Evaluation of Soil Quality

Rafiq Islam, Ph.D.

Ohio State University South Centers

islam.27@osu.edu

Tel. 614-292-4900 ext 147

Soil quality is the capacity of the soil to perform functions related to

- Plant growth and food production
- Air and water quality
- Recycling of disposed materials
- Construction and engineering
- Animal and human health/nutrition
- Public health and sanitation

in response to management practices

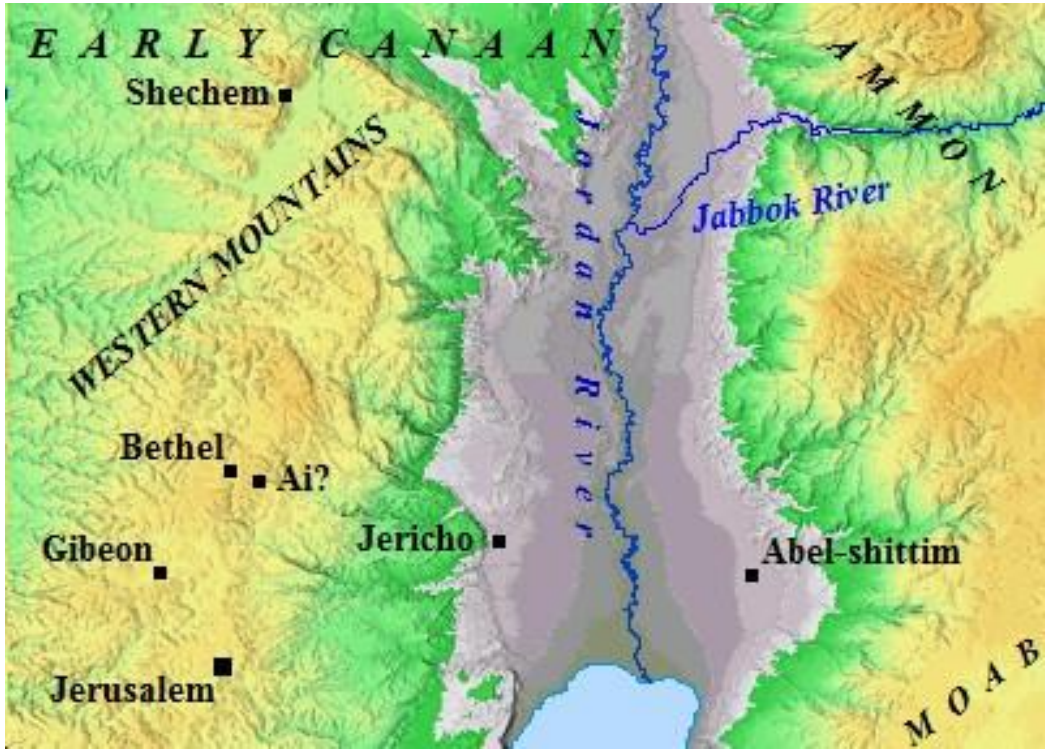
Islam and Weil (1996)

The term **soil quality** is often confused with the term **soil health**.

Scientific literature refers **soil quality** because of its ***quantifiable*** biological, chemical and physical properties.

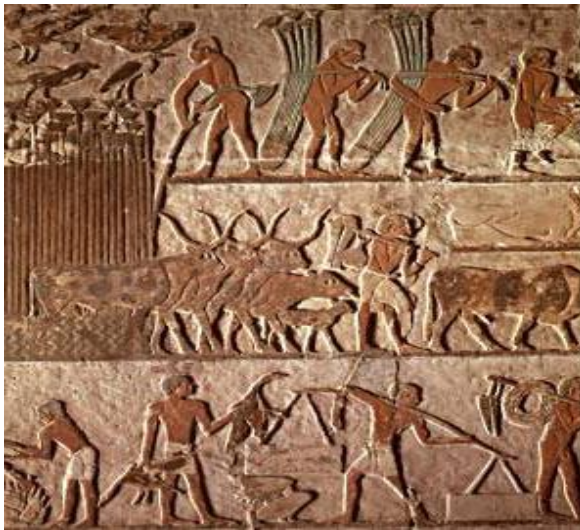
Popular press refers **soil health** because soil portrays as a ***living system*** which acts holistically rather than as a mixture of sand, silt, and clay.

Historically, the ***Bible depicts Moses*** as understanding that ***fertile soil*** was essential to the well-being of his people (**approx. 1400 B.C**.) as they entered Canaan.

