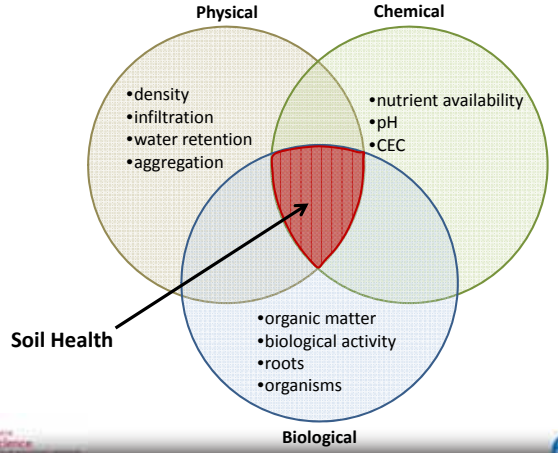
Soil Health for Wisconsin

Francisco J. Arriaga
Assistant Professor and Extension Soil Scientist
Soil and Water Management
UW-Extension and Dept. of Soil Science

Winter Farmer Forum
January 13, 2017

Soil Health Indicators
(**or** Soil Properties that Influence Function)



Proposed Basic Soil Health Indicators
-- What to Measure? --

Table 1-1. Proposed soil physical, chemical, and biological characteristics to be included as basic indicators of soil quality.

Soil characteristic	Methodology	Reference for methodology or interpretation, comments
	Physical	
Soil texture	Hydrometer method	Gee & Bauder, 1986
Depth of soil and rooting	Soil coring or excavation	Taylor & Terrell, 1982
Soil bulk density and infiltration†	Field determined using infiltration rings	Blake & Hartge, 1986
Water holding capacity†	Field determined after irrigation of rings	Cassel & Nielsen, 1986
Water retention characteristics	Water content at 33 and 1500 kPa tension	Klute, 1986
Water content†	Gravimetric analysis; wt. loss, 24 h at 105 °C	Sampled in field before and after irrigation
Soil temperature†	Dial thermometer or hand temperature probe	Measured at 4-cm soil depth
	Chemical	
Total organic C and N	Wet or dry combustion, *volumetric basis*‡	Nelson & Sommers, 1982; Schulte, 1988
pH	Field or lab determined, pocket pH meter	Eckert, 1988; 1:1 soil/water mixture
Electrical conductivity	Field or lab, pocket conductivity meter	Dahnke & Whitney, 1988; 1:1 soil/water
Mineral N (NH_4 and NO_3), P, and K	Field or lab analysis, *volumetric basis*	Gelderman & Fixen, 1988; Knudsen & Beegle, 1988; 2 *M* KCl extract for NH_4 and NO_3
	Biological	
Microbial biomass C and N	Chloroform fumigation/incubation, *volumetric basis*	Parkinson & Paul, 1982
Potentially mineralizable N	Anaerobic incubation, *volumetric basis*	Keeney, 1982
Soil respiration†	Field measured using covered infiltration rings, lab measured in biomass assay	Anderson, 1982; CO_2-specific gas analysis tubes (Draeger)
Biomass C/Total org. C ratio	Calculated from other measures	Estimate of ecosystem stability; Visser & Parkinson, 1992; Chapt. 5, this book
Respiration/biomass ratio	Calculated from other measures	Visser & Parkinson, 1992; Chapt. 5, this book

† Measurements taken simultaneously in field for varying management conditions, landscape locations, and time of year.
‡ Gravimetric results must be adjusted to volumetric basis using field measured soil bulk density for meaningful interpretations.

