Soil Health Management

John Idowu

Extension Agronomist,

June 8th, 2023

New Mexico State University

Extension Plant Sciences

Contact: John Idowu

Email: jidowu@nmsu.edu

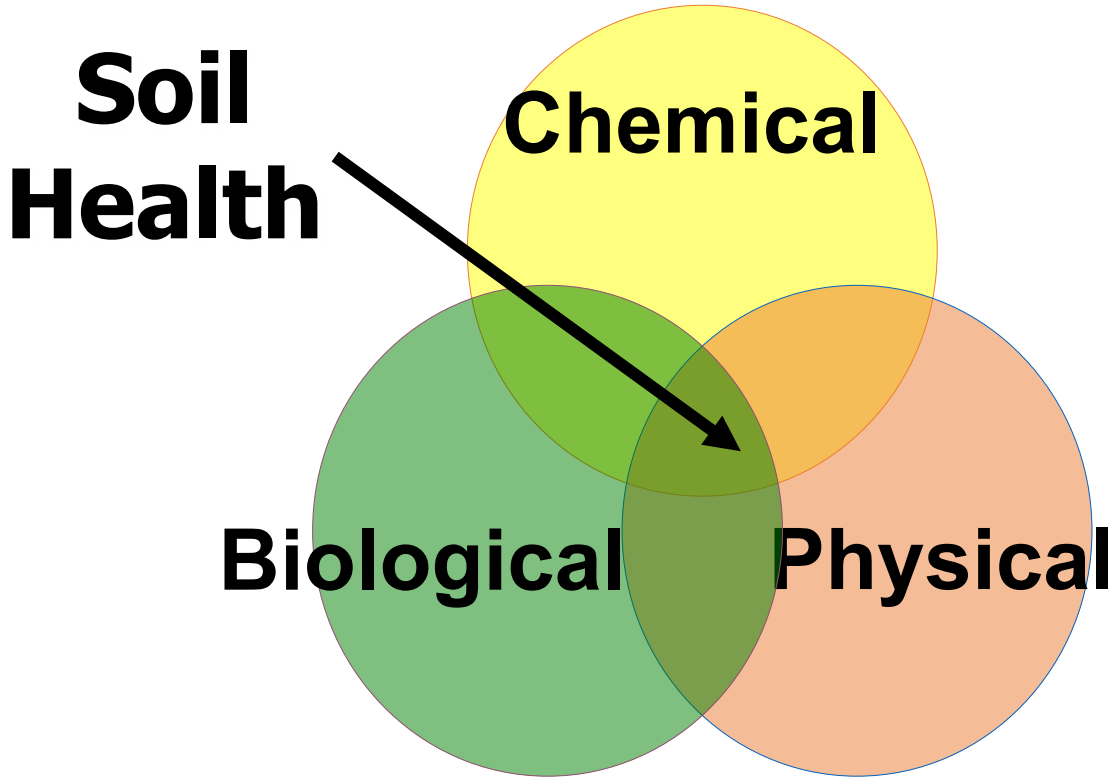
Phone: 575-646-2571

What is Soil Health (Quality)?

- Ability of the soil to support crop growth … (Power & Myers, 1989)
- Capacity of the soil to function in a productive and sustained manner … (NCR-59 Madison WI, 1991)
- The capability of the soil to produce safe and nutritious crop …. (Parr et al., 1992)
- Fitness for use (Pierce & Larson 1993)

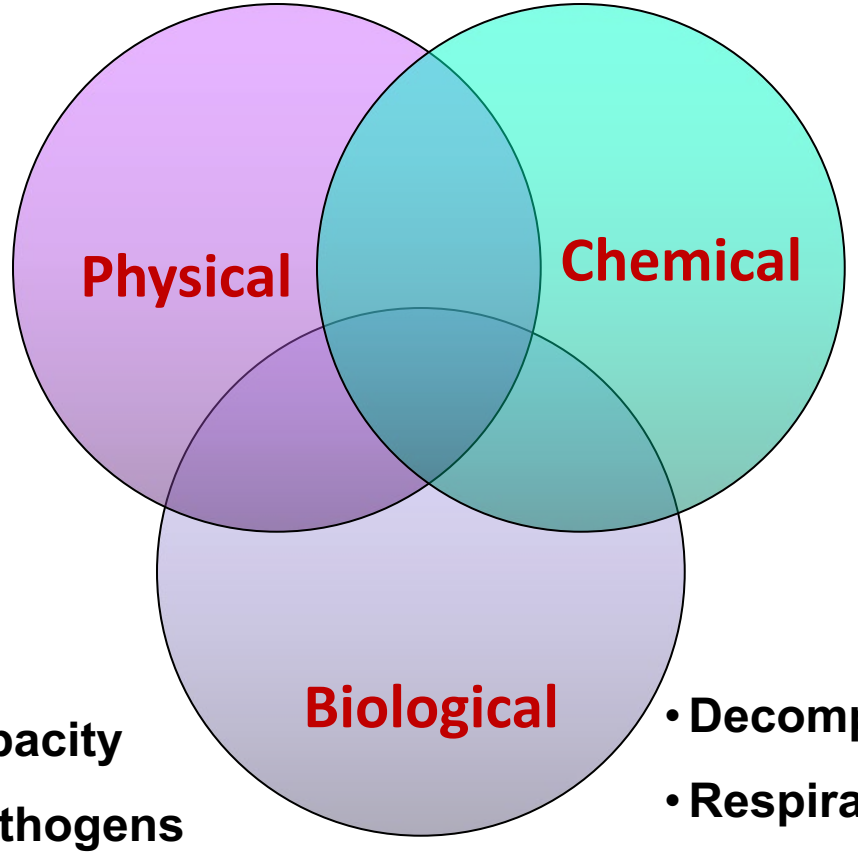
Approach to Soil Health

- **All Soil Components are Equally Important**



Soil Health Indicators (Measurements)

- Bulk density
- Penetration resistance
- Aggregate stability
- Water infiltration rate
- Water holding capacity
- Pore size distribution



- Cation exchange capacity
- N, P, K
- Salinity, Sodicity
- Micronutrients
- [Toxins, pollutants]

- Soil disease suppressive capacity
- Beneficial organisms and pathogens
- N mineralization rate (PMN)

- Decomposition rate
- Respiration rate
- Earthworm counts
- *Organic matter (Active, Passive, etc.)*