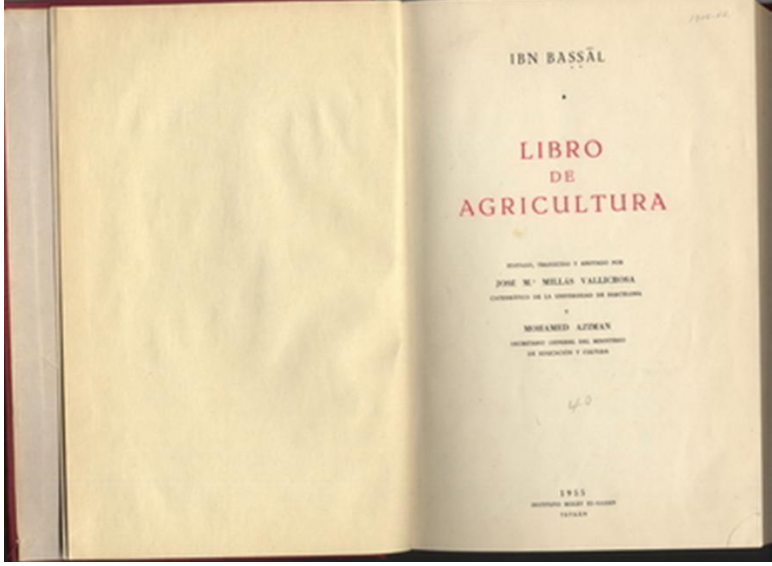


http://www.google.com

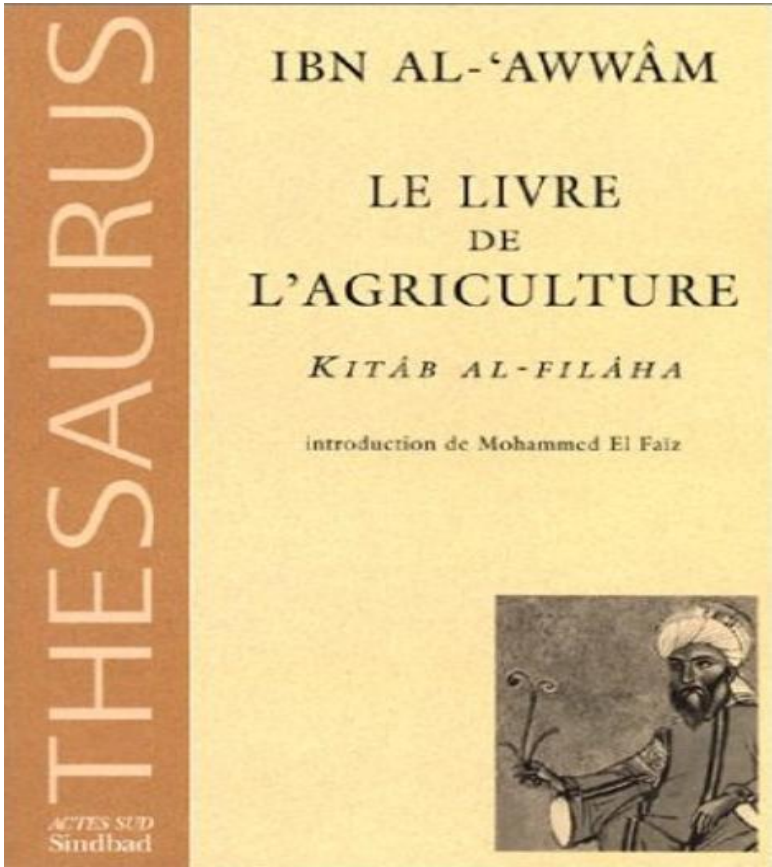
In Levant and Mesopotamia (Canaan, Egypt, Assyria), Indus, Greek, Roman, Mayan, Aztec and Norte Chico (Peru) civilizations, ***taxes and revenues*** were collected by the rulers based on deductive soil quality (***crop yields***)



Ibne Basaal **(11th Century)** in Moorish Spain classified soils according to their **quality**. He had 10 soil quality classes, each assigned with a different ***life sustaining*** capability.



In **"Kitab al-Filaha (The Book of Agriculture)"** written by **Ibne Awwam** in Andalusia (Spain)



