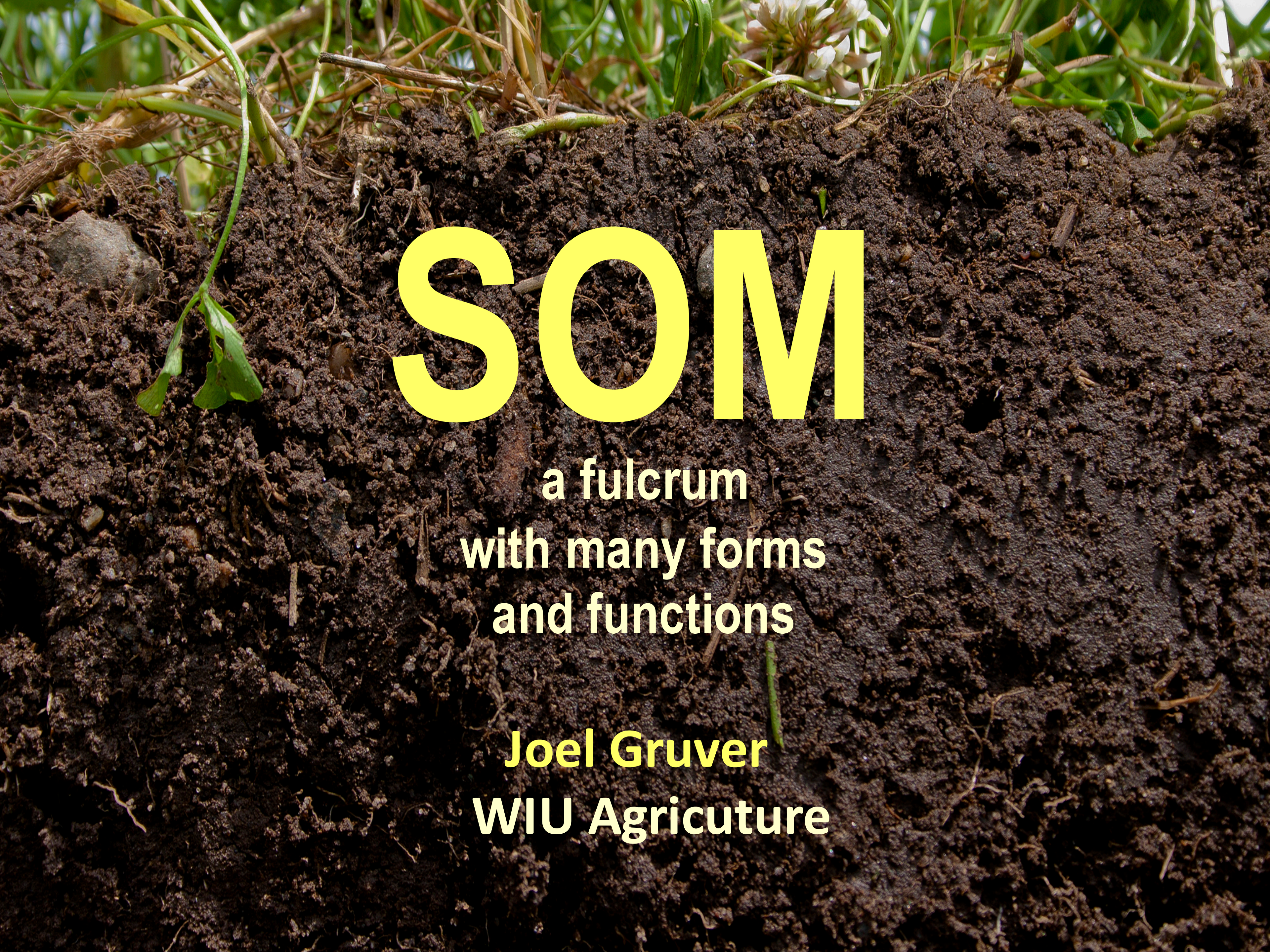

SOM
a fulcrum
with many forms
and functions
Joel Gruver
WIU Agricuture


Careers in Agriculture
MIZZOU
AGRICULTURE
WIU AGRICULTURE
Joel
Gruver

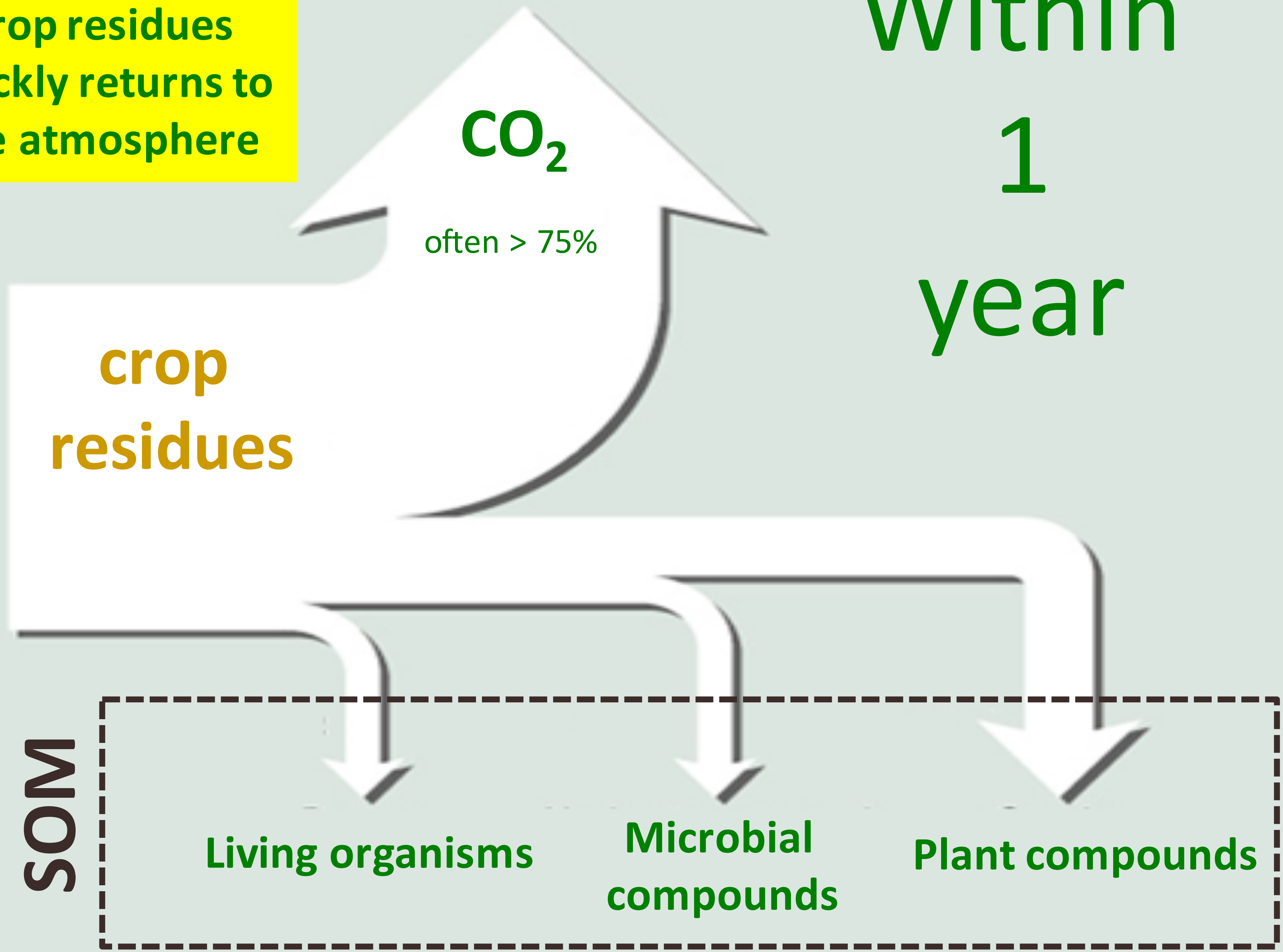

Jimmy, this farm's yields have tripled!


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
~1/3rd of the total
?

Most of the C in crop residues quickly returns to the atmosphere

Within 1 year



Effects of agriculture on the classification of Black soils in the Midwestern United States

Jessica J. Veenstra[1] and C. Lee Burras[2]

