ppm L	9 - 30 ppm	Yes	♥ IWM
17	Boron	0.12	1.31	0.4	low	0.9	105.4 ppm H	29 - 45 ppm	No	
18	Molybdenum					none	not	analyzed	No	♥ Soil Amendments (e.g. gypsum)
19	Sodium	54.41	592.0		use SAR		0.02% O	0 - 0.1	No	
20	Chloride	71.96	783.0				not analyzed	> 0.5% excess	No	
21	Bicarbonate	175.68	1,911.4							
22	Carbonate	2.40	26.1							♥ IPM

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

- Electrical Conductivity of Irrigation Water (ECiw) = 0.81mmhos/cm
- Sodium Adsorption Ratio (SAR) from water test = 1.71 & pH = 7.9
- Irrigation Water Quality infiltration assessment (degree of restriction on use is none). Total Dissolved Solids = 518.40 mg/l
- Soluble salts applied = 5,640.2 lb./ac./yr.
- Soluble Salts = 0.36 mmhos/cm (Satisfactory)
- Soil pH = 8.7 (Problem. e.g., nutrient availability)
- Sodium is 2.6% of Total Cation Exchange Capacity (Satisfactory)
- Refer to Crop Salt Tolerance Table (Section 2) to evaluate for potential yield reduction (No yield reductions due to existing salinity levels)

Natural Succession of Plants & Soil



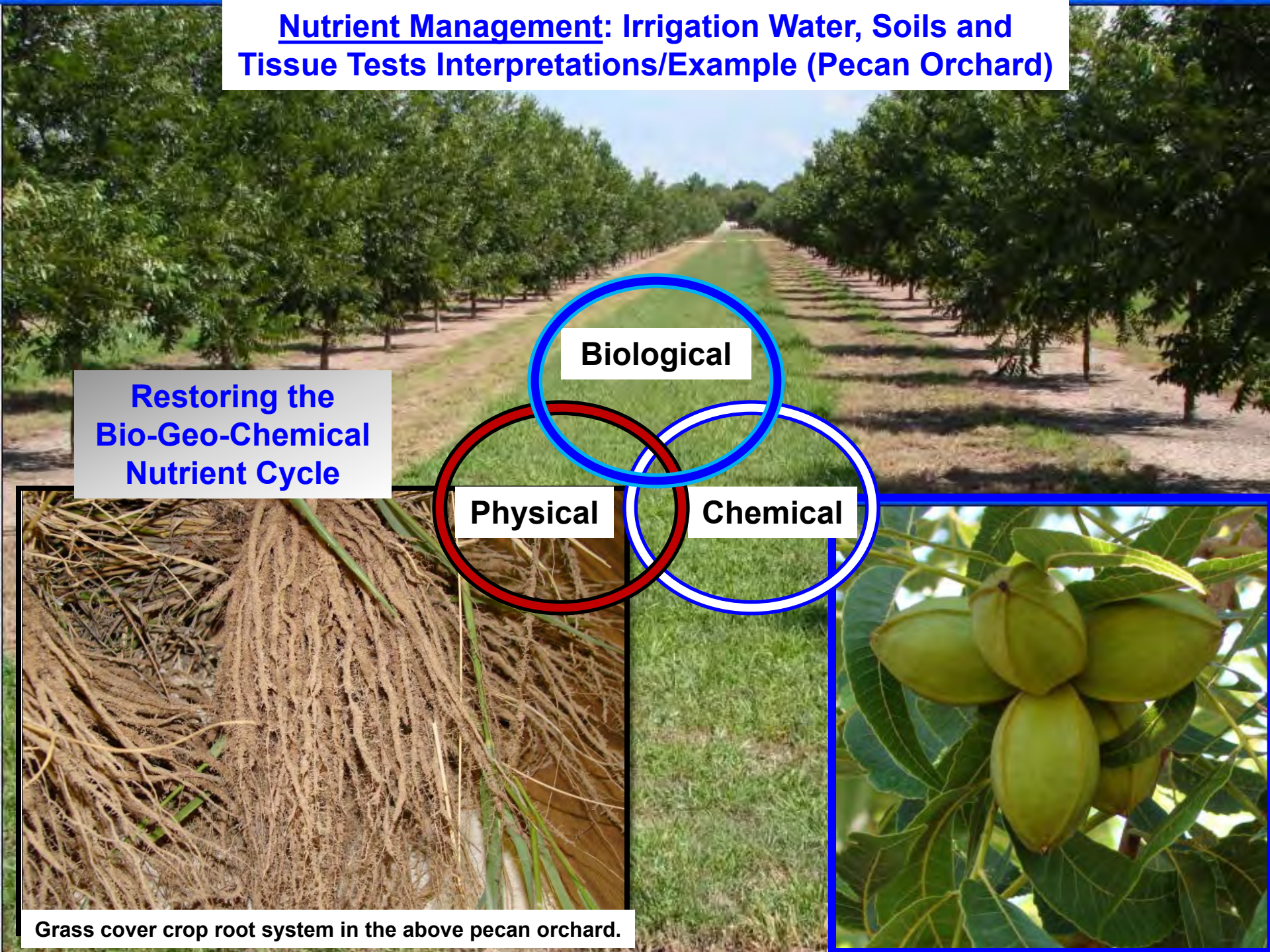

Healthy Soil = Diverse Soil Food Web
Humans
Animals
Birds
Energy, Carbon & Nutrient transformations, as depicted by the direction of the arrows.
Compost, Manure
Organic Material (crop residues, wastes, etc.)
Resistant Substrates
Ancient Substrates (humus)
Emphasis on managing Your farm as an Ecosystem.

Basic facts about the Soil food web

The soil food web:

1) Is complex
2) Individual organisms are small in size
3) Individual organisms are numerous
4) Is greatly impacted by temperature and moisture
5) Is most active near the soil surface

Nutrient Management: Irrigation Water, Soils and Tissue Tests Interpretations/Example (Pecan Orchard)



Grass cover crop root system in the above pecan orchard.

HEALTHY SOILS = NUTRITIOUS FOOD

2010 SOIL HEALTH WORKSHOP AT EL PASO, TEXAS. HOSTED BY TEXAS AGRILIFE CENTER WITH PARTICIPATION FROM NM USDA-NRCS

Review and discuss Irrigation Water, Soils and Tissue tests/analysis for Pecan Orchard evaluated (including additional components of a Soil Health Management System).

THE END