Physical issues

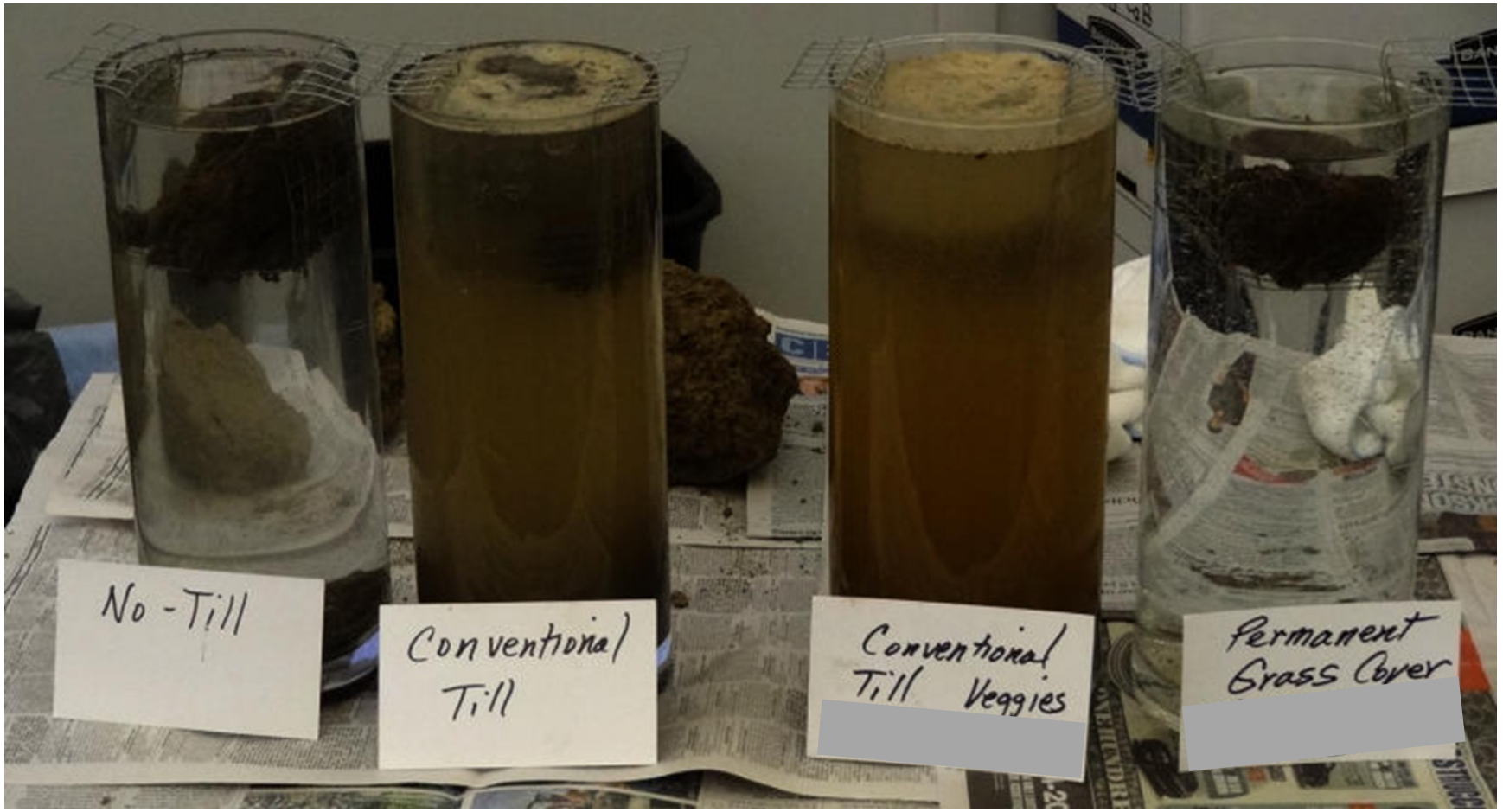
- **Poor aggregation** – how well the soil binds together
- **Low water Retention** – how much water the soil can retain
- **Field compaction** – how tightly the soil is packed together

Aggregation

Affects

- Soil erosion by water and wind
- Pore size distribution (water movement/retention)
- Drought tolerance of soils
- Root growth and proliferation
- Soil aeration

