Principles of Soil Health Management

John Idowu

Extension Agronomist, New Mexico State University

April 24th, 2014

Extension Plant Sciences Online Training Series

Contact: John Idowu
Email: jidowu@nmsu.edu
Phone: 575-646-2571

NM STATE

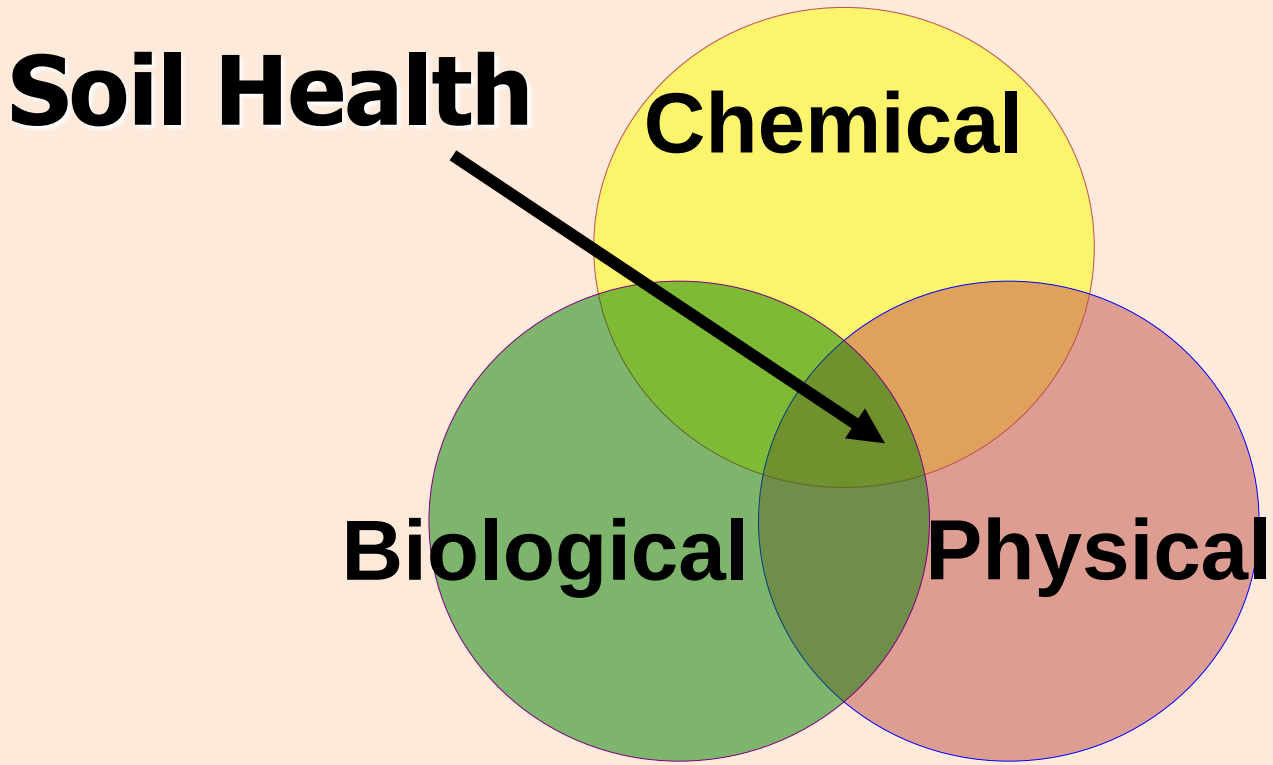
Presentation Contents

- What do we mean by “Soil Health”
- Why is soil health important
- Soil health issues on farms
- Some strategies for overcoming soil health constraints

What is Soil Health (Quality)?