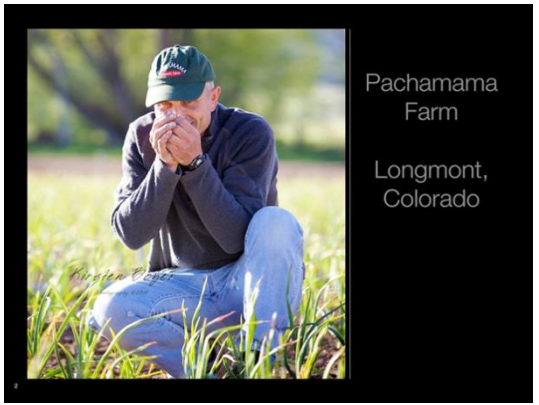
http://www.heritage.com/Default.aspx

Evaluation of Soil Quality

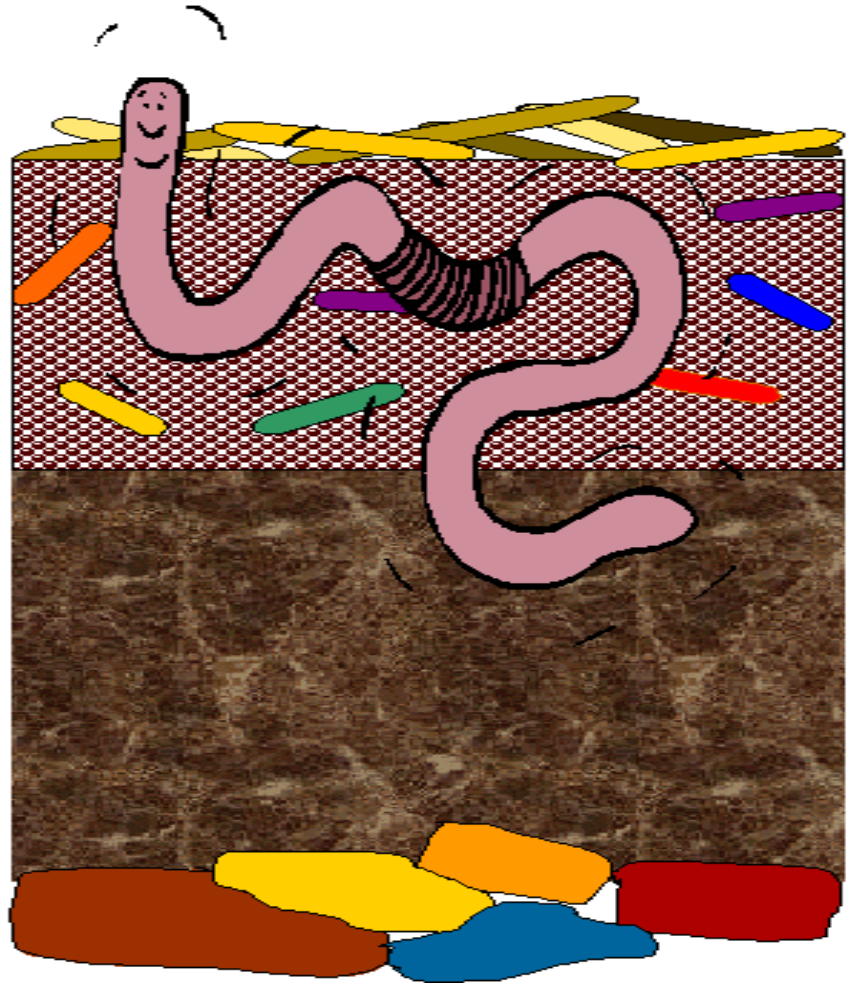
Deductive approach: Based on crop growth and yield

Evaluation of Soil Quality….

Inductive approach (***Qualitative***): Based on feel, smell, taste, and touch of the soil



Inductive approach (***semi-quantitative***): Based on soil health card - Color, organic matter, crop residues, texture, earthworms, structure, workability, etc.



Inductive approach (***quantitative***): USDA-NRCS soil quality test kit (Dr. *John Doran*)

This approach based on ***actual measurement*** of several soil dynamic properties in the field such as:

- Reaction (pH)
- Respiration rates
- Earthworms
- Salt (Ec)
- Nitrate-N
- ***Organic matter***
- Bulk density
- Aggregate stability

Soil quality indicator properties……

Ephemeral	**Intermediate**	**Permanent**
Changes within days/weeks **(Very dynamic)**	Subject to management over several years **(Dynamic)**	Inherent to profile or site **(Inherent)**
Water content	Microbial biomass	Depth
Field respiration	Basal respiration	Slope
pH and salts	Earthworm/nematode	Climate
Available N	***Organic matter****	Texture
Available P	Particulate organic matter	Stoniness
Available K	Enzymes	Fragipan
Bulk density	Aggregate stability	Mineralogy

→ **Increasing permanence** →

Islam and Weil (2000)

Numerical calculation of soil quality

Inductive additive approach based on *normalization*, *summation*, and *average* of selected soil quality indicator properties into a single *integrator* was used to calculate soil quality index (SQ_{index}):

$$SQ_{index} = \Sigma(X\ X_{max}^{-1})\ n^{-1}$$

Where **X** is the value of any particular soil property, $\mathbf{X_{max}}$ is highest value of that particular soil property, and **n** is the total number of soil properties used in the calculation.

SQ_{index} ranges from > 0 to $\leq$ 1.00

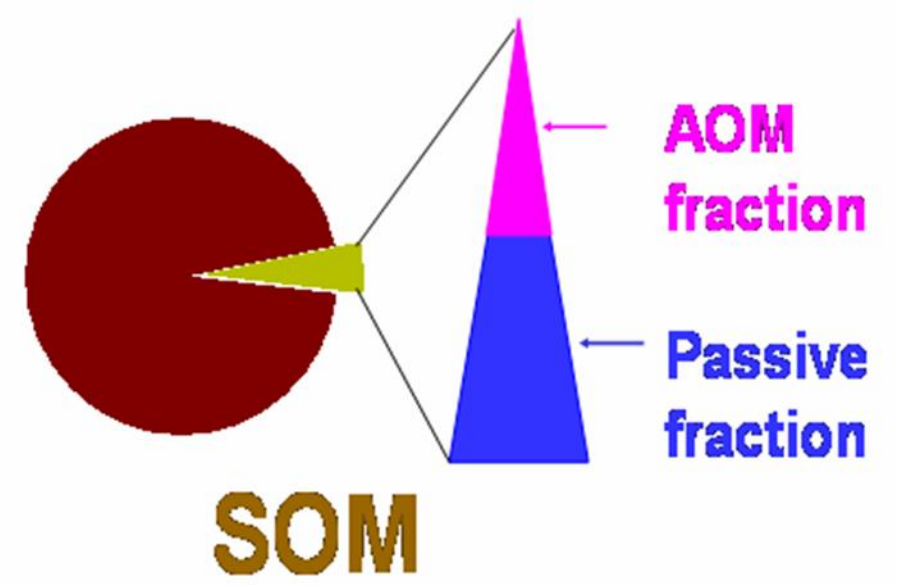
Numerical calculation of soil quality

Ex: SMB=Soil microbial biomass, TN=Total nitrogen, EN=Enzyme activity, and As=Aggregate stability

SMB	TN	EN	AS	SQ_{index}
200	5	45	0.40	
300	10	50	0.55	
400	20	55	0.75	
250	10	40	0.45	
500	20	56	0.70	
0.40	0.25	0.80	0.53	0.50
0.60	0.50	0.89	0.73	0.68
0.80	1.00	0.98	1.00	0.95
0.50	0.50	0.71	0.60	0.58
1.00	1.00	1.00	0.93	0.98

Most important to soil quality is the **active fraction** of SOM which composed of partially decomposed plant and animal residual and microbial biomass C. Usually 20±5% of C in SOM is in active form (Weil and Islam 2003).