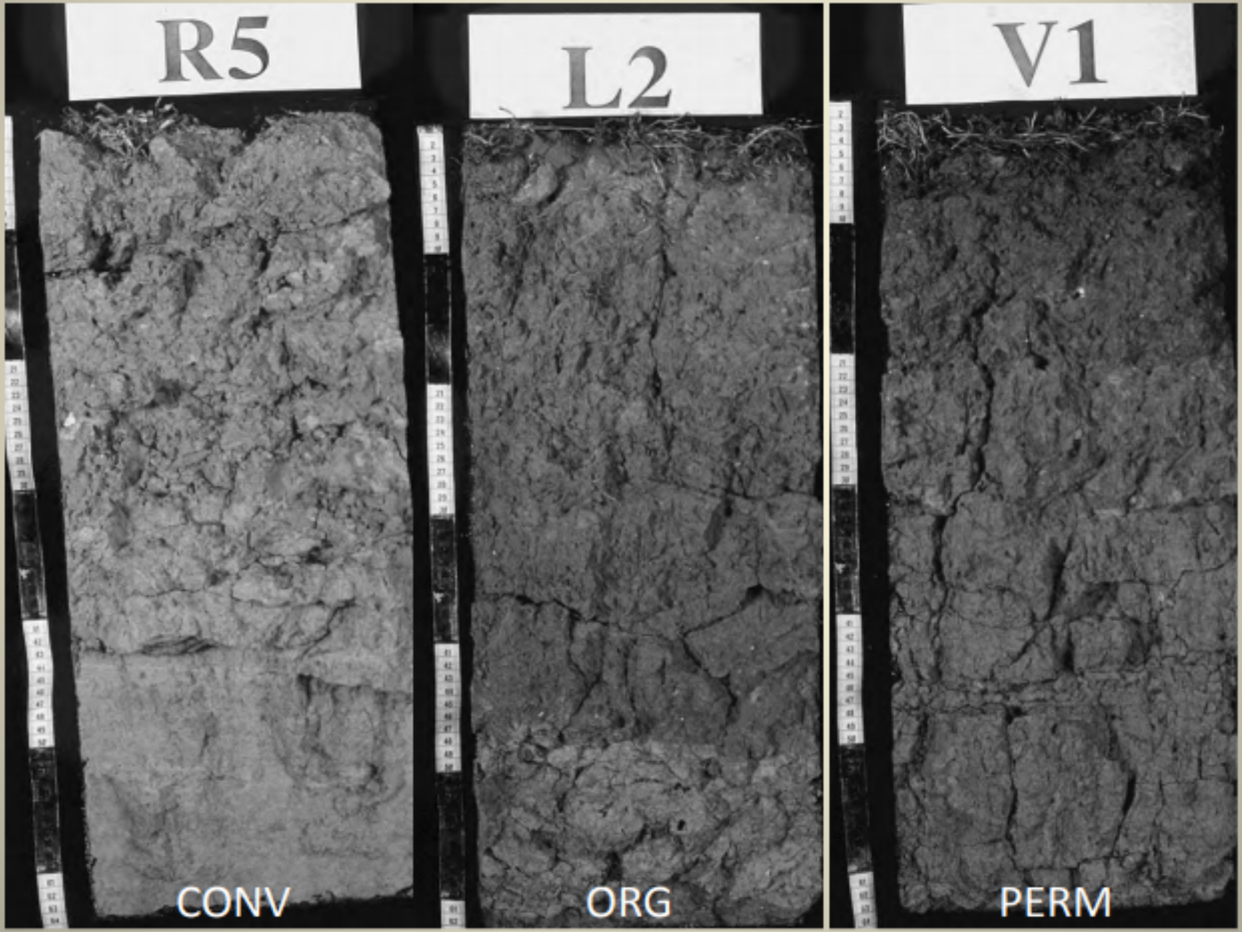
[1]*Flagler College, Natural Sciences, 74 King St. Saint Augustine, Florida, USA 32084; and* [2]*Iowa State University, Agronomy, 100 Osborn Dr. Ames, Iowa, USA 50011.* *Received 28 October 2010, accepted 9 September 2011.*

Veenstra, J. J. and Burras, C. L. 2012. **Effects of agriculture on the classification of Black soils in the Midwestern United States**. Can. J. Soil Sci. **92**: 403–411. Soil surveys are generally treated as static documents. Many soil survey users assume that pedon data generated 30 to 50 yr ago still represents today's soil, as short-term changes in soil properties are perceived to be li … zed 82
pedons … profile
properti … urrent
data, w … ulture
Associat … cantly
enough … pedons
differed …) level
with 11 … 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.

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) <u>no longer</u> classified as Black soils.