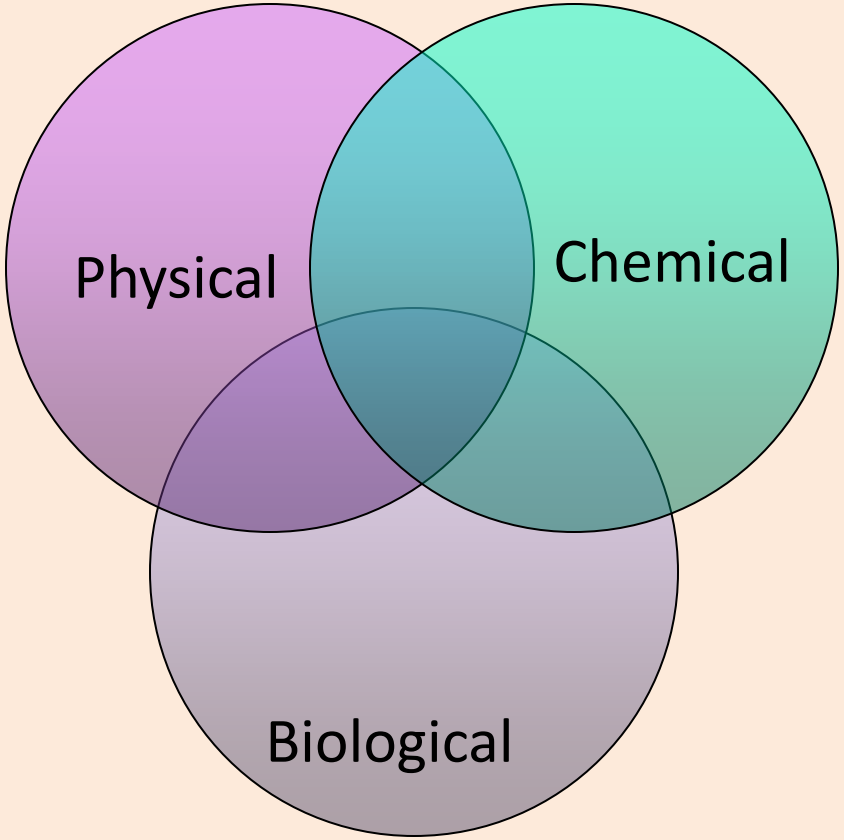
- Ability of the soil to support crop growth … (Power & Myers, 1989)
- Capacity of the soil to function in a productive and sustained manner … (NCR-59 Madison WI, 1991)
- The capability of the soil to produce safe and nutritious crop …. (Parr et al., 1992)
- Fitness for use (Pierce & Larson 1993)

Approach to Soil Health



Soil Health Indicators

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



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

- Soil disease suppressive capacity
- Beneficial and pathogenic nematodes, [other pathogens]
- N mineralization rate (PMN)

- Decomposition rate
- Respiration rate
- Earthworm counts
- *% OM*
- *"Active" C, N in OM*

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

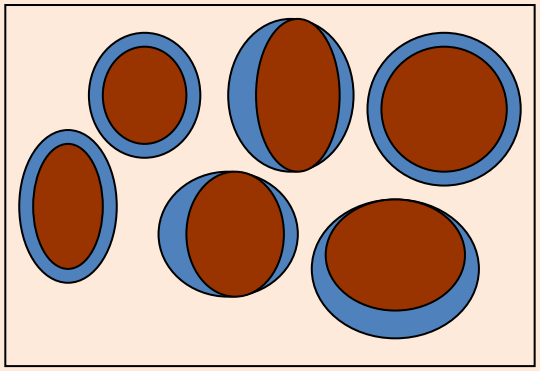
Aggregation as a function of soil management

Low water retention

Affects

- Plant water availability
- Susceptibility to drought
- Reduced yield of crops

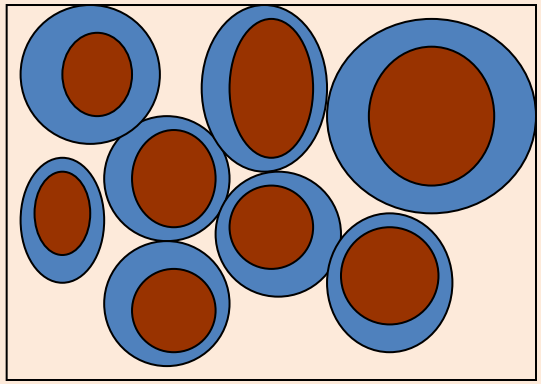
Soil water relationships



Adhesion water

All pores drained

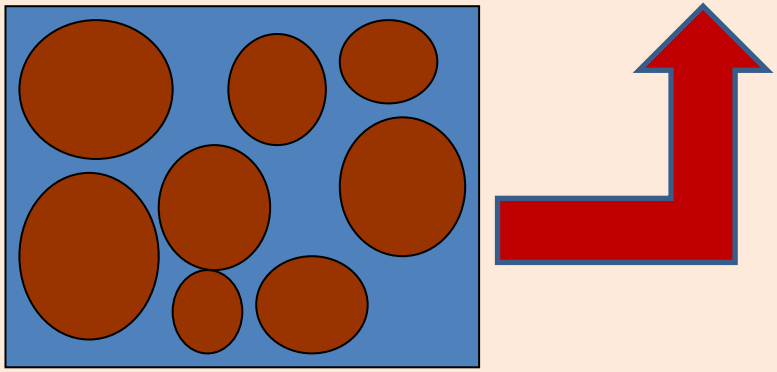
Wilting point



Micropores full; macropores have air

Macropores drained

Field Capacity



All pores full

Saturated Soil

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 mostly soil dependent**

Soil water availability – Plant Available Water Capacity

- ***Plant Available Water Capacity (PAWC)*** – the amount of water available for the growth of a crop
  - Often less than the AWC
  - It is soil dependent (**Organic Matter Important**)
  - Some crops can survive in drier soil than others
  - PAWC may vary for different crops in the same soil

