SOM
a fulcrum
with many forms
and functions

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WIU Agriculture
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Joel Gruver
Jimmy, this farm’s yields have tripled!
Grandpa, has our SOM tripled?
Current corn yields add ~10 t/a of biomass each year, equivalent to ~1% of the weight of an acre plow layer. Grain, stover and roots each comprise ~1/3rd of the total biomass.
Most of the C in crop residues quickly returns to the atmosphere within 1 year. Living organisms, microbial compounds, and plant compounds break down crop residues, releasing CO₂, which is often > 75% of the original carbon content. This process is part of the soil organic matter (SOM) cycle, where carbon is cycled back into the atmosphere.
Veenstra and Burras resampled and analyzed 82 pedons in IA with historical descriptions in IA and classified the soils according to the US, Canadian and FAO-WRB taxonomic systems. 11 to 33% of the pedons originally classified as Black soils (e.g., Mollisols) no longer classified as Black soils. The change in soil classification over such a short-time period challenges the validity and usefulness of treating existing soil maps as static documents as well as traditional soil classification hierarchies.

Key words: Soil taxonomy, classification, Black soils, Midwestern United States, agriculture
Genoform vs. Phenoform: one soil series (Mn25A) or: loamy, mixed, mesic Typic Fluvaquents in Soil Taxonomy and Haplic Fluvisols in WRB, has three phenoforms:

(Bouma et al., 2016)
The current amount of OM in a soil => the long-term balance between organic matter inputs and outputs

grown in place, redistributed on-farm, imported from off-farm

harvested, decomposed, lost to erosion
Have you read this classic commentary?
Journal of Soil and Water Conservation - 1995

Conventional row crop agriculture: Putting America’s soils on a white bread diet

T. H. DeLuca

An analysis of the soils of the great plains will reveal their incredible wealth of native fertility, tilth, and rich dark color. Even after 100 years of cultivation, these soils retain much of their attractive appearance. Conservation, however, aged soils reveal the few roots, and little live from virgin counterparts. Is it simply synthetic fertilizers there a greater over way that we have approached agriculture?

It appears that the demand for synthetic fertilizers and pesticides may be a symptom of the poor diet that the soils have been given over the last 100 years, a diet that has only worsened with the advent of synthetic fertilizers.

It appears that the demand for synthetic fertilizers and pesticides may be a symptom of the poor diet that the soils have been given over the last 100 years, a diet that has only worsened with the advent of synthetic fertilizers. It has a single crop of corn or soybeans grown in a linear pattern with the majority of the proteins, fats, and vitamins removed at the end of the growing season during harvest. Even if the straw isn’t removed, human immune system and result in chronic illness including anemia, colds, flu, and numerous secondary bacterial and even fungal infections. The medical profession might prescribe a heavy dose of antibiotics to eliminate the bacteria and as a side effect reduces beneficial microflora in digestive organs. Likewise, the “immune system” of the soil on the white bread diet will begin to fail and the plants growing in this soil will be faced with unchecked outbreaks of aggressive antagonistic and pathogenic organisms. In this case the prescribed cure would be to apply fungicides, nematicides, insecticides, or antibiotics to control the pathogens, but ultimately result in the further beneficial organisms, thus worsen the health of the soil.

Wrong here? We are well poorly balanced diet for human disaster in the form of death, hair, and nails, bad teeth, skin failure, cancer, heart disease, etc... Why can’t we look at the soil in a similar light? Soils need a well balanced diet of proteins, cofactors, minerals, and carbohydrates. Our conventional agricultural practices are silently killing our soils nation wide by feeding the soil nothing but white bread and vitamins.
When there is more grass, I eat more!!