Aggregate Stability and Soil Management

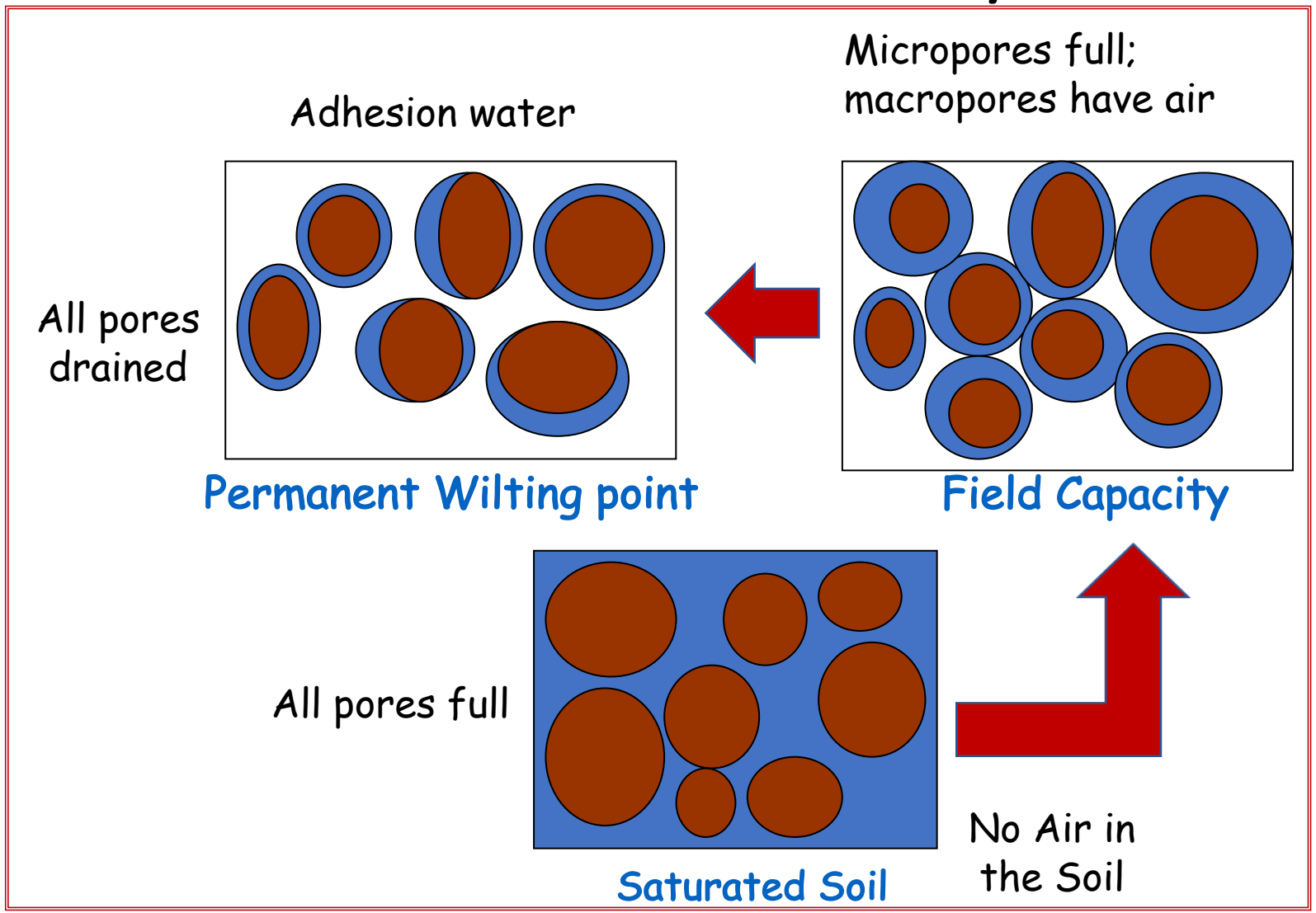


Water retention in the Soil

Affects

- Plant water availability
- Susceptibility to drought
- Yield of crops

Soil Water Availability



Soil Water Availability – Available Water Capacity

- ***Available Water Capacity (AWC)*** – the difference between the water held at field capacity and the permanent wilting point

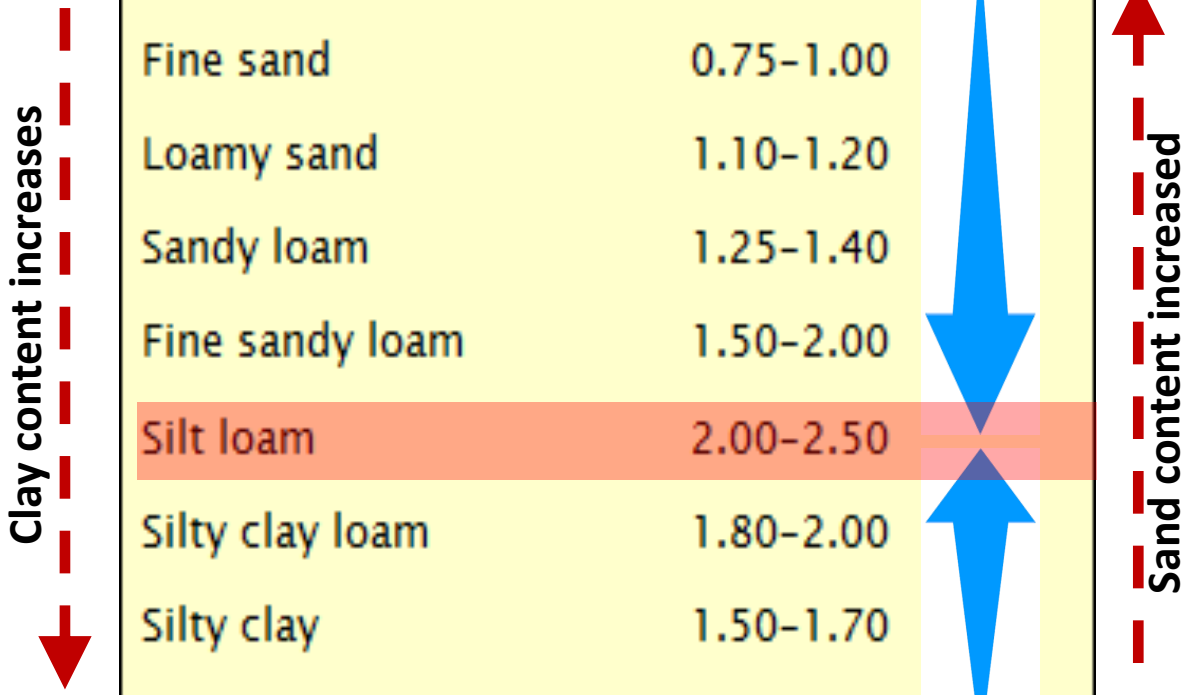
AWC = FC – PWP

- **AWC is soil dependent – function of (Texture, Structure, Organic Matter, Porosity)**

Availability of water in relation to soil texture

Available Water Capacity by Soil Texture

Textural Class	Available Water Capacity (Inches/Foot of Depth)
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00
Silt loam	2.00–2.50
Silty clay loam	1.80–2.00
Silty clay	1.50–1.70
Clay	1.20–1.50



Water increases to a maximum at **SILT LOAM TEXTURE** and then decreases

Compaction

Affects

- Water movement
- Water holding capacity
- Root growth and proliferation
- Soil aeration