(Doran and Parkin, 1994)

Three Step Program

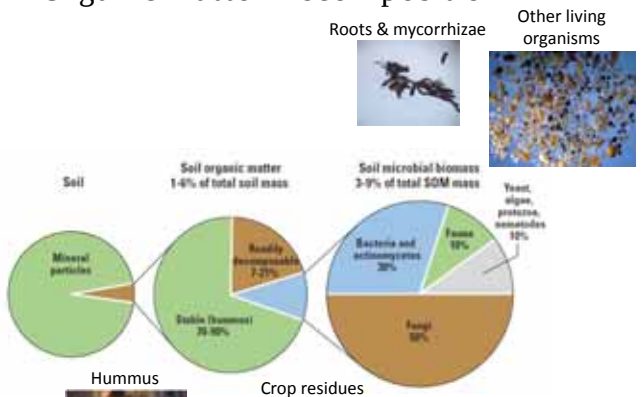
Step 1. Maintain Proper Soil Fertility

- It is important for crop production to begin with soils that are properly managed from a fertility stand point.
- The acidity of the soil, or pH, is one such fertility parameter that must be managed to have adequate conditions for the biology of the soil and crops.

Step 2. Increase/Maintain Soil Carbon

- The total amount of soil organic carbon in the soil is important.
- Crop rotations and cover crops can help add soil organic carbon variety to the soil.

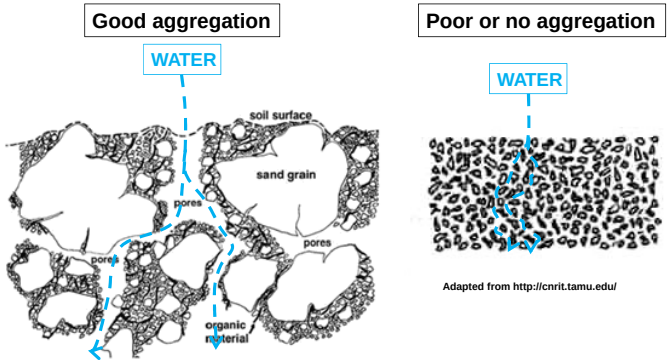
Organic Matter Decomposition



(Al-Kaisi,2016)

Step 3. Improve Soil Aggregation

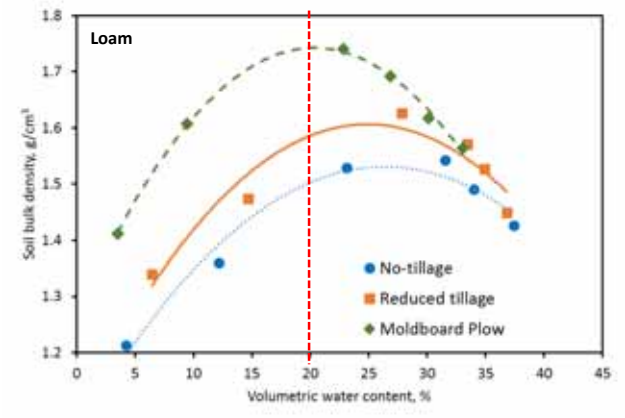
Aggregation, Water Infiltration and Flow in Soils



Adapted from http://vro.depi.vic.gov.au/

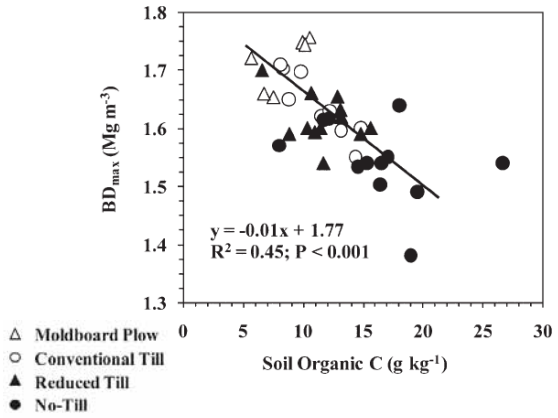
Adapted from http://cnrit.tamu.edu/

Soil Aggregation and Soil Compaction



(Blanco-Canqui,2009)

Aggregation and Soil Compaction (cont.)