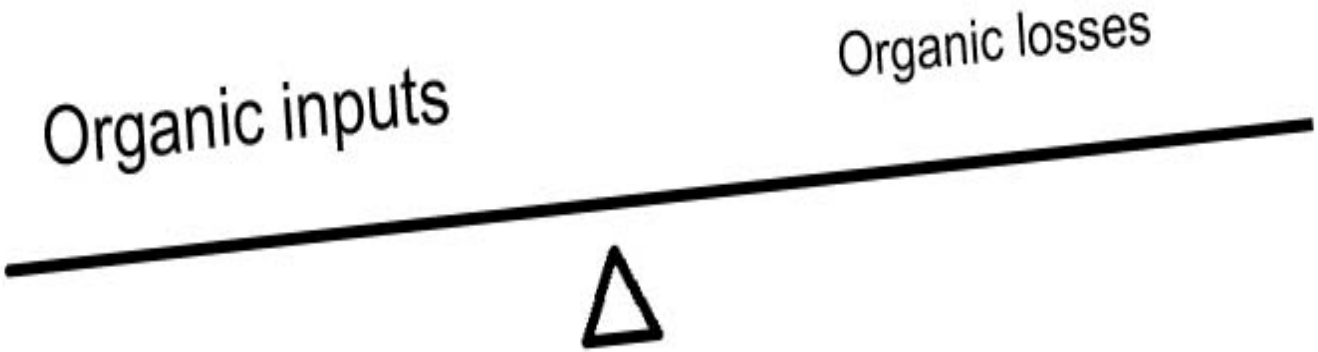
Key words: Soil taxonomy, classification, Black soils, Midwestern United States, agriculture

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

COMMENTARY

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 appe
servation, however,
aged soils reveal the
few roots, and little
virgin counterparts.
change? Is it simply
synthetic fertilizers
there a greater over
way that we have approached agriculture?

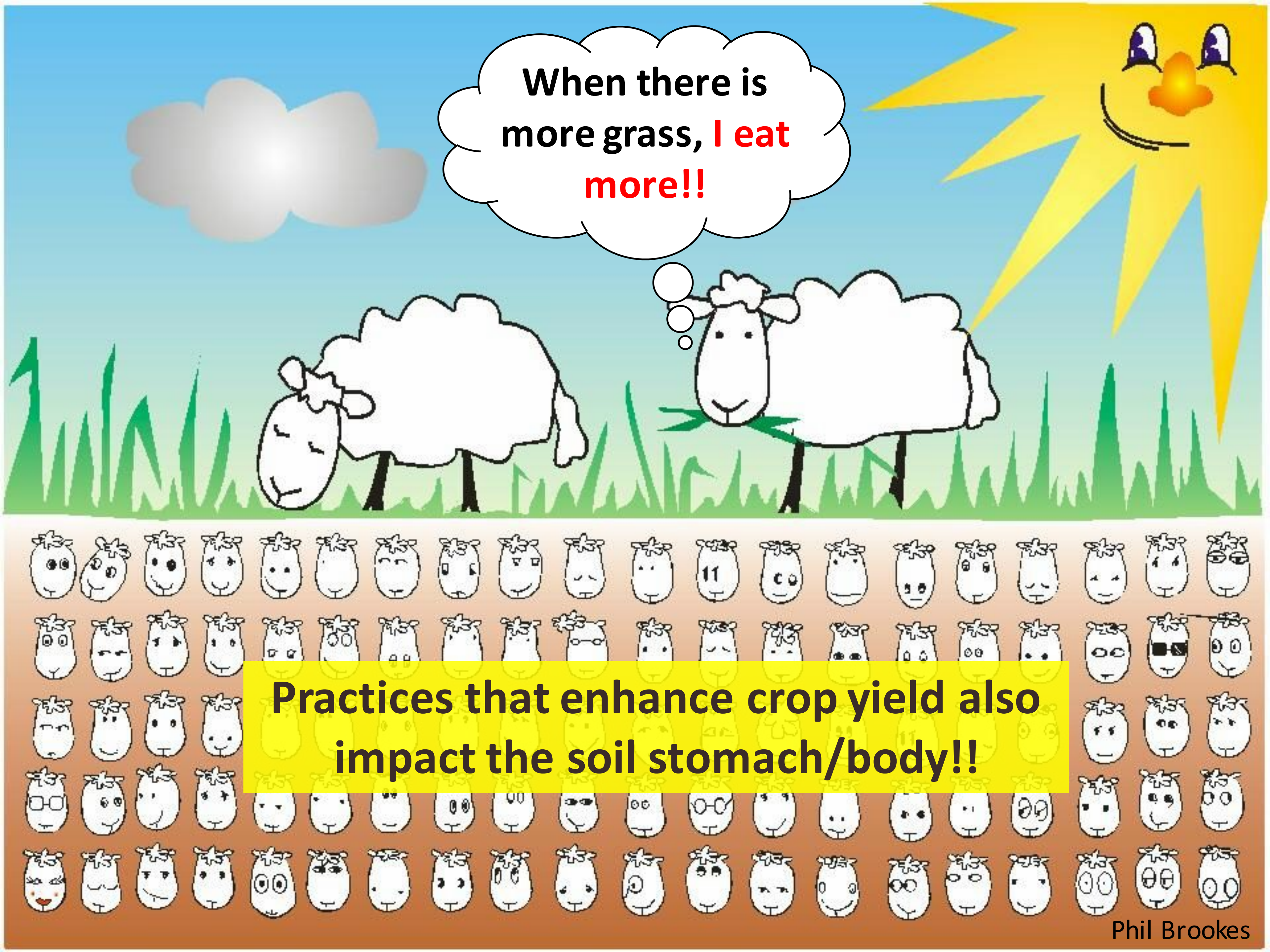
It appears that the demand for synthetic fertilizers and pesticides may be a symptom of the poor diet that the soils have been given over the last 100 years, a diet that has only worsened with the advent of synthetic fertilizers.

