Soil Quality and Sustainable Agriculture









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Soil and Sustainable Agriculture

- Maintain productivity with reduced external inputs
- Provide ecosystem services
 - Support plant growth
 - Cycle nutrients
 - Hold and release water
 - Exchange gases
 - Conserve natural enemies and suppress pests
 - Store carbon



Soil Quality

- The ability of a soil to function within ecosystem boundaries to support healthy plants and animals, maintain or enhance air and water quality, and support human health and habitation
- Soil quality integrates the physical, chemical and biological condition of the soil



In 1 teaspoon of healthy soil there are...

- 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



Travis & Gugino - PSU



Ecosystem Services Provided by Soil Organisms

- Many beneficial effects by activities of soil organisms
- Decomposition and mineralization
- Contribute to plant nutrition (*Rhizobia*, Mycorrhizae)
- Soil aggregation, aggregate stability, and porosity
- Infect, compete with or antagonize pests



Predatory Mite





Insect-parasitic Fungus

Earthworms and other ecosystem engineers



Ground and rove beetles

What Do Soil Organisms Need?



Soil Disturbance in Agriculture







Some Effects Associated with Tillage

- Soil organisms more abundant and more diverse in systems that reduce soil disturbance
- Organisms vary in sensitivity
- Tillage increases fluctuations in:
 - Soil Moisture
 - Soil Temperature
 - Crop Residue and SOM
- Soil Mixing
- Disruption of soil structure
- Erosion risk



Soil Organic Matter Management as a Balancing Act

Equilibrium level of SOM attained



•Roots

- Leaves
- •Mulches
- •Manures
- •Composts

SQ in Organic vs. No-Till

Sustainable Agriculture Demonstration Project, USDA, Beltsville, MD 1994-2002

Total Soil C, 2002

Total Soil N, 2002



Teasdale et al., 2007. Agron. J. 99: 1297-1305.

SQ in Organic vs. No-Till

Sustainable Agriculture Demonstration Project, USDA, Beltsville, MD 1994-2002 Uniformity Trial

System 1994-2002	Grain Yield, 2004 (Mg/ha)	Soil Nitrate N, 2004 mg/kg	Corn Ear Leaf N, 2004 (%)
No-Till*	5.8	14.8	2.49
Organic	6.7	21.0	2.99

*All significant at P< 0.05

Teasdale et al., 2007. Potential Long-Term Benefits of No-Tillage And Organic Cropping Systems for Grain Production and Soil Improvement. Agron. J. 99: 1297-1305. Crop rotation and sustainable agriculture: Effects of crop rotation on soil quality and productivity

R. Weil, Univ. MD



Management and Conservation of Biological Control

- Goal: Improve environment for beneficial organisms and processes
- "Farmscaping": provide resource plants or habitats, e.g.,
 - pollen and nectar resources required by many insect natural enemies and pollinators
 - refuge strips of flowering plants, hedgerows
 - beetle banks or grassy drive lanes
 - perennial crops
 - cover crops



Cover Crops and Ecosystem Services

- Cover crops can enhance numbers of soil organisms
- Add diversity to system
- Add food resources for beneficial insects – pollen and nectar
- Residue creates habitat for predators
- Compete with weeds
- Protect soil
- Soil fertility and nutrient retention



Hairy Vetch



Buckwheat

Mustard

Photos: T. Pisani Gareau

Summary: Agricultural Management for Soil Quality and Ecosystem Services

- Continuous resources
 - e.g., hay/pasture, perennial crops, mulches, cover crops, high root:shoot ratio, controlled grazing, composts, manures
- Plant and management diversity
 - e.g., crop rotation, refuge strips, hedgerows, polycultures, cover crops
- Reduce disturbance
 - e.g., woodlands/orchards, pasture, reduce or rotate tillage, refuges, perennial crops or cover crops, reduce biocides





The End

Photo by M. Greenwood

Ecosystem Service: Mineralization and Immobilization

Organisms consume SOM and other organisms and excrete inorganic wastes

Organic nutrients are stored in soil organisms and organic matter



Inorganic nutrients are usable by plants, and are mobile in soil

Organisms take up and retain nutrients as they grow

Suppression of Plant Disease and Pests

Induction of Systemic Acquired Resistance

Systemic Acquired Resistance



Plant Growth Promoting Rhizobacteria

Travis and Gugino

PGPR-Cucumber Beetles-Bacterial Wilt

- Beetles prefer plants high in bitter cucurbitacin
- PGPR reduce bitter cucurbitacins in cucurbit plants
- Plants less attractive to beetles
- Less feeding damage
- Less bacterial wilt









In Bt-corn, neonicotinoid seed treatments major mortality factor for carabids - not Cry3Bb1

Spring-emerging ground beetle adults (e.g., Scarites quadriceps) risk mortality by direct or indirect exposure to neonicotinoids