Compaction

Affects

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

Roots in loose or compacted soil

Soil Compaction

How compaction occurs

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

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 of 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

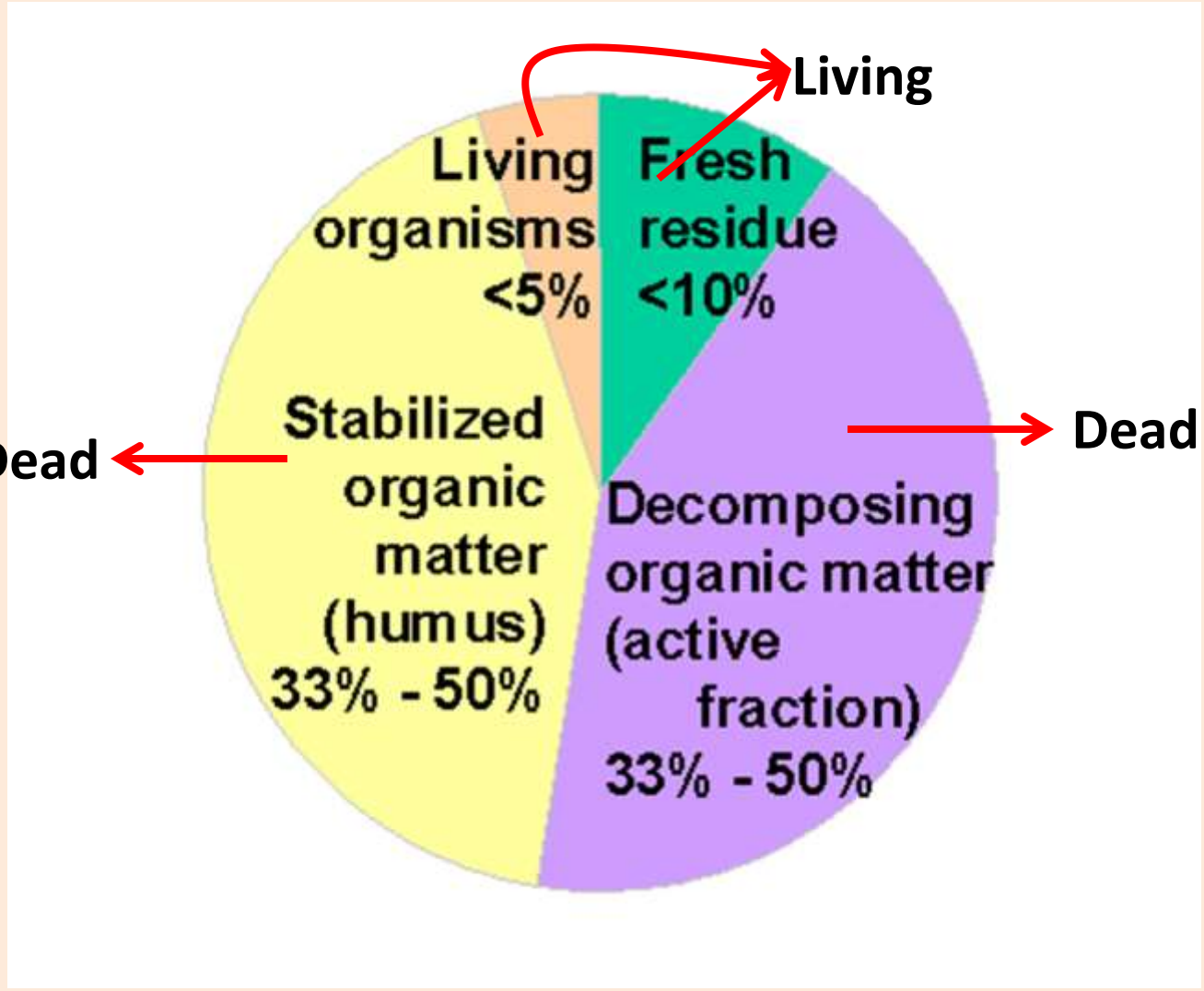
–Diversity of Flora and Fauna

–Soil Nitrogen Mineralization

–Organic Matter Decomposition

–Soil Borne Pathogens

Types of organic matter



Organic Matter

—Living —

organisms of various sizes such as bacteria, fungi, nematodes, earthworms, mites, springtails, moles, etc.

plant roots

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 gives 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