Most of what's left is the **passive fraction** of SOM which is resistant to microbial decomposition.

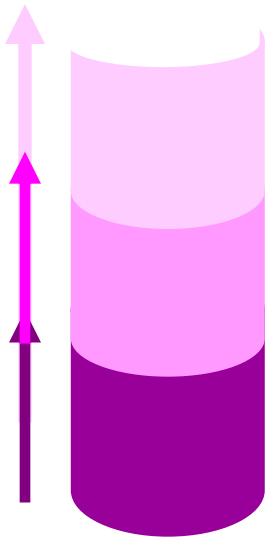


From a practical point of view, testing for active C as a routine measure of soil quality would need to:

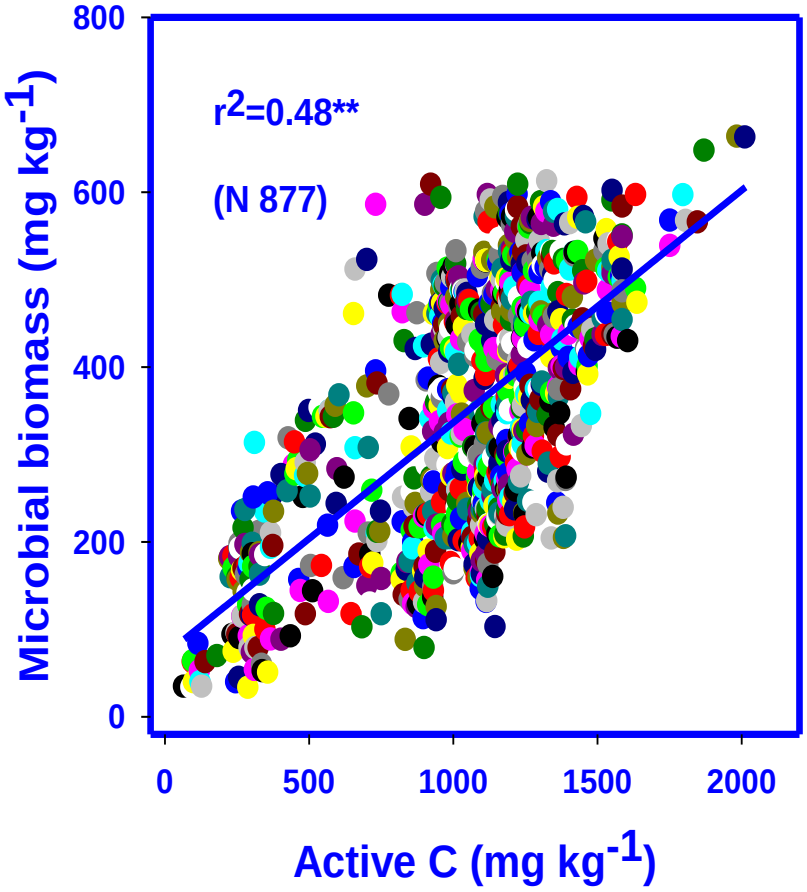
- Be visual (can see)
- Be sensitive and precise (reliable)
- Be rapid and non-toxic
- Use few chemicals
- Correlate to key soil quality properties
- Predict crop growth and yield
- Be economical

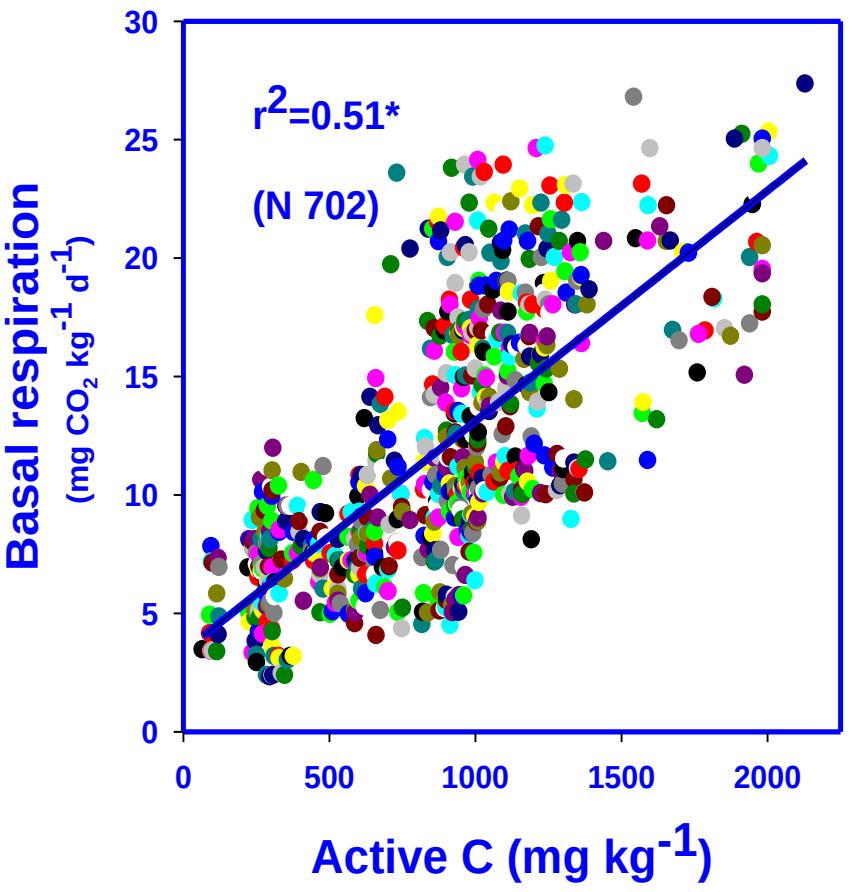
We found potassium permanganate ($KMnO_4$) is the right chemical to measure active C