have 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 re-

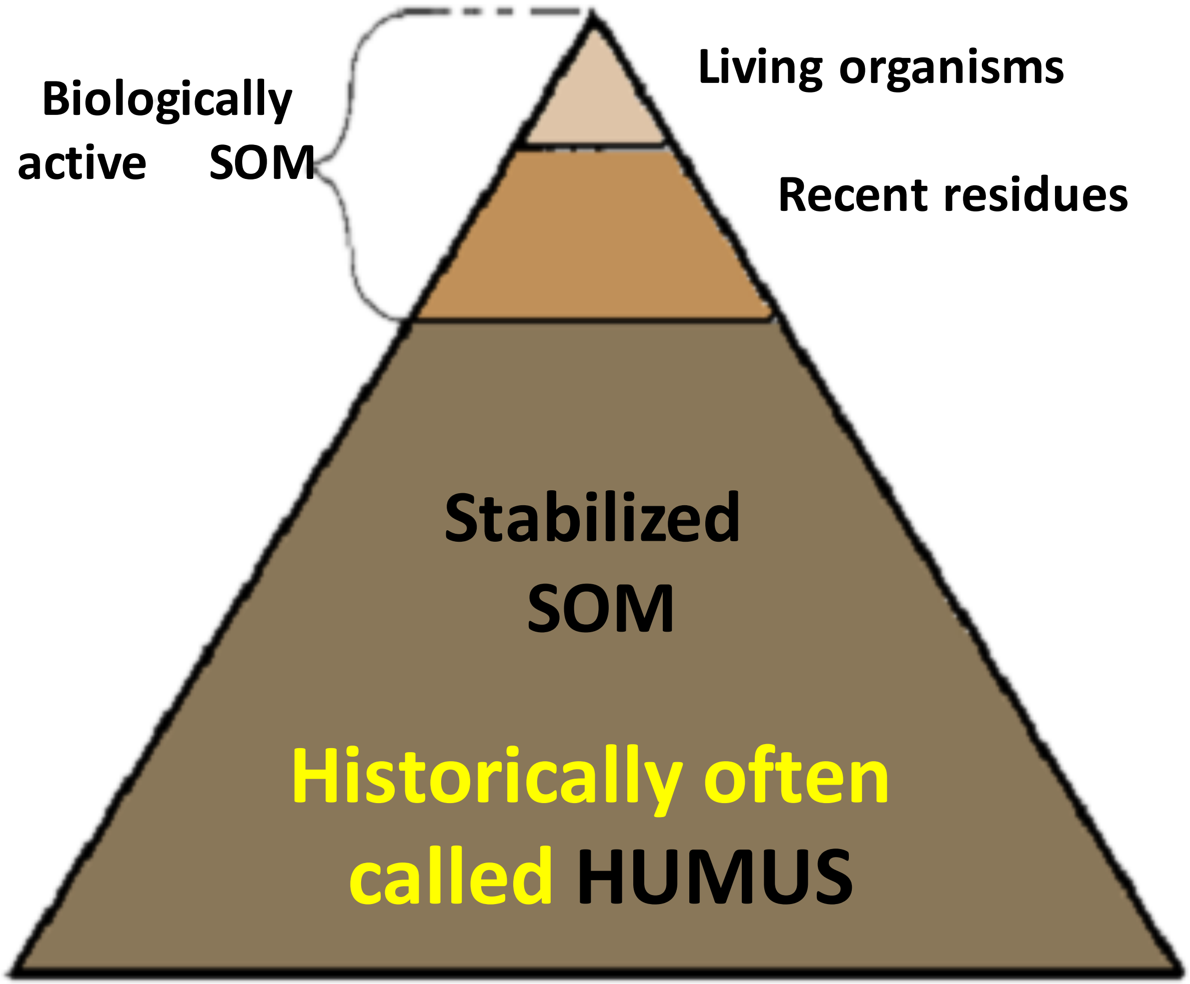
To take the above mentioned analogy a bit further, imagine yourself living on a diet of commercial white bread and water. You would look pretty sick within few weeks. Based on the vitamin revolution of the 1960s, humans eating such a diet would be told to "take a vitamin pill" or "eat bread