Practices that enhance crop yield also impact the soil stomach/body!!
SOM is a complex mixture of living, dead and very dead OM

Historically often called HUMUS

Living organisms
Recent residues
Stabilized SOM
Biologically active SOM
Early research based on an extraction method assumed that a ‘humification’ process creates recalcitrant and large ‘humic substances’ to make up the majority of soil ‘humus’ however, these ‘humic substances’ have not been observed by modern analytic techniques.
At the next SSSA conference (January 2019 in San Diego), there will be a day-long special session on whether soil humic research has any meaning/value. There will be a morning debate between proponents and opponents of humic acid extraction and characterization and afternoon poster session and oral session for volunteered presentations. The two sides will each write a review paper using a shared theme for publication in Journal of Environmental Quality this summer, and likely more review papers will follow from the SSSA conference.
Articles about SOM!
Limited effect of organic matter on soil available water capacity

European Journal of Soil Science - 2017

B. Minasny & A. B. McBratney
Sydney Institute of Agriculture, The University of Sydney, 1 Central Avenue, 2015 Eveleigh, New South Wales Australia

Summary

Soil water-holding capacity is an important component of the water and energy balances of the terrestrial biosphere. It controls the rate of evapotranspiration, and is a key to crop production. It is widely accepted that the available water capacity in soil can be improved by increasing organic matter content. However, the increase in amount of overestimation of water-holding capacity at high organic matter content is not linear, but increases with increasing soil organic matter content. The effect of soil organic matter on available water capacity is not significant. However, a 1% mass increase in soil OC on average increased available water capacity by 1.16%, volumetrically.

Highlights

- We analysed data from 60 published studies and global databases with more than 50,000 measurements.
- A 1% mass increase in soil OC on average increased available water capacity by 1.16%, volumetrically.
Sandy soils and macropores are most enhanced by SOM
Modelled response of the rate of increase in AWC (mm 100 mm⁻¹) with an increase in OC content from 5 to 15 g kg⁻¹ as a function of sand and clay contents. The model was trained on the NSSC dataset.
SOIL WATER CHARACTERISTICS

HYDRAULIC PROPERTIES CALCULATOR

This program estimates soil water tension, conductivity and water holding capability based on the soil texture, organic matter, gravel content, salinity, and compaction.

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### Soil Characteristics

<table>
<thead>
<tr>
<th>Texture Class:</th>
<th>Silt Loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilting Point</td>
<td>10.6 % Vol</td>
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<tr>
<td>Field Capacity</td>
<td>28.4 % Vol</td>
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<tr>
<td>Saturation</td>
<td>45.1 % Vol</td>
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<tr>
<td>Available Water</td>
<td>2.13 in/ft</td>
</tr>
<tr>
<td>Sat. Hydraulic Cond.</td>
<td>0.56 in/hr</td>
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<tr>
<td>Matric Bulk Density</td>
<td>90.87 lb/ft³</td>
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</table>

<table>
<thead>
<tr>
<th>Texture Class:</th>
<th>Silt Loam</th>
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<tbody>
<tr>
<td>Wilting Point</td>
<td>12.5 % Vol</td>
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<tr>
<td>Field Capacity</td>
<td>32.1 % Vol</td>
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<tr>
<td>Saturation</td>
<td>55.5 % Vol</td>
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<tr>
<td>Available Water</td>
<td>2.35 in/ft</td>
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<tr>
<td>Sat. Hydraulic Cond.</td>
<td>1.40 in/hr</td>
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<tr>
<td>Matric Bulk Density</td>
<td>73.65 lb/ft³</td>
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</table>

### Organic Matter

- **Wt:**
  - 2.0 %
  - 5.0 %

### Salinity

- **dS/m:**
  - 0.0

### Gravel

- **Wt:**
  - 0 %

### Compaction

- **Level:**
  - Loose
  - Normal
  - Dense
  - Hard
  - Severe

- **%:**
  - 1.0
Crop rotations for increased soil carbon: perenniality as a guiding principle

ALISON E. KING AND JENNIFER BLESH

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Abstract. More diverse crop rotations have been promoted for their potential to remediate the range of ecosystem services compromised by biologically simplified grain-based agroecosystems, including increasing soil organic carbon (SOC). We hypothesized that functional diversity offers a more predictive means of characterizing the impact of crop rotations on SOC concentrations than species diversity per se. Furthermore, we hypothesized that functional diversity can either increase or decrease SOC depending on its associated carbon (C) input to soil. We compiled a database of crop rotations and functional biodiversity across a range of agroecosystems and crop categories. We compared crop rotation functional biodiversity with SOC concentrations, and results were consistent with our hypotheses. Within our data, we found that increasing the functional biodiversity of crop rotations increased SOC concentrations, potentially by exploiting niches in time that would otherwise be unproductive, that is, increasing the “perenniality” of crop rotations.
The importance of anabolism in microbial control over soil carbon storage

Chao Liang¹*, Joshua P. Schimel² and Julie D. Jastrow³

Studies of the decomposition, transformation and stabilization of soil organic matter (SOM) have dramatically increased in recent years owing to growing interest in studying the global carbon (C) cycle as it pertains to climate change. While it is readily accepted that the magnitude of the organic C reservoir in soils depends upon microbial involvement, as soil C dynamics are ultimately processed and explain soil organic C content. This understanding is especially true in the context of the soil ‘microbial carbon pump’ (MCP) and its contribution to the stabilization of organic matter, which we define as the entombing effect (EE).