- Powerful reactant (oxidizing agent)
- Dilute neutral solutions are more useful
- Oxidizes active (labile) fraction of SOM
- Serves as its own indicator (bleaching effect)
- Correlates with soil quality properties
- Safe to handle (0.006 – 0.3M solutions)
- Non-significant reaction with charcoal/$CaCO_3$

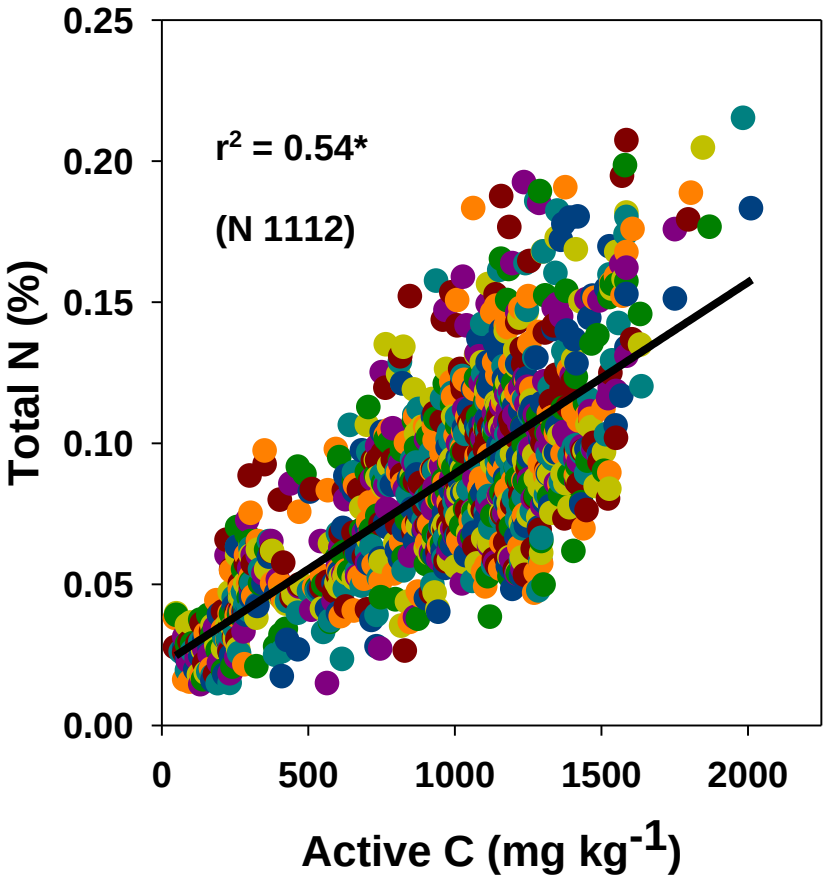


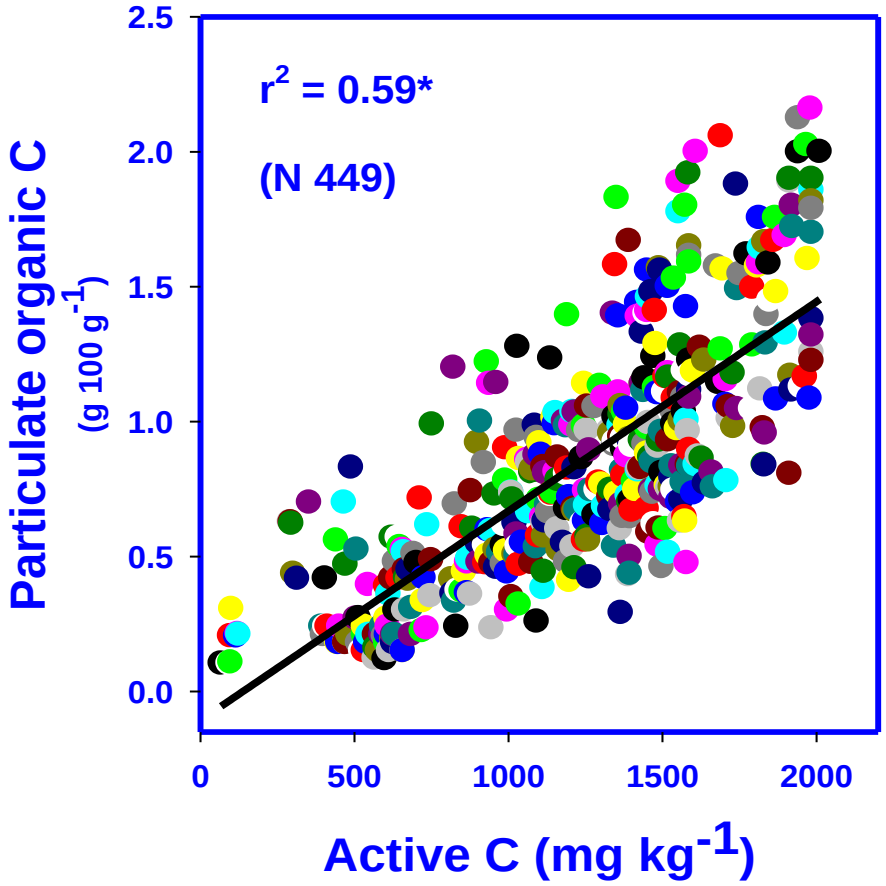
Correlation of active C with soil microbial biomass and biological activity