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 reduce 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
ltimately result in the further
neficial organisms, thus wors-
lth of the soil.
wrong here? We are well
poorly balanced diet for hu-
disaster in the form of dead
, hair, and nails, bad teeth,
em 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.

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


When there is more grass, I eat more!!
Practices that enhance crop yield also impact the soil stomach/body!!
Phil Brookes

SOM is a complex mixture of living, dead and very dead OM



Adapted from Magdoff and Weil (2003)

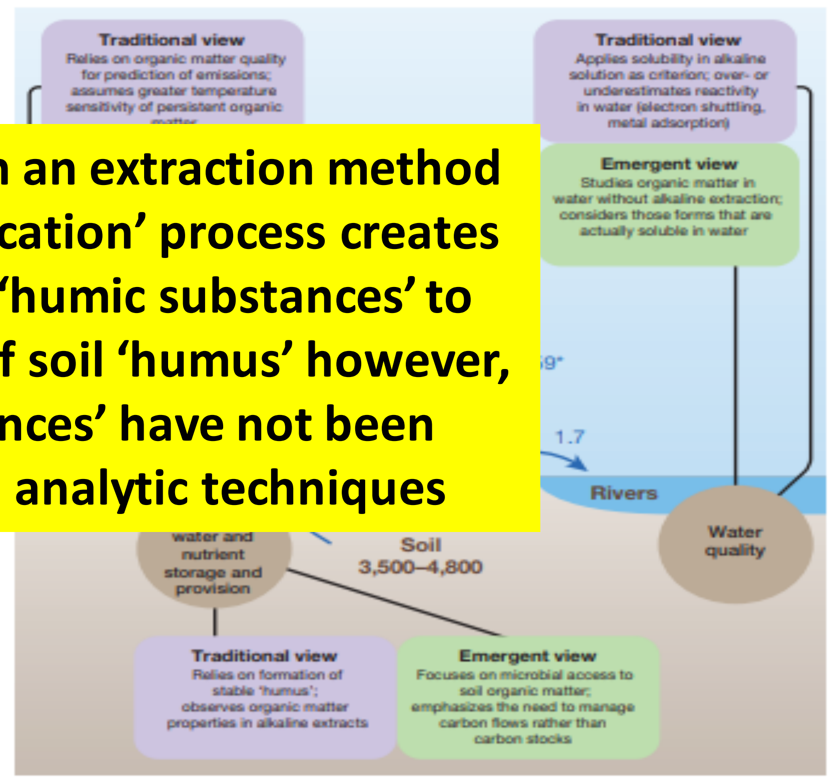
The contentious nature of soil organic matter

Johannes Lehmann[1,2*] & Markus Kleber[3,4*]

The exchange of nutrients, energy and carbon between soil organic matter, the soil environment, aquatic systems and the atmosphere is important for agricultural productivity, water quality and climate. Long-standing theory suggests that soil organic matter is composed of inherently stable and chemically unique compounds. Here we argue that the available evidence does not support the formation of large-molecular-size and persistent 'humic substances' in soils. Instead, soil organic matter is a continuum of progressively decomposing organic compounds. We discuss implications of this view of the nature of soil organic matter for aquatic health, soil carbon–climate interactions and land management.