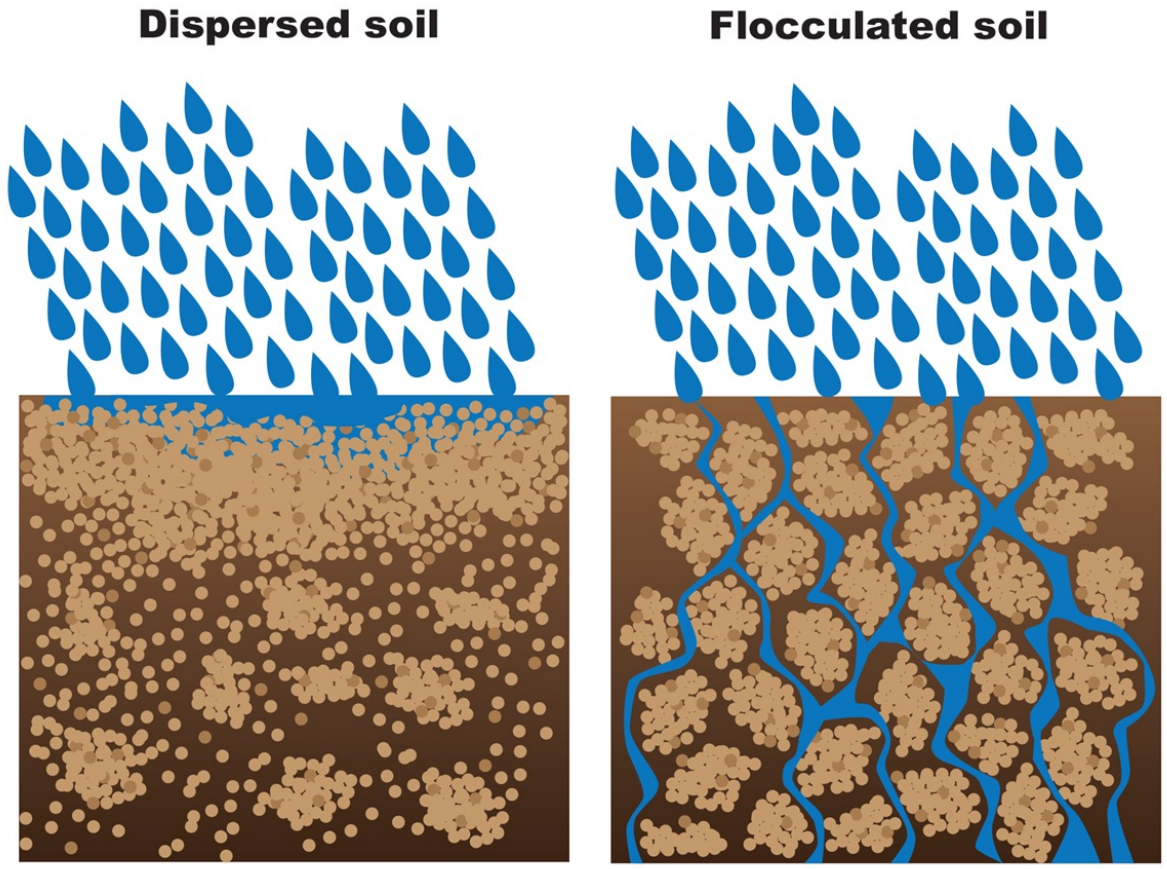
Roots in loose or compacted soil

Loose and well-structured soil

Compacted soil

Soil Compaction

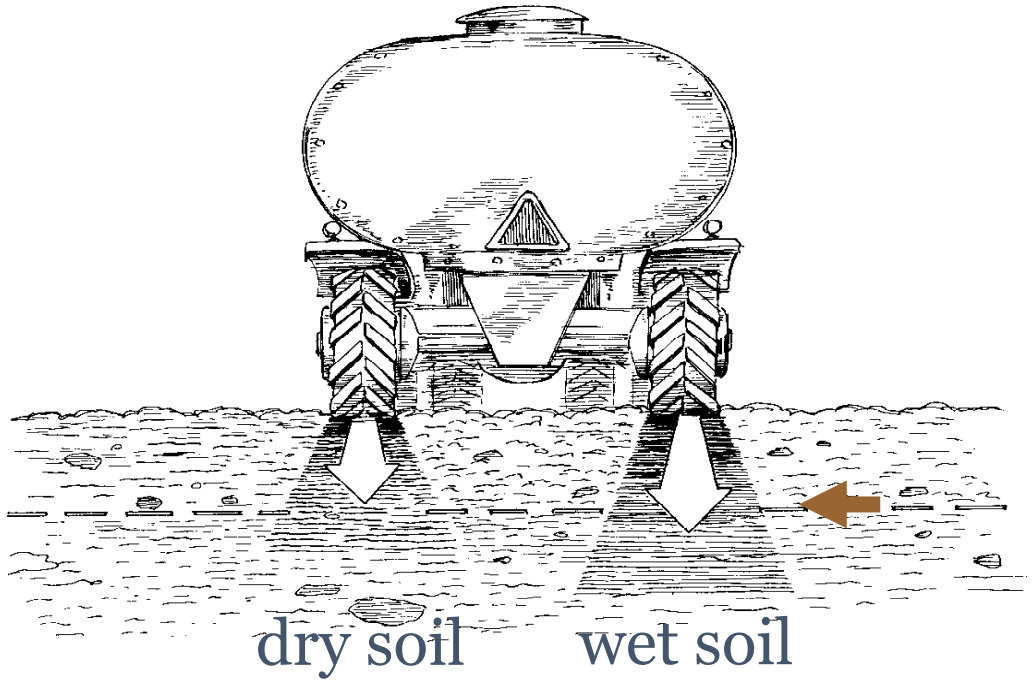
Surface Crusting



To address surface crusting:

- Managing organic matter in the topsoil
- Surface Mulching/residue
- Adding organic amendments

How Subsurface Compaction Occurs



Damage is greatest
- when soils are wet
- when loads are high

Compaction Alleviation -Subsoiling

Compaction Alleviation - Tillage Radish: Bio-drilling

https://talk.newagtalk.com/forums/thread-view.asp?tid=205569

Compaction Prevention

- Avoid tillage of wet soils
- Use wider tires, dual tires
- Maintain minimum tire inflation
- Avoid over-sized equipment
- Combine field operations
- Add organic matter to the soil
- Practice controlled traffic

Chemical aspects of soil health

- Nutrient sufficiency
- Soil salinity levels/Sodium issues
- Water salinity levels

Resolving Chemical Issues

Soil Testing is Important !!!

- Helps to know what is in your soil
- Helps to plan how much nutrients to apply
- Nutrient needs vary with soil and crop
- Helps to know if your soil is building up salts
- Will let you know if your management is improving, degrading, or maintaining your soil

Biological aspects of soil health

- Amount Soil Organic Matter
- Soil Microbial Activity
- Diversity of Flora and Fauna
- Soil Nitrogen Mineralization
- Organic Matter Decomposition
- Soil Borne Pathogens

Soil Organisms

In one teaspoon of soil

• Bacteria	100 million to 1 billion
• Fungi	6-9 ft fungal strands put end to end
• Protozoa	Several thousand flagellates & amoeba One to several hundred ciliates
• Nematodes	10 to 20 bacterial feeders and a few fungal feeders
• Arthropods	Up to 100
• Earthworms	5 or more

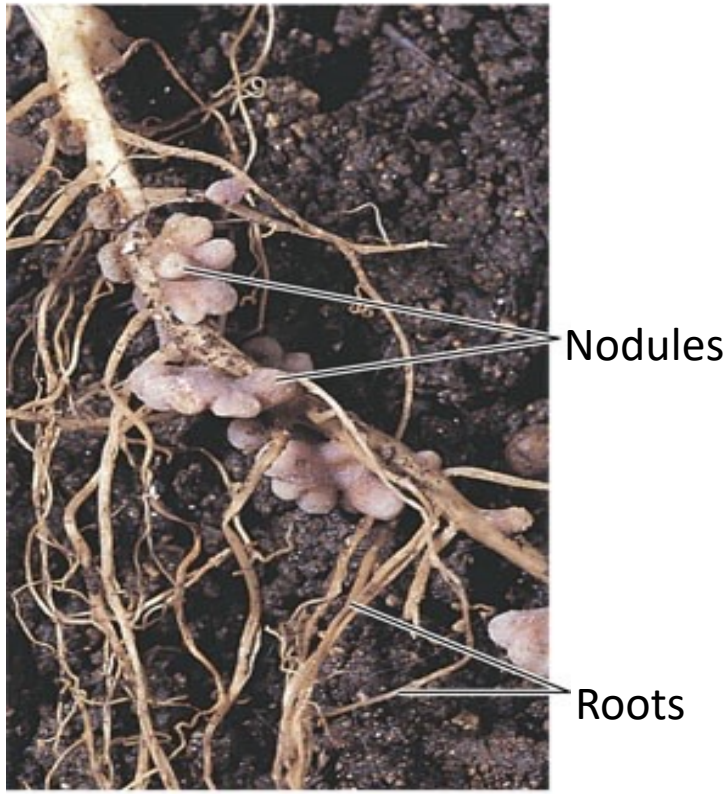
Healthy soils maintain a diverse community of soil organisms that:

- Suppress plant disease, and insect and weed pests;
- Form beneficial symbiotic associations with plant roots
  - Mycorrhizae, Rhizobium
- Recycle essential plant nutrients
- Improve soil structure for water and nutrient retention
- Ultimately, increase grower profits and protect the environment

Nitrogen Fixation Through Legumes (making nitrate-N available to crops)

- Examples of legumes are alfalfa, clovers, beans
- Bacteria that make nitrate in plant roots with plants are called Rhizobium
- Nitrogen come from the soil air (79% N_2 in soil)
- It is a relationship of give and take
- Plants supply bacteria with food and bacteria give back nitrate to plants

Symbiotic = up to 270 Ib N/ac/year
Non-symbiotic = up to 20 Ibs N/ac/year



Sesbania Nodules

- Sesbania used as green manure in an organic rotation experiment

Active Nodules
Reddish-pink

Potential of legumes to add N to Soil

Summer green legume experiment conducted in Las Cruces, NM under irrigated system

Cover Crop	C:N	Nitrogen (lb N/ac)	Biomass (t/ac)
Sesbania	25	248	7.3
Cowpea I&C	15	221	3.7
Lablab	14	192	3.3
Cowpea CA	12	182	2.7
Cowpea CC36	18	150	2.9
Bush bean	10	146	1.9
Pigeon Pea	10	131	1.6
Guar Durga	15	124	2.3
Tepary Bean	14	120	2.0
Lima Bean	12	119	1.8
Green Bean	15	82	1.5
Guar Evergreen	18	79	1.6
Mung Bean	21	70	1.8
Adzuki Bean	11	70	1.0
Moth Bean	15	69	1.3

Barley after sesbania summer legume

Oats after sesbania summer legume

Wheat after sesbania summer legume

Rye after sesbania summer legume

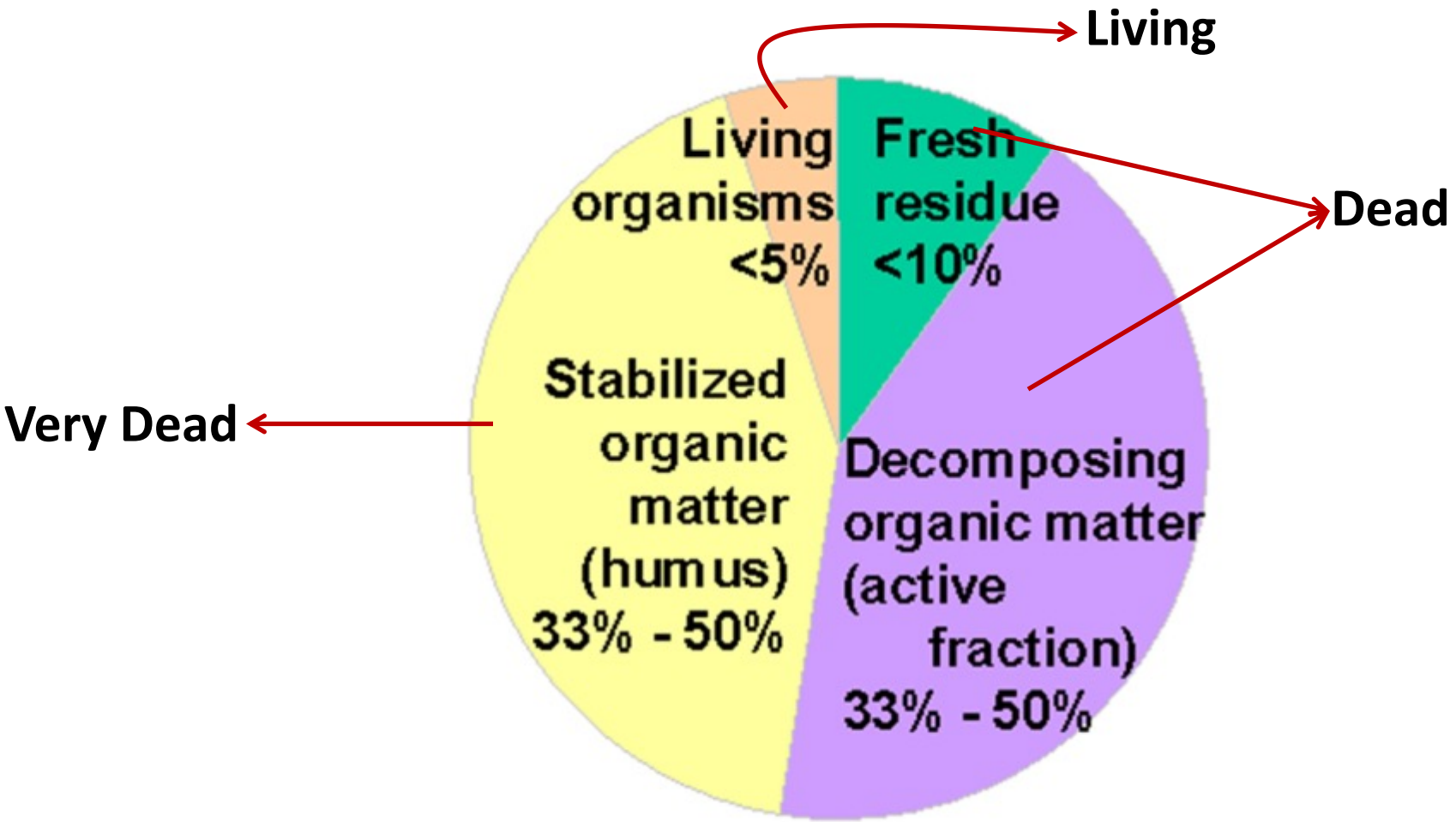
Improving Soil Health

- Long-term Thinking and Strategy

Basic Methods (Toolbox)