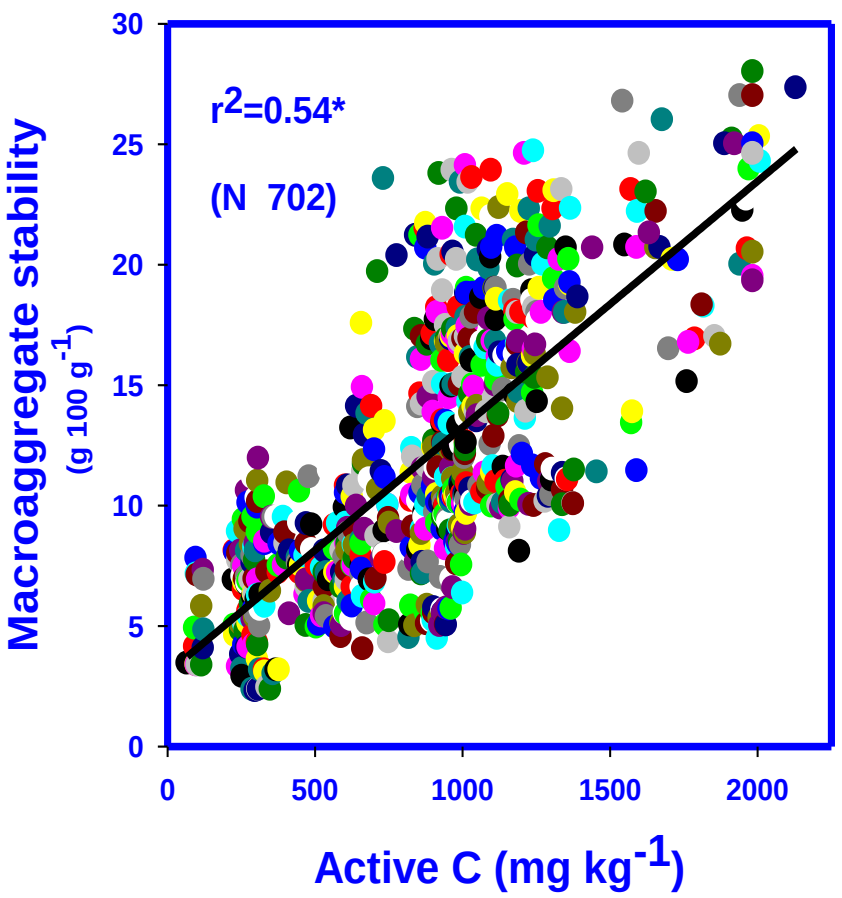


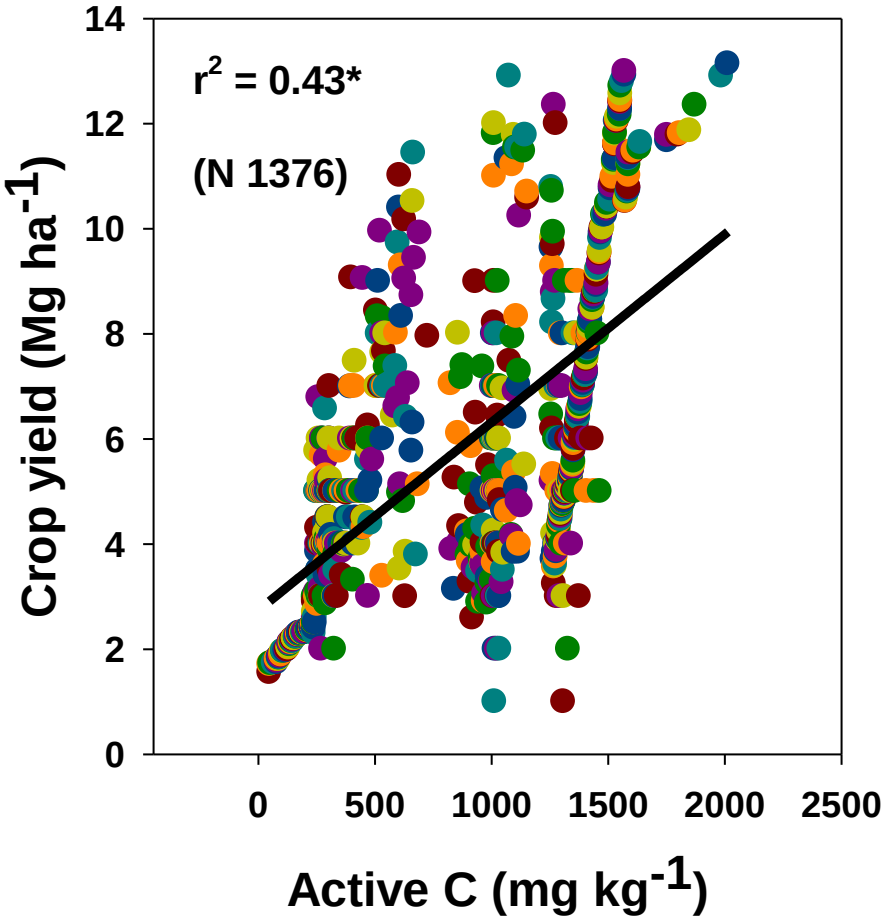
Correlation of active C with total nitrogen (TN) and particulate organic carbon (C)