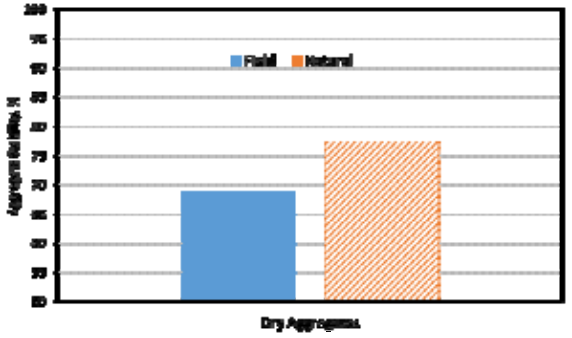


(Blanco-Canqui,2009)

Dry Aggregate Size Distribution

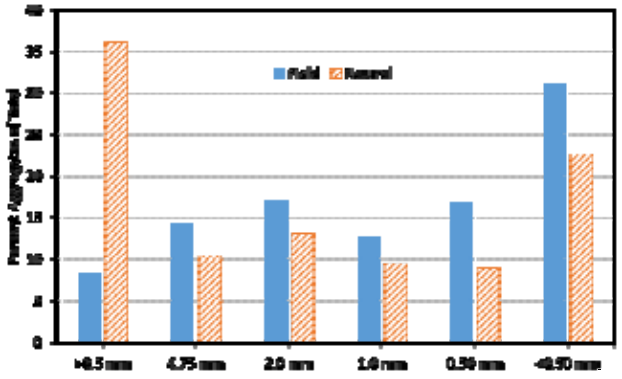
- Stack of sieves of different size openings:
  - 9.5 mm
  - 4.75 mm
  - 2.0 mm
  - 1.00 mm
  - 0.50 mm
  - Pan ("loose soil)

Dry Aggregate Stability



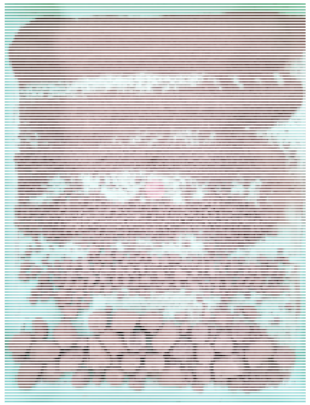
Dry Aggregate Size Distribution

2016

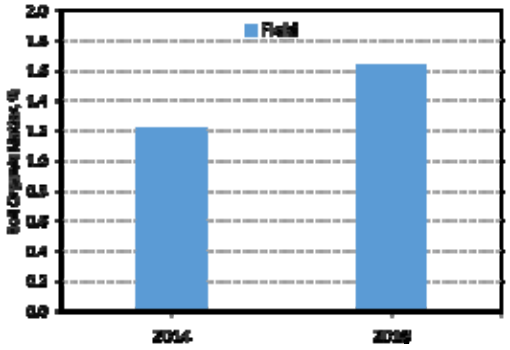


Dry Aggregate Size Distribution

Field **Natural**



Soil Organic Matter



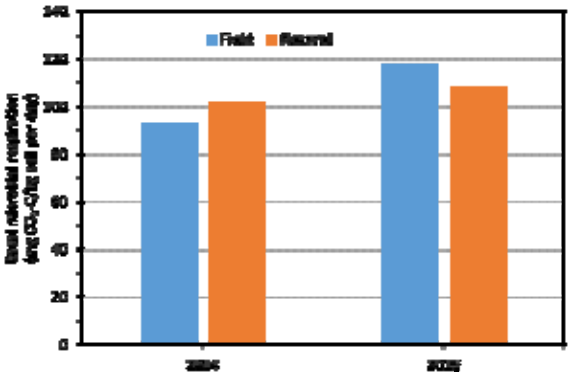
At current organic carbon accumulation rates, it would take:

- 1.7 years to reach a SOM of 2%
- 6.6 years to reach a SOM of 3%

Microbial Activity

- Soil incubation in mason jar
- Sodium hydroxide (NaOH) trap
  - $NaOH + CO_2 \rightarrow HCO_3 + NaHCO_3$
- Titrate with hydrochloric acid (HCl) using a pH dependent color indicator
- Basal respiration provides an indication of microbial activity