...we use the conceptual framework of the soil ‘microbial carbon pump’ (MCP) to demonstrate how microorganisms are an active player in soil C storage. The MCP couples microbial production of organic compounds to their further stabilization, which we define as the entombing effect (EE).
The microbial C pump (MCP) and entombing effect (EE)
2 major pathways by which microorganisms influence SOM stabilization

**ex vivo (extracellular) modification**, in which extracellular enzymes attack and transform plant residues, resulting in deposition of plant-derived C that is not readily assimilated by microorganisms.

**in vivo turnover** of organic substrates via cell uptake–biosynthesis–growth–death, resulting in deposition of microbial-derived C

Through these 2 pathways, compounds are produced that are more resistant to further degradation or more readily stabilized.
Net stabilization of C when EE > PE
Our study demonstrates that soil fungi can form mineral-stabilized SOM not only by oxidative conversion of the SOM but also by synthesizing mineral surface reactive metabolites.
We conclude that the proportion of residues physically protected within aggregates decreases and priming effects increase with increasing C input leading to decreasing rate of long-term C stabilization within SOM by increasing residue addition.
High above ground residue inputs = low efficiency of SOM stabilization

(Shahbaz et al., 2016)
We believe the industry will indeed become more knowledge-based and the credibility of humic products will improve as (i) we learn more about their field efficacy across ranges of field conditions for improving crop yield and soil health, (ii) we gain further insights into possible mechanistic explanations, and (iii) the consumer gains the ability to discern genuine products from fraudulent materials.
Descriptions of humate products often refer to humic and fulvic acid content

**Fulvic acid** = soluble in strong base and still soluble when pH => 7

**Humic acid** = soluble in strong base but precipitates when pH => 7

HA & FA are solubility fractions NOT specific compounds
TIDIC acid production system 😊
Reputable companies should be able to provide analytical results obtained using this new standardized method.
Humate products are not a substitute for good soil organic matter management.
POXC better reflected practices that promote organic matter accumulation or stabilization and therefore can be a useful indicator of long-term soil C sequestration. Conversely, mineralizable C better reflected practices that promote organic matter mineralization and therefore can be a useful indicator of short-term soil nutrient availability.
Figure 2 – Color Reference Chart, Digital Color Reader, Beakers, Jars and Gel Paddles
This past fall, students in my Soil Properties class brought in paired (Crop field & Fence Row) soils from their family’s farm. In all cases, the fence row soils had higher soil respiration in 24 hrs after wetting.
The SituResp method is therefore a reliable method for performing a cheap, rapid and efficient assessment of microbial activity in the field which could be included in soil quality monitoring.
Cuvettes containing pH indicator Cresol Red in agar gel provide a cheap sensitive measurement of respiration.

(Thoumazeau et al, 2017)
Go beyond T - Manage for C!

Managing soil organic matter is the key to air and water quality.

- reduced tillage
- organic matter
- water holding capacity
- fewer pollutants
- less dust
- prescribed grazing
- high biomass rotations
- soil organisms
- infiltration
- nutrients
- soil structure
- air quality
- water quality
- productivity
- less sediment
- drought & disease resistance

Is this really possible?
Saturation of capacity

Potential C \[ \rightarrow \] capacity factors

Practically attainable C \[ \rightarrow \] Input factors

Actual C \[ \rightarrow \] Disturbance factors

Saturation deficit = opportunity

(Dick and Gregorich, 2004)
Fields or parts of fields with the lowest OM content (relative to their potential) will benefit the most from practices that build SOM.
Some effects of higher OM quantity and/or quality occur relatively quickly.

Other effects take longer.

Crop yield increases when limiting factors are reduced.