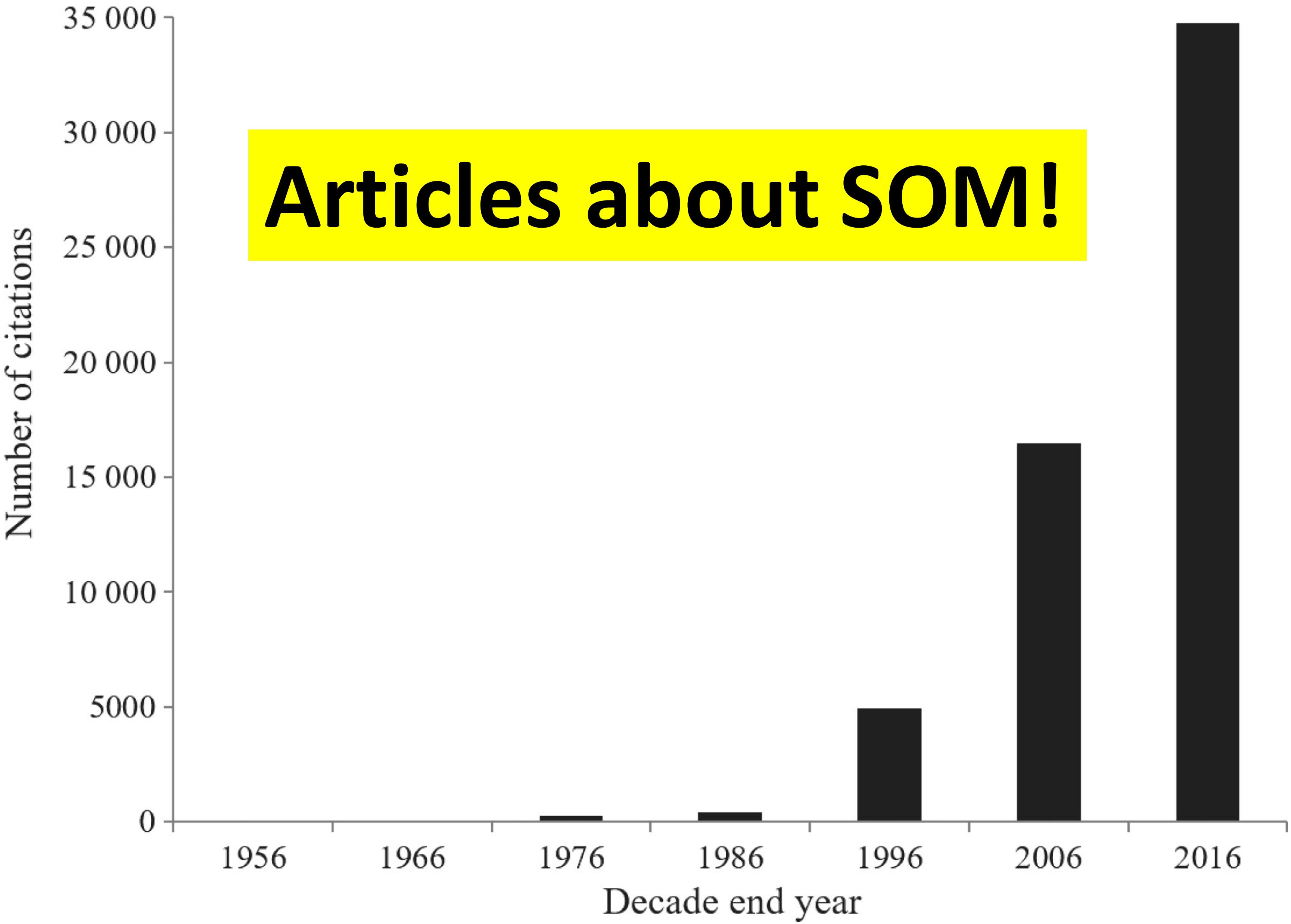
Soil organic matter contains more organic carbon than global vegetation and the atmosphere combined (Fig. 1). For this reason, the release and conversion into carbon dioxide or methane of even a small proportion of carbon contained in soil organic matter can cause quantitatively relevant va
these greenhouse gases[1].
well as pollutants in the s
water quality[2]. Soils are al
implications for biogeoch
Despite its recognized imp
nature of soil organic mat
Biological, physical an
dead plant material into c
associations with soil mi
of soil organic matter. Ea
assumed that a 'humifica
decomposition) and large
soil 'humus' (see Box 1). H
observed by modern ana
that 'humification' is increasingly questioned, yet the underlying theory persists in the contemporary literature, including current textbooks[4–6].