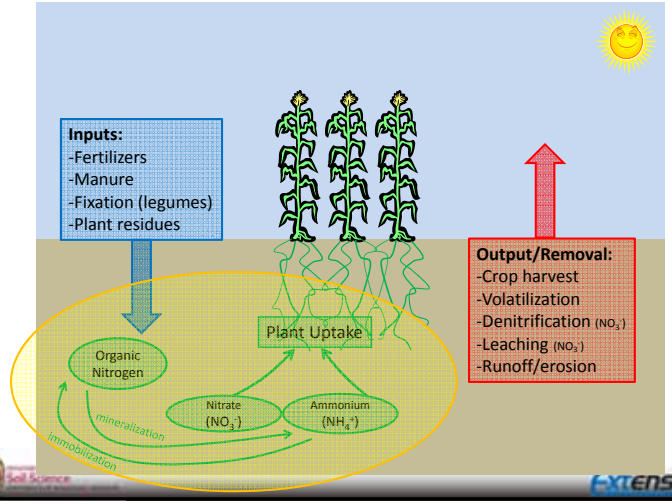
Microbial Activity



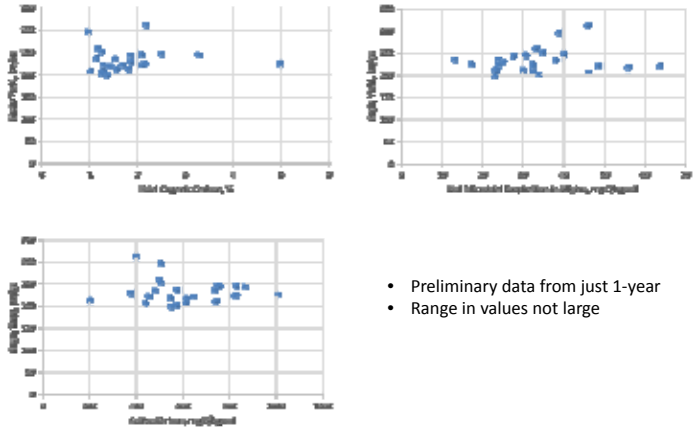
Soil Health Measurements for NUE Project

- Total organic carbon
  - total dry combustion
- Soil microbial respiration
  - 24 hour after re-wetting
- Biologically active carbon
  - $KMnO_4$ oxidizable carbon (POxC)
- Potentially mineralizable nitrogen