- **Organic Matter Addition & Management**
- **Tillage Management (Reducing tillage)**
- **Cover Cropping**
- **Crop Rotation**

Types of organic matter



Organic Matter

—Living —

- Organisms of various sizes such as bacteria, fungi, nematodes, earthworms, mites, springtails, moles, etc.
- Plant roots

Organic Matter ➔ Active Fraction

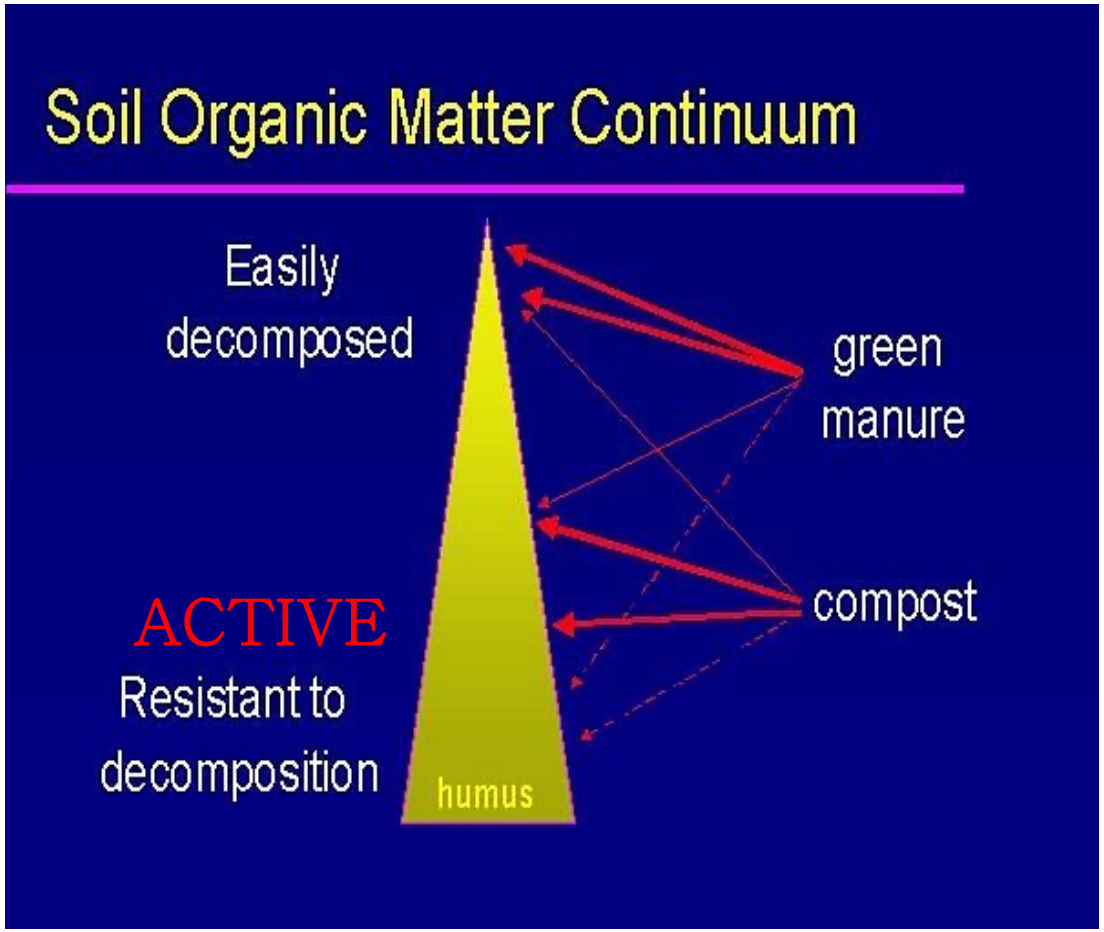
—Dead —

Recently dead soil organisms and crop residues provide the food (energy and nutrients) for soil organisms to live and function.

Also called “active” or “particulate” organic matter.

Active Fraction

- 10 to 30% of the soil organic matter (active fraction) is responsible for maintaining soil microorganisms.
- The active fraction of organic matter is most susceptible to soil management practices.
- The active fraction drives the soil microbial population and activities



Organic Matter

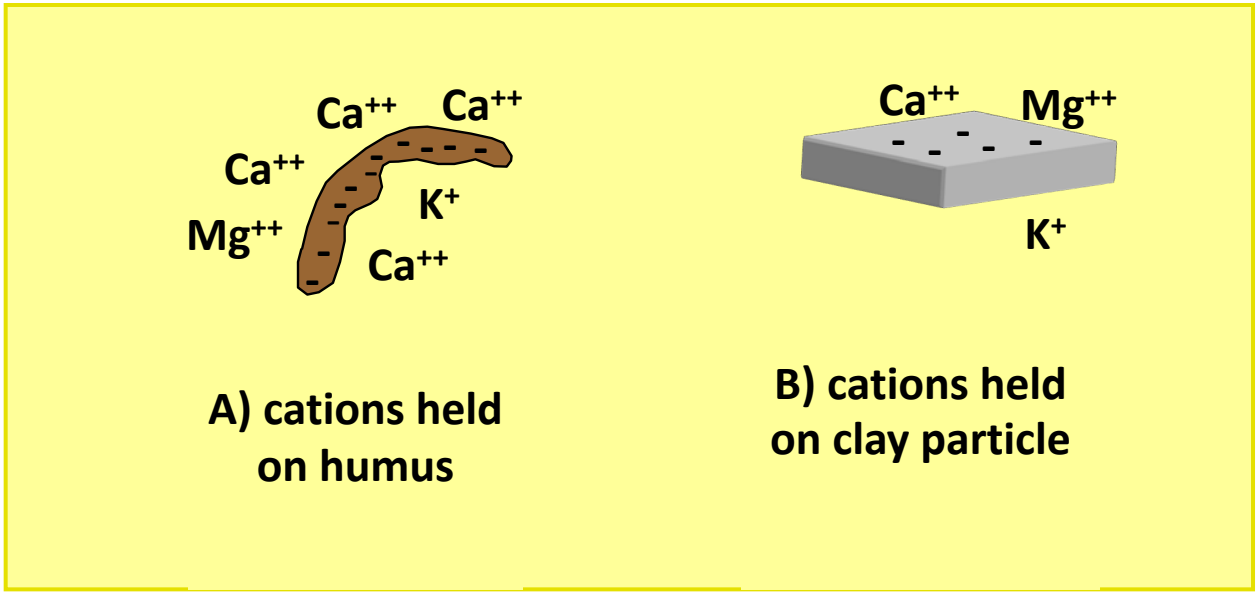
—Very Dead —

Well-decomposed organic matter ➔ **Humus**

Humus contains negative charges

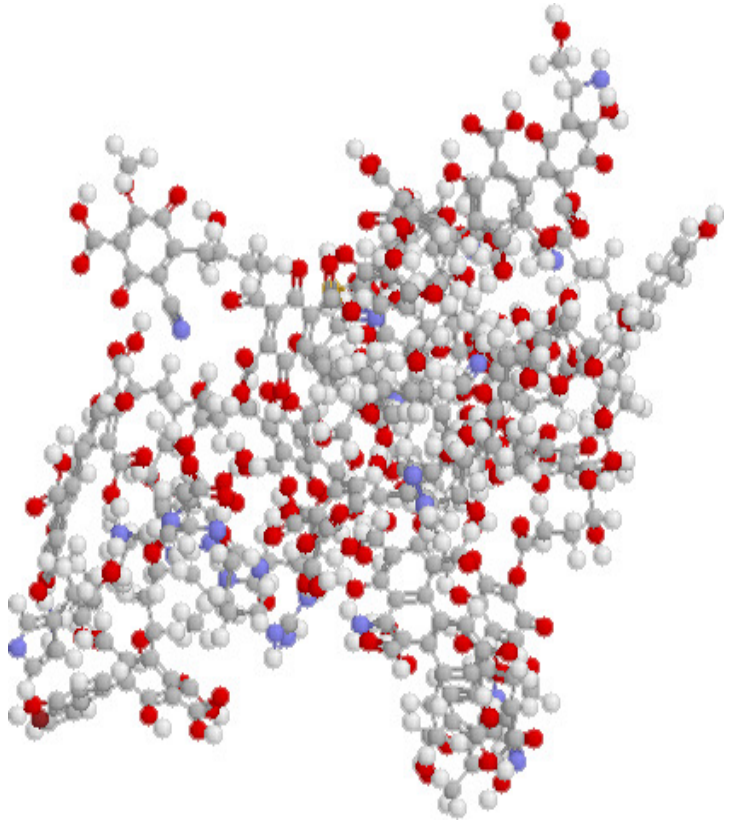
Stable Organic Matter -Humus

- Cation nutrients are held on negatively charged organic matter and clay



Stable Organic Matter -Humus

- Over time, soil organic compounds become stabilized and resistant to further changes by microorganisms
- Stabilized organic matter acts like a sponge and can absorb 2-6 times its weight in water



Organic Matter

- Adding organic matter improves the nutrient supply of the soil
- tends to reduce pesticide toxicity
- increases microbial degradation of pesticides
- increases soil biological activities
- improves soil structure
- improves water holding capacity
- prevents soil erosion

Nutrient content of organic materials

Organic Material	Nutrient Content*		Fertilizer Pounds Needed for 1 Pound of Nutrient**	
	Percent N	Percent P_2O_5	N	P_2O_5
Alfalfa hay	2.3	0.3	43	333
Blood meal	12.0	3.0	8	33.3
Bone meal	3.0	28.0	33	3.5
Compost, garden	1.0	0.2	100	500
Cottonseed meal	7.0	1.0	14	100
Fish meal	12.0	3.0	8	33
Manure - hen	1.1	0.8	98	125
Manure - horse	0.7	0.3	143	333
Manure - pig	0.5	0.3	200	333
Manure - rabbit	2.4	1.4	42	71
Manure - sheep	0.7	0.3	143	333
Manure - steer	0.7	0.3	143	333
Peanut shells	3.6	0.7	28	143
Rock phosphate	0.0	0.5	0	200
Sewage sludge	5.0	3.0	20	33
Sunflower seed oil	5.5	1.0	18	13
Wood ashes	**Do Not Use**	**Do Not Use**	**Do Not Use**	**Do Not Use**

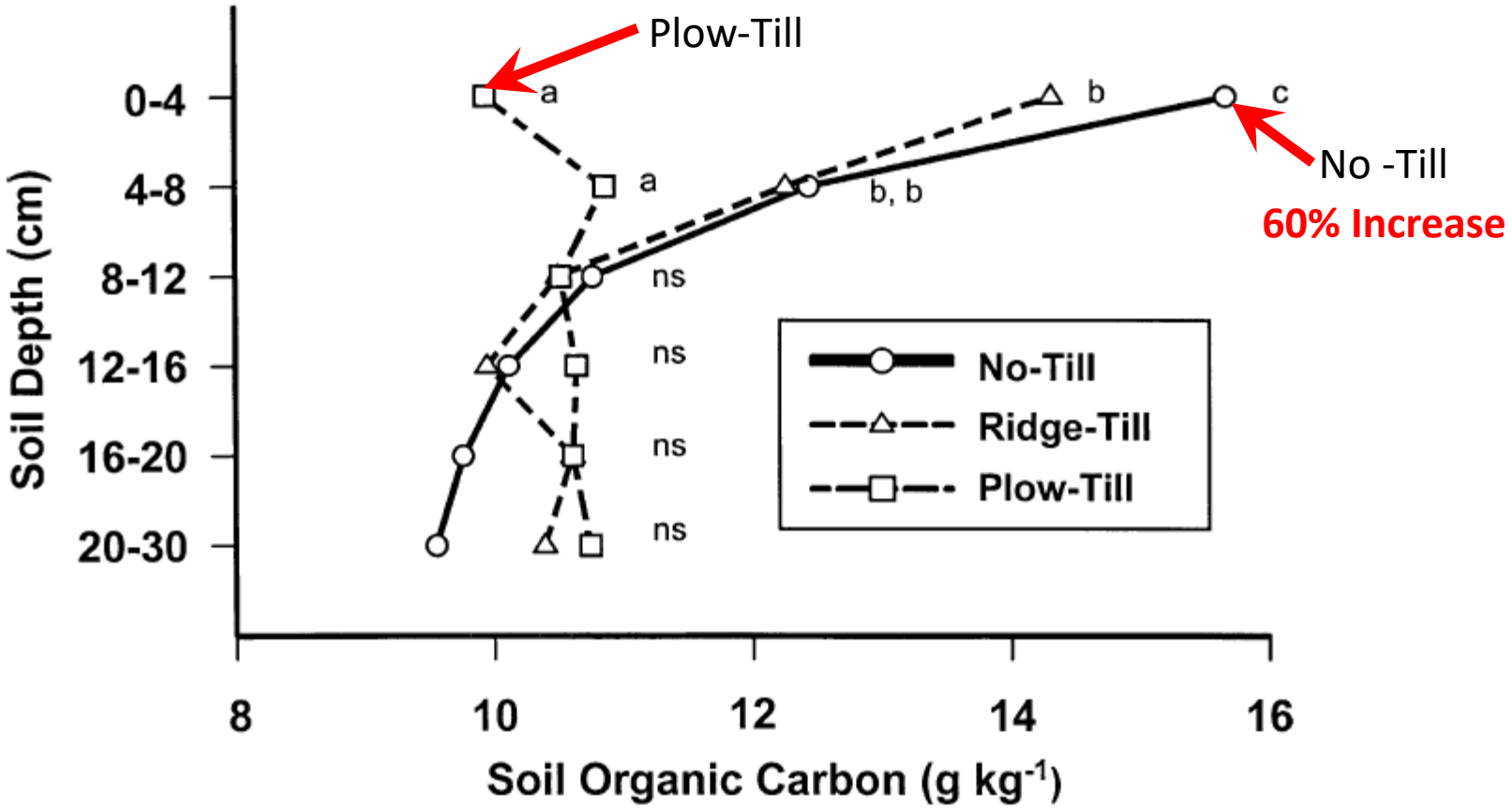
Reduced Tillage Goals

- **Enhance soil quality**
  - **Conserve soil organic matter**
  - **Conserve soil moisture**
- **Reduce erosion**
- **Reduce fuel use**
- **Optimize weed control**
- **Maintain yields**

Reduced Tillage Facts

- Depends on equipment (capital intensive)
- Depends on crop (works better for large seeds)
- Little difference between full width tillage and reduced tillage in terms of yield (short-term)
- Labor savings during early season field prep.
- Investment in long term soil health

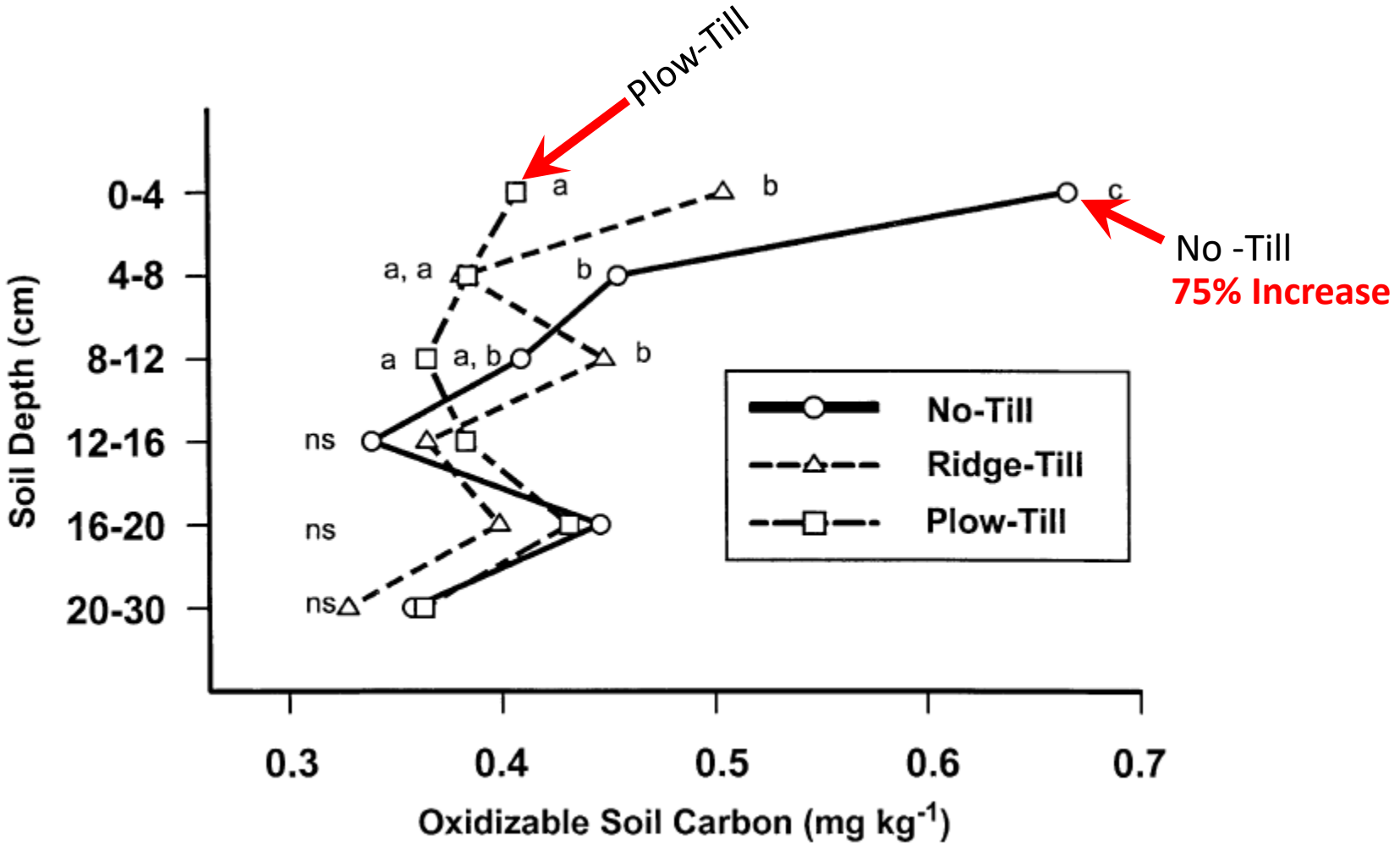
Tillage and Organic Carbon



Soil organic carbon by depth after 9 years of no-till, ridge-till, or plow-till treatment

L.M. Zibilske et al. / Soil & Tillage Research 66 (2002) 153–163

Tillage and Active Carbon



Oxidizable carbon by depth after 9 years of no-till, ridge-till, or plow-till treatment

L.M. Zibilske et al. / Soil & Tillage Research 66 (2002) 153–163

Cover Crops

- Cover crops can help prevent erosion
- reduce leaching of nutrients by serving as catch crops
- can help alleviate soil compaction
- can help suppress perennial and winter annual weeds
- can add organic matter to the soil

Important:
- what is your goal?
- selection of proper cover crop
- seeding time
- good management techniques

Crop Rotation

- Good crop rotation can break the disease cycle
- Decrease pest pressure from insects, weeds, and diseases
- Enhances soil biological diversity
- Enhances sustainable cropping systems

Merits/demerits of using proprietary products from different vendors

- Beware of “magical products”
- Query the science of the product
- Ask for University research on the product
- If you are convinced of the science, test out the product in a way that you can see the difference
- Evaluate the cost-to-benefit ratio of the product, especially those that need to be applied yearly


Thanks!