Here we argue in favour of a soil continuum model (SCM) that focuses on the ability of decomposer organisms to access soil organic matter and on the protection of organic matter from decomposition provided by soil minerals. Viewing soil organic matter as a continuum spanning the full range from intact plant material to highly oxidized carbon in carboxylic acids[7] represents robust science and will facilitate the way we communicate between disciplines and with the public. Only such an evidence-based



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!
Number of citations
35 000
30 000
25 000
20 000
15 000
10 000
5000
0
1956
1966
1976
1986
1996
2006
2016
Decade end year

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

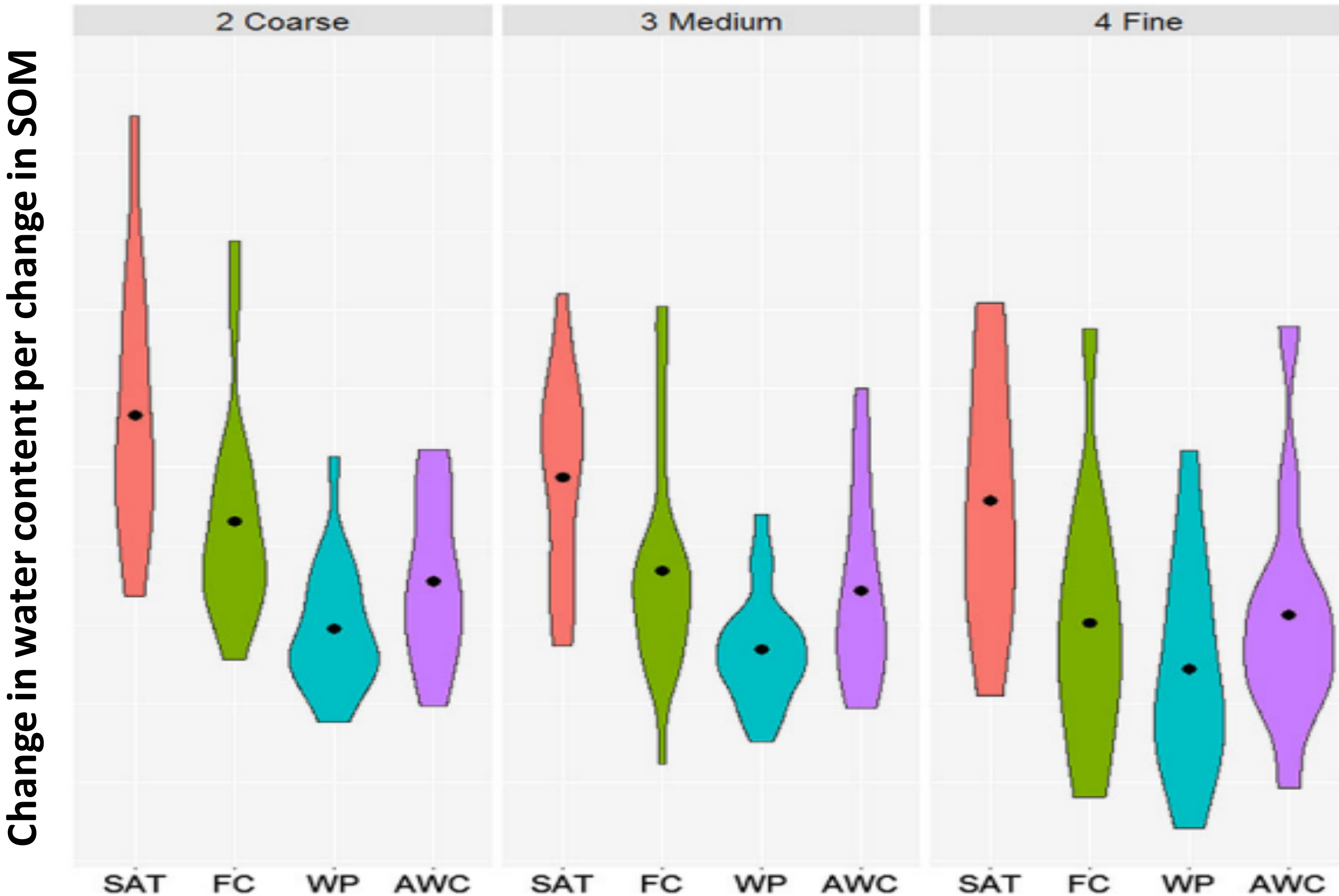
Summary

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 ... nd may be
overestima ... ysed large
databases (... and water
content at ... ncrease in
organic car ... 0 g C kg^{-1}
soil minera ... able water
capacity by ... andy soils,
followed b ... ll; 75% of
the studies ... Compared
with report ... stems, the
effect on soil available water is negligible. Thus, arguments for sequestering carbon to increase water storage are questionable. Conversely, global warming may cause losses in soil carbon, but the effects on soil water storage and its consequent impact on hydrological cycling might be less than thought previously.