Simplified Nitrogen (N) Cycle

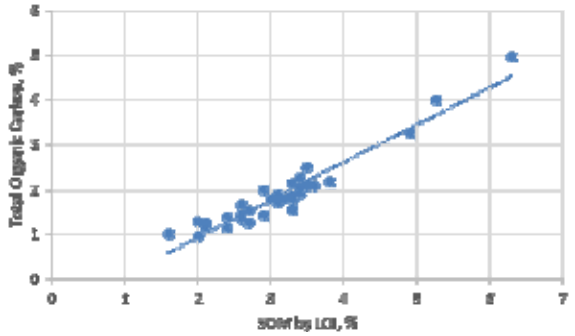


Yield versus Some of the Measures

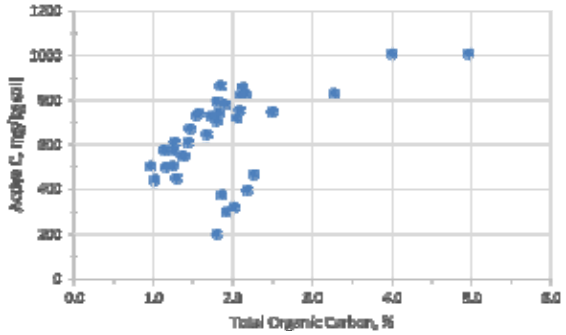


- Preliminary data from just 1-year
- Range in values not large

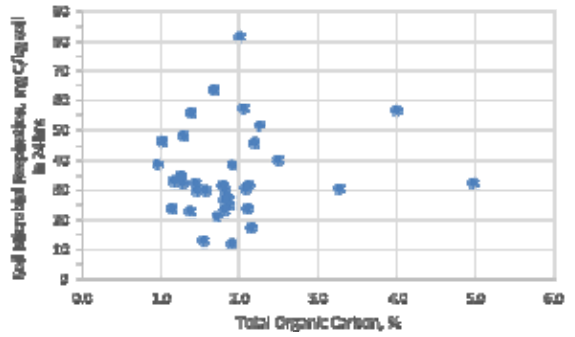
SOM by Loss-on-ignition versus Total Organic Carbon



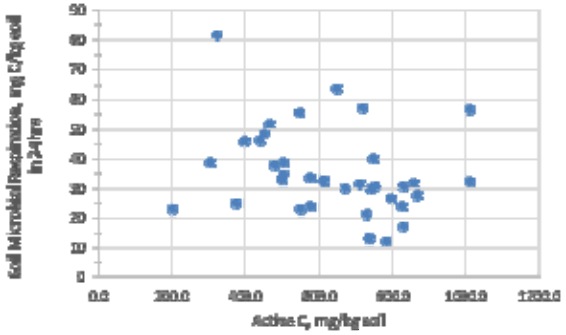
Total Organic Carbon versus Active Carbon



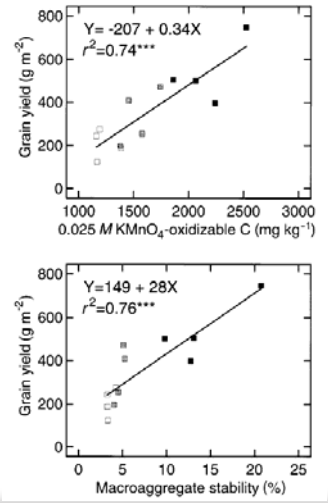
Total Organic Carbon versus Soil Microbial Respiration



Active Carbon versus Soil Microbial Respiration



Corn Yield



Tillage:
- conventional
- reduced
- no-till

(Stine & Weil, 2002)

Tillage & Soil Health Biological Indicators

Continuous Corn System with Residue Harvest (32 years)

		OM	Nem $_P$	Nem $_B$	Decomp	PMN	EEG	TG
		-- % --	-- #/100g soil --		- %/wk -	- ppm/wk-	--- mg/g soil ---	
No till	unharvested	5.39 a	80 ab	320 a	8.93 a	1.73 a	1.73 a	6.63 a
	harvested	4.99 a	125 a	1140 a	2.45 b	1.65 a	1.12 b	4.90 b
	NT mean	5.19 A	103 A	730 A	5.69 A	1.69 A	1.42 A	5.76 A

- No-tillage had a larger positive impact on improving indicators than returning corn residue to soil
- Most sensitive indicators were: **Db, AWC, OM, Decomp and TG**

OM- Soil organic matter
Nem $_P$ – Parasitic nematodes
Nem $_B$ – Beneficial nematodes
Decomp – Cellulose decomposition rate
PMN – Potentially mineralizable N
EEG – Easily extractable glomalin conc.
TG – Total glomalin concentration

(Moebius-Clune et al.,2008)

Closing Thoughts

- Soil health is the ability of a soil to function in a way that benefits both humans and the environment:
  - medium plants to grow, recycling nutrients, habitat for organisms, and system for water supply and purification.
- The three steps presented here are key for productivity of Wisconsin soil:
  1. Maintain proper soil fertility
  2. Increase/maintain soil organic carbon
  3. Improve soil aggregation
- Patience and a steady hand at the tiller are key.

CT **Roto-tilled** **NT**

Organic matter oxidation
Conc. H_2O_2

NT **Roto-tilled** **CT**

Aggregate stability
Slake test

photos: F. Arriaga, Soil Science

Francisco J. Arriaga
farriaga@wisc.edu
Office phone: 608-263-3913