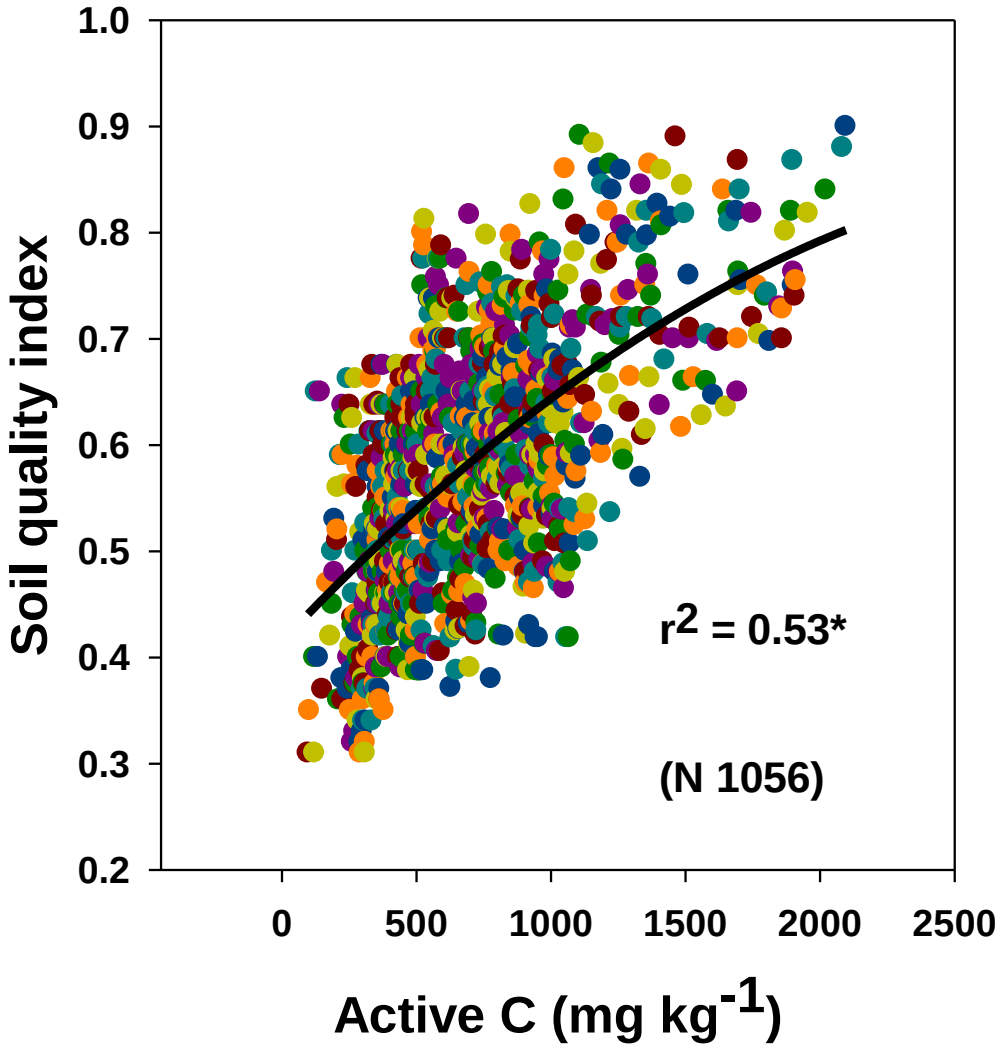


Correlation of active C with soil aggregate stability and crop yields

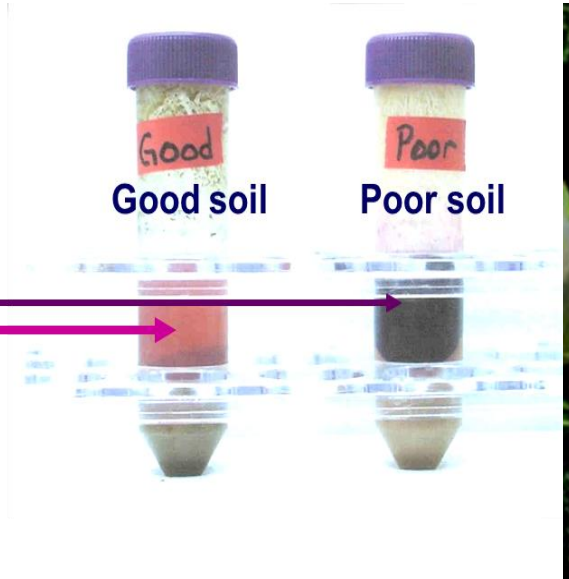




Correlation of active C with soil quality index



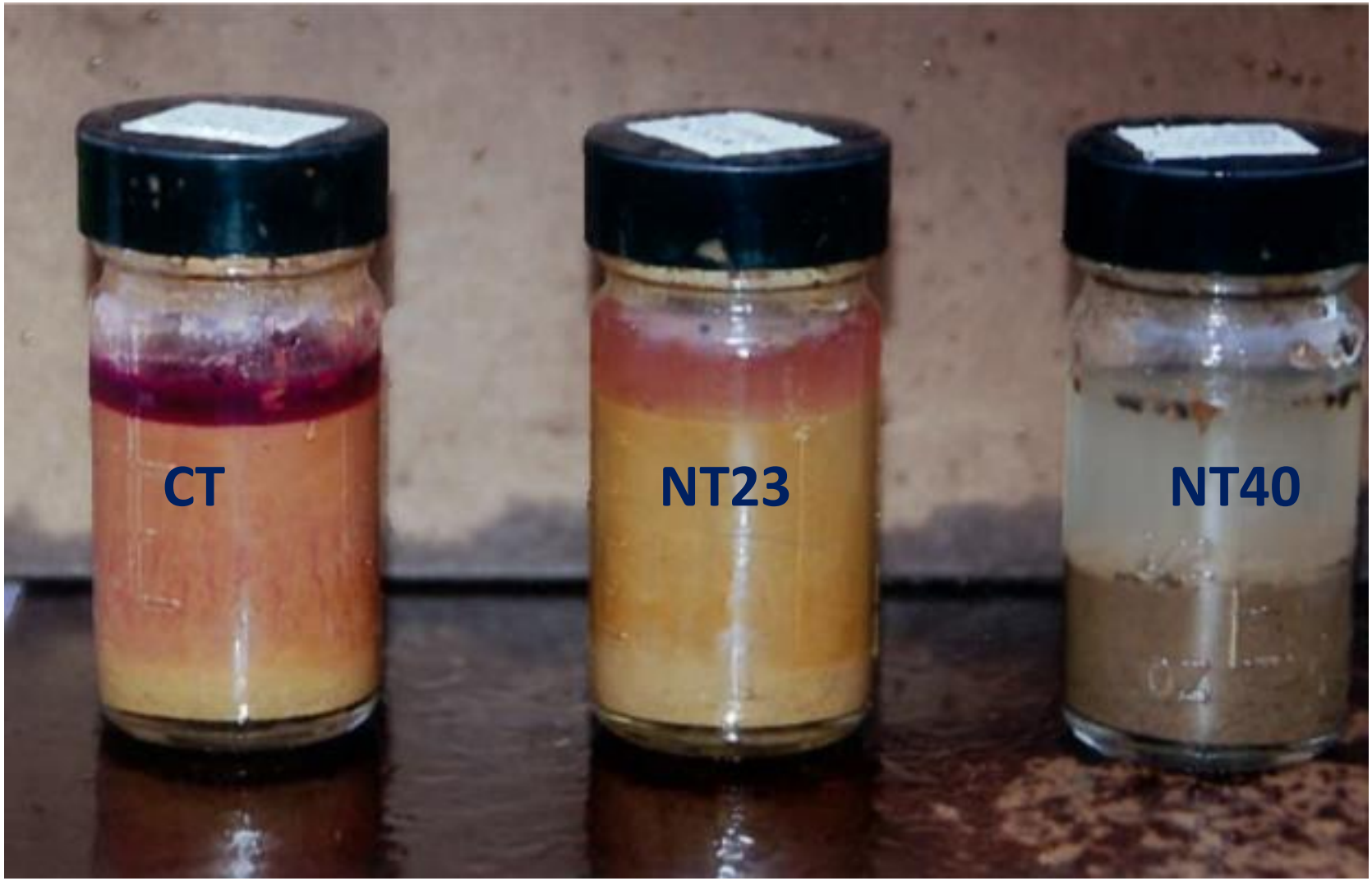
The test based on 2 min shaking of 5-g air-dried soil with neutral 0.02M solution of $KMnO_4$ reagent. Solution absorbance measurement with a field colorimeter or laboratory spectrophotometer at 550-nm. Standard curve using a sequential dilution of $KMnO_4$ (Islam and Weil 2000)



Cornell soil health test

http://soilhealth.cals.cornell.edu/

Color chart development for soil quality field test



Soil quality, active organic matter (AOM), and available N color chart

Poor soil quality	Fair soil quality	Good soil quality	Excellent soil quality
> 0 to 400 AOM lbs/ac	> 400 – 800 AOM lbs/ac	> 800 – 1600 AOM lbs/ac	> 1600 AOM lbs/ac
> 0 - 12 lbs available N/ac	> 12 - 26 lbs available N/ac	> 26 - 40 lbs available N/ac	> 40 lbs available N/ac

Soil quality is evaluated by changes in the deep purple color to shades of pink in poor, fair, good and excellent ratings using a simple color chart.

Soil Quality Field Test Kit

This video is a demonstration

for

The Soil Quality Field Test Kit

Soil, Water & Bioenergy Resources
The Ohio State University
South Centers

Questions?