Potential of legumes to add N to Soil

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

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

NM STATE

Barley after sesbania summer legume

Oats after sesbania summer legume

Wheat after sesbania summer legume

Rye after sesbania summer legume

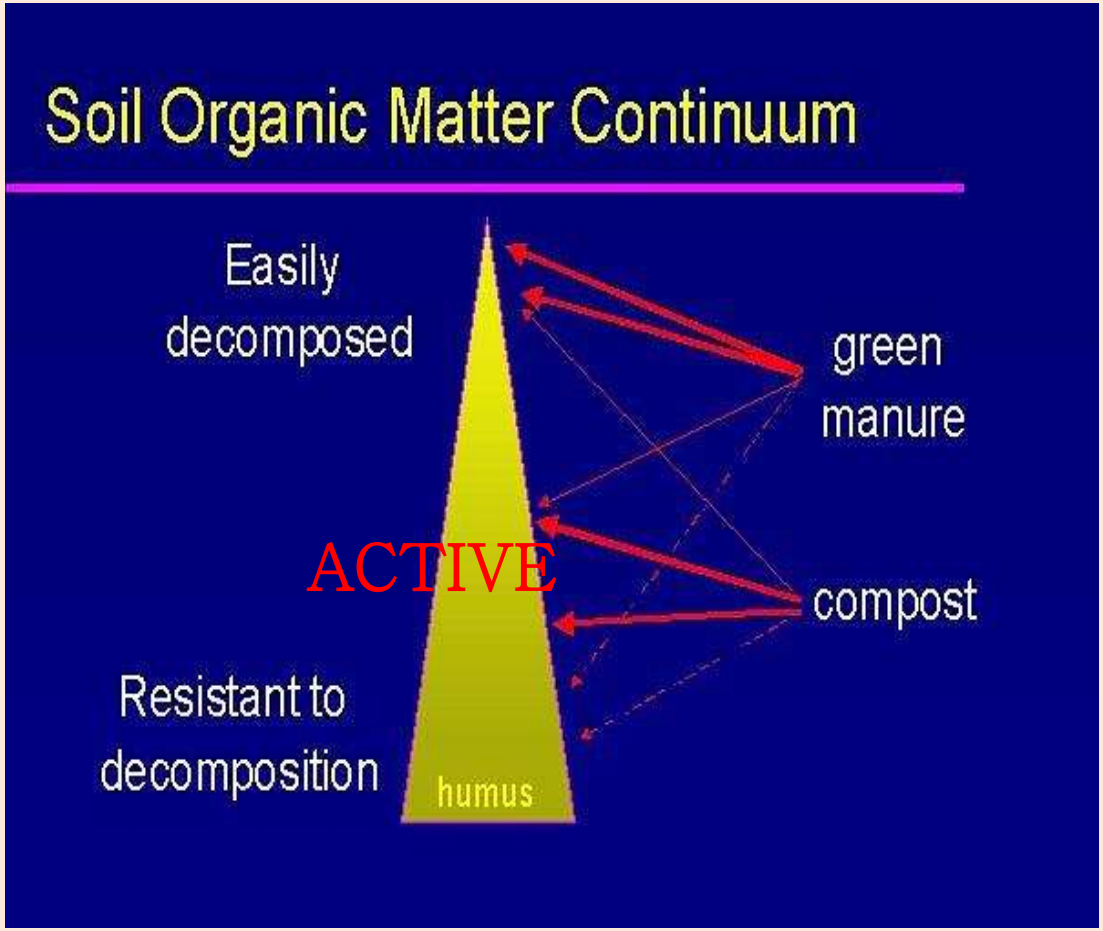
Organic Matter ➔ Active Fraction

—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.



Organic Matter

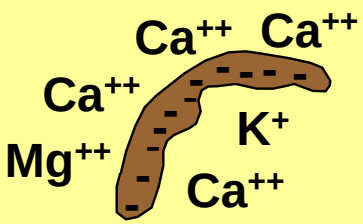
—Very Dead —

Well decomposed organic ➔ **Humus**

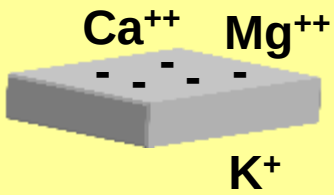
Humus contains very high amounts of negative charge

Stable Organic Matter -Humus

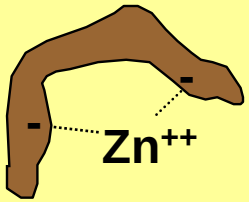
- Cation nutrients are held on negatively charged organic matter and clay



a) cations held on humus



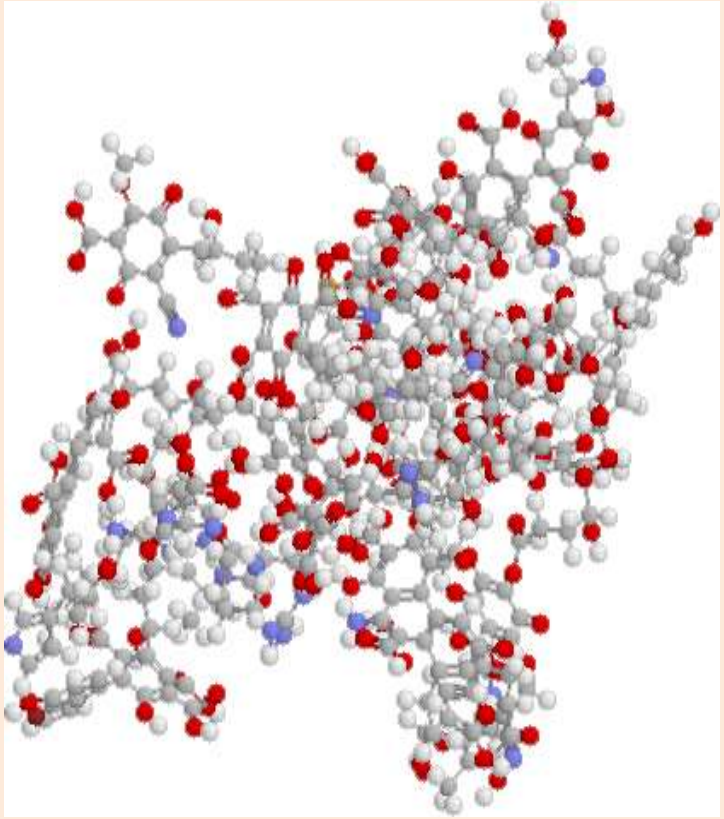
b) cations held on clay particle



c) cations held by organic chelate

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



Improving Soil Health

- Long-term Thinking and Strategy

Basic Methods (Toolbox)

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

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

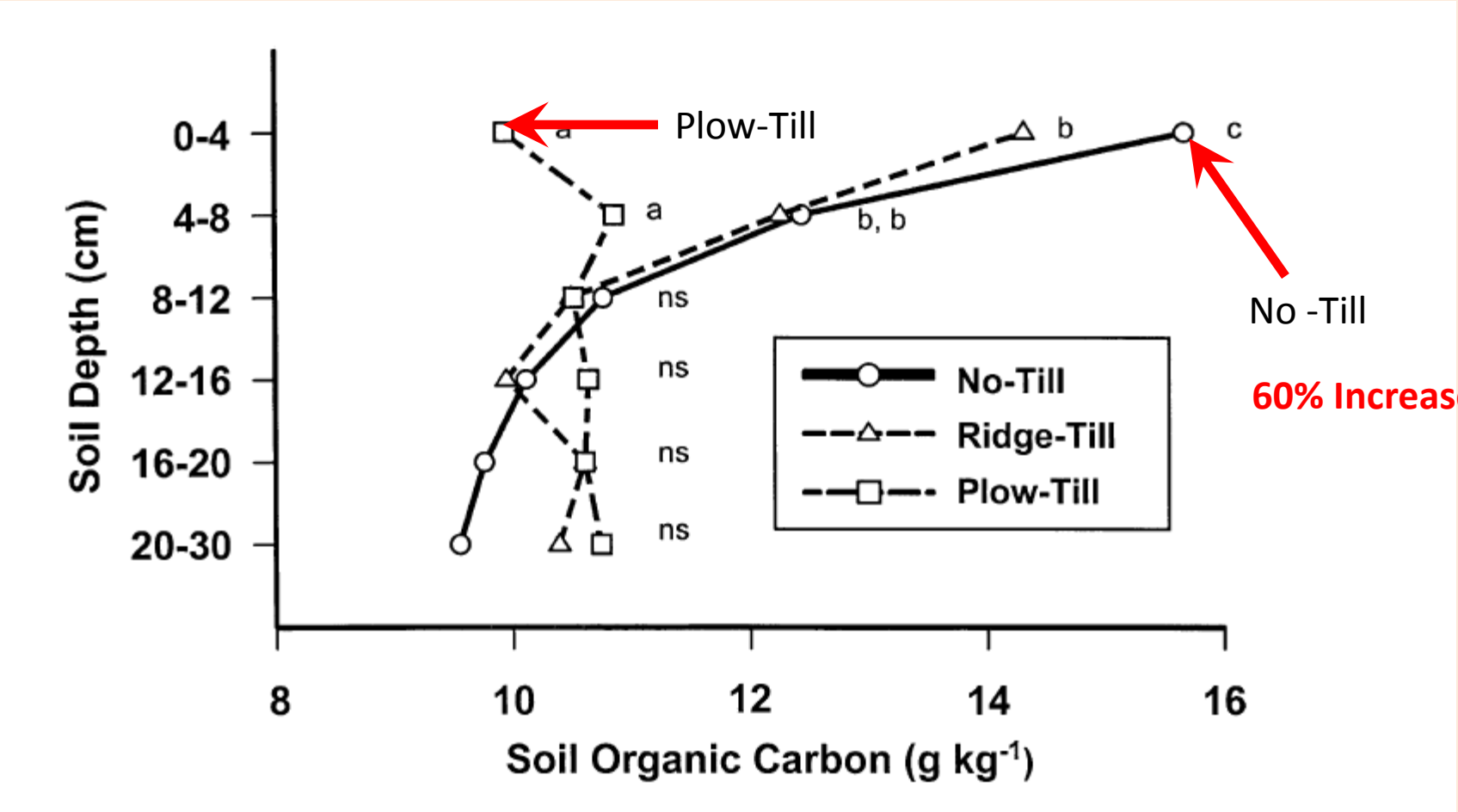
Reduced Tillage Goals

- 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

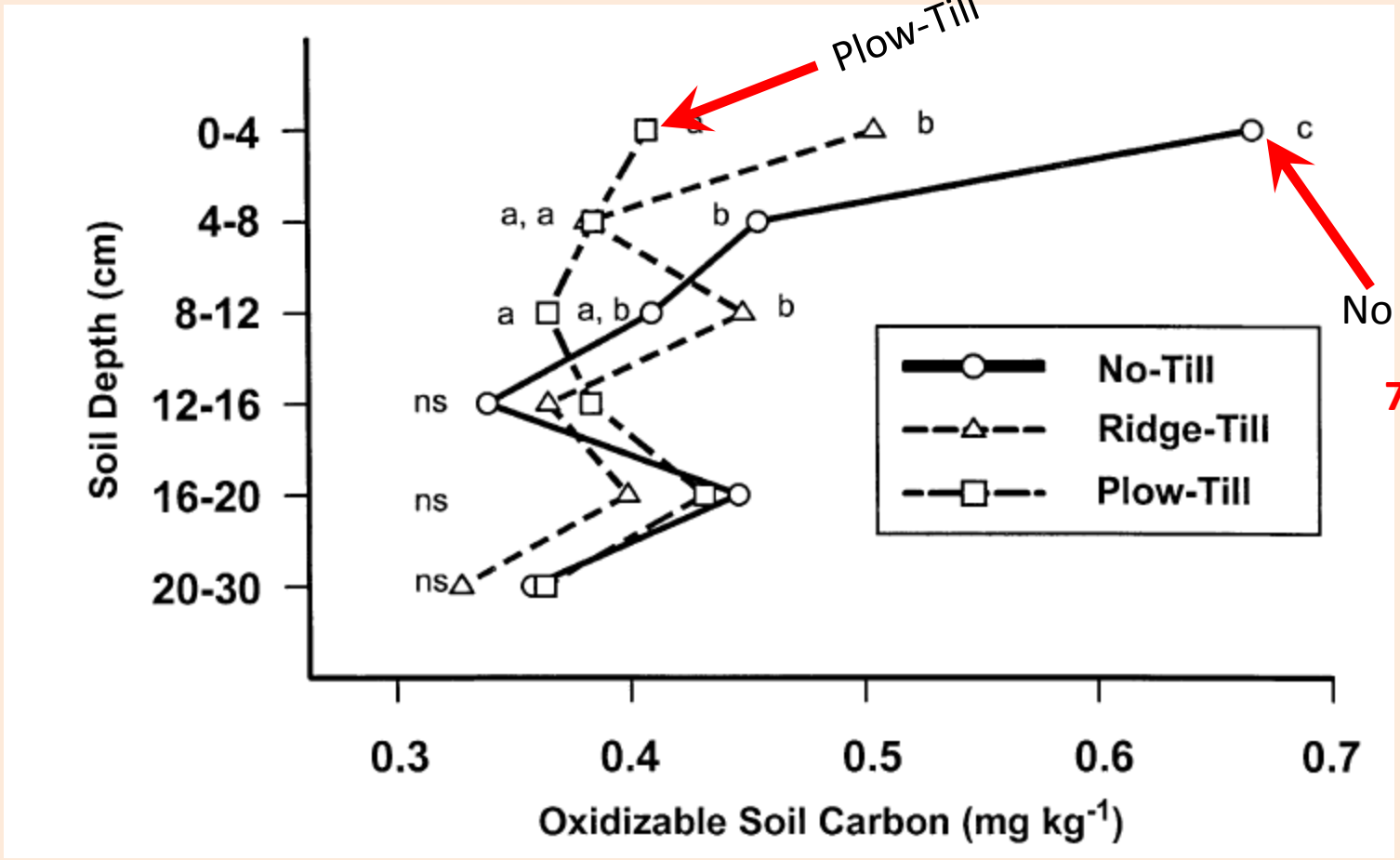
Tillage and Organic Carbon



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

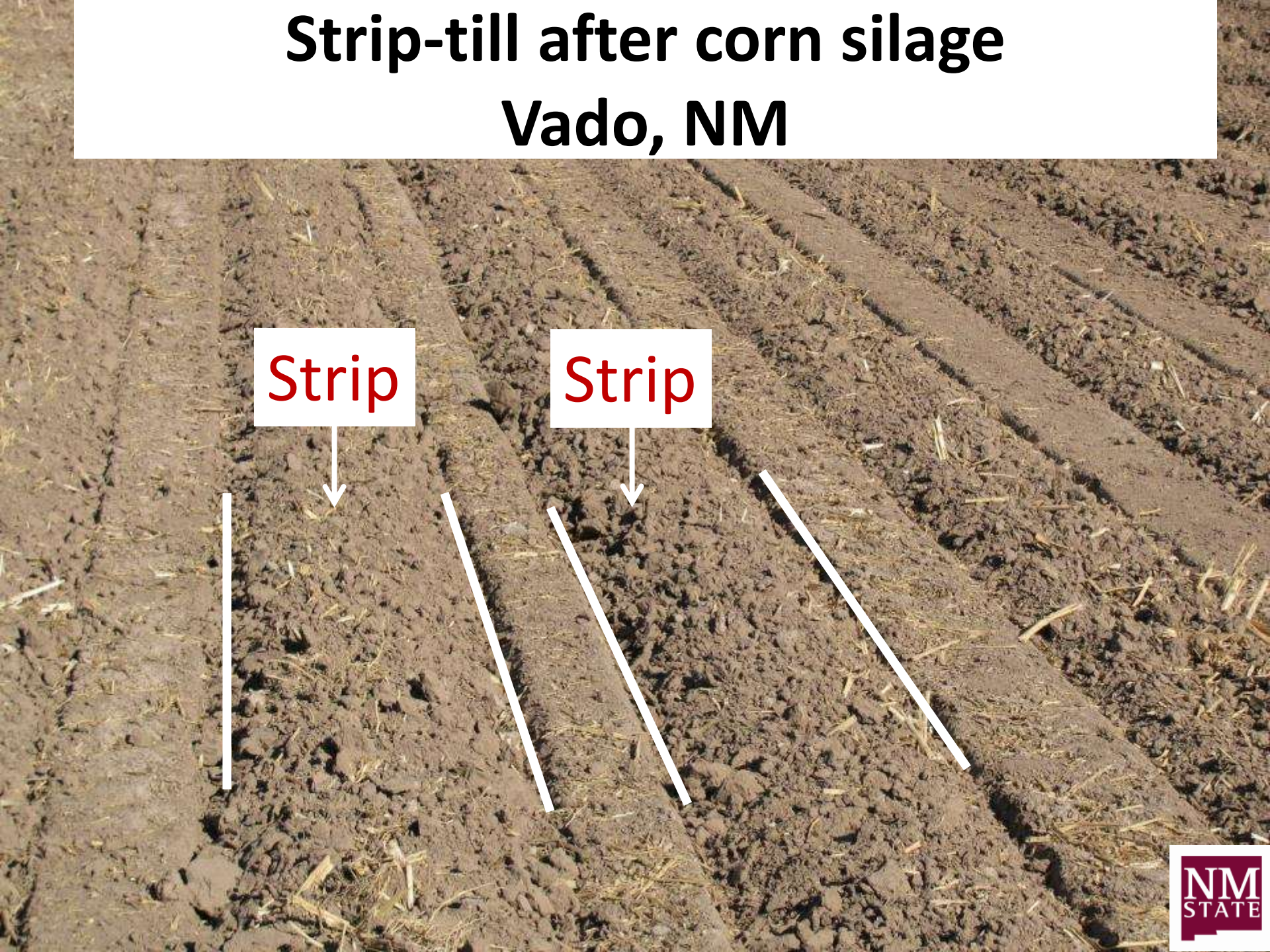


Oxidizable carbon by depth after 9 years of no-till, ridge-till or plow-till treatment

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

No-till wheat after corn silage
Vado, NM

Strip-till after corn silage
Vado, NM

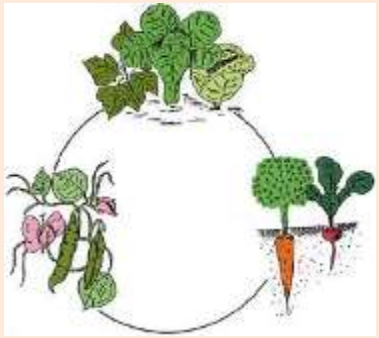


Cover Crops

- 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

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

Crop Rotation

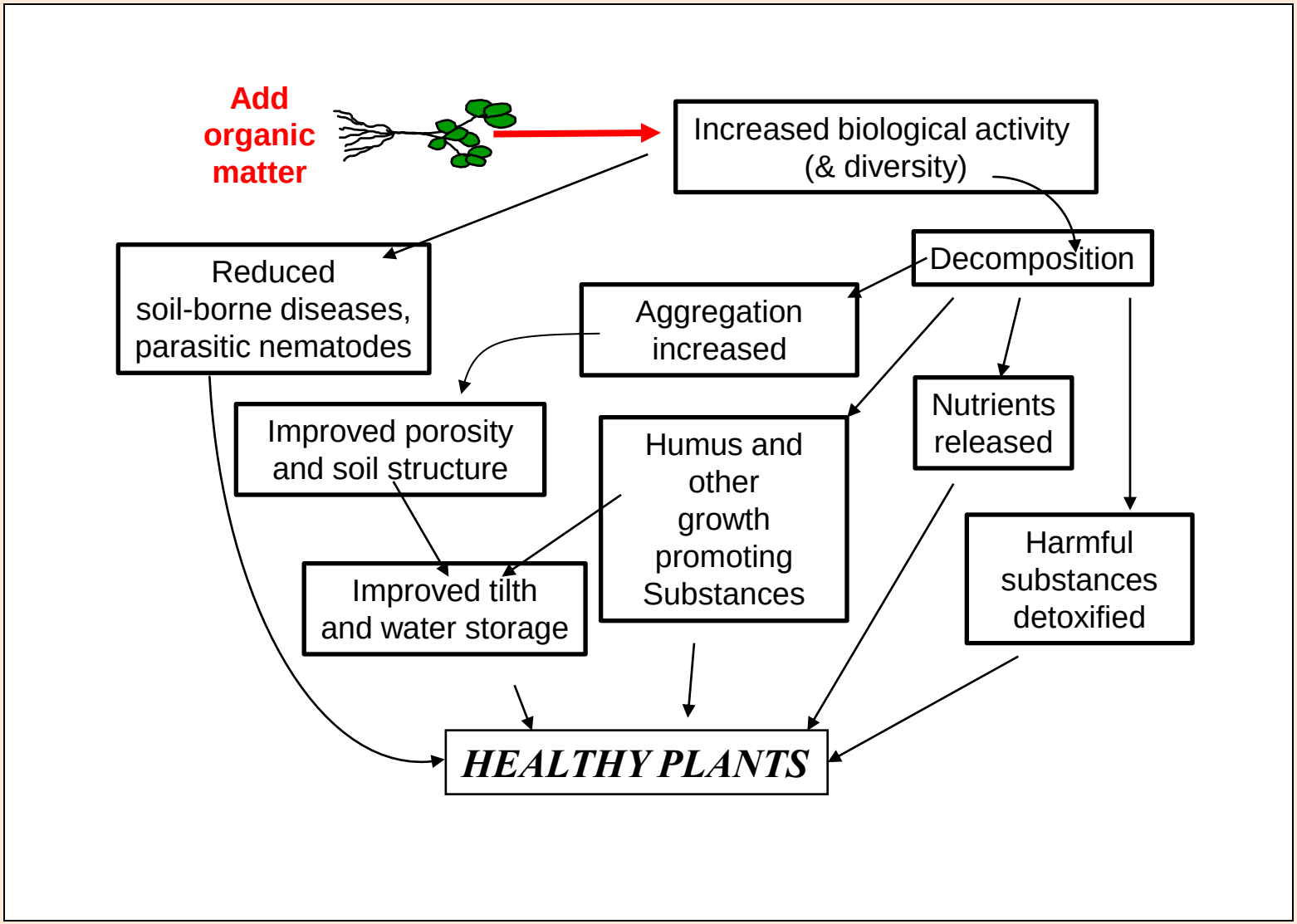


- Good crop rotation can break disease cycle
- decrease pest pressure from insects, weeds and diseases
- enhances soil biological diversity
- enhances sustainable cropping systems

Organic Matter

- Adding organic matter improves 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

Adding organic matter results in many changes.



Modified from Drinkwater and Oshins, 1998.

Animal Manures

- Cow manure
  - Good general nutrient source (especially K)
  - OM benefit depends on amount of bedding
  - Can carry weed seed
- Poultry manure
  - Potent source N, P, Zn, and lime
  - Organic matter addition is relatively low
  - Best if composted
- Horse manure
  - Heavily bedded with wood shavings
  - **Nitrogen availability can be a problem in the first year**

Peat Moss

- Improves soil moisture retention
- Minor improvement to nutrient holding capacity
- Provides negligible nutrient benefit
- High proportions may make soil hydrophobic

Materials to Avoid

- Sawdust, wood shavings, wood chips
  - very high carbon/nitrogen ratio
  - will tie up all available N during breakdown (immobilization)

- Worst when tilled in
  - minor detrimental effect if used as mulch

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**


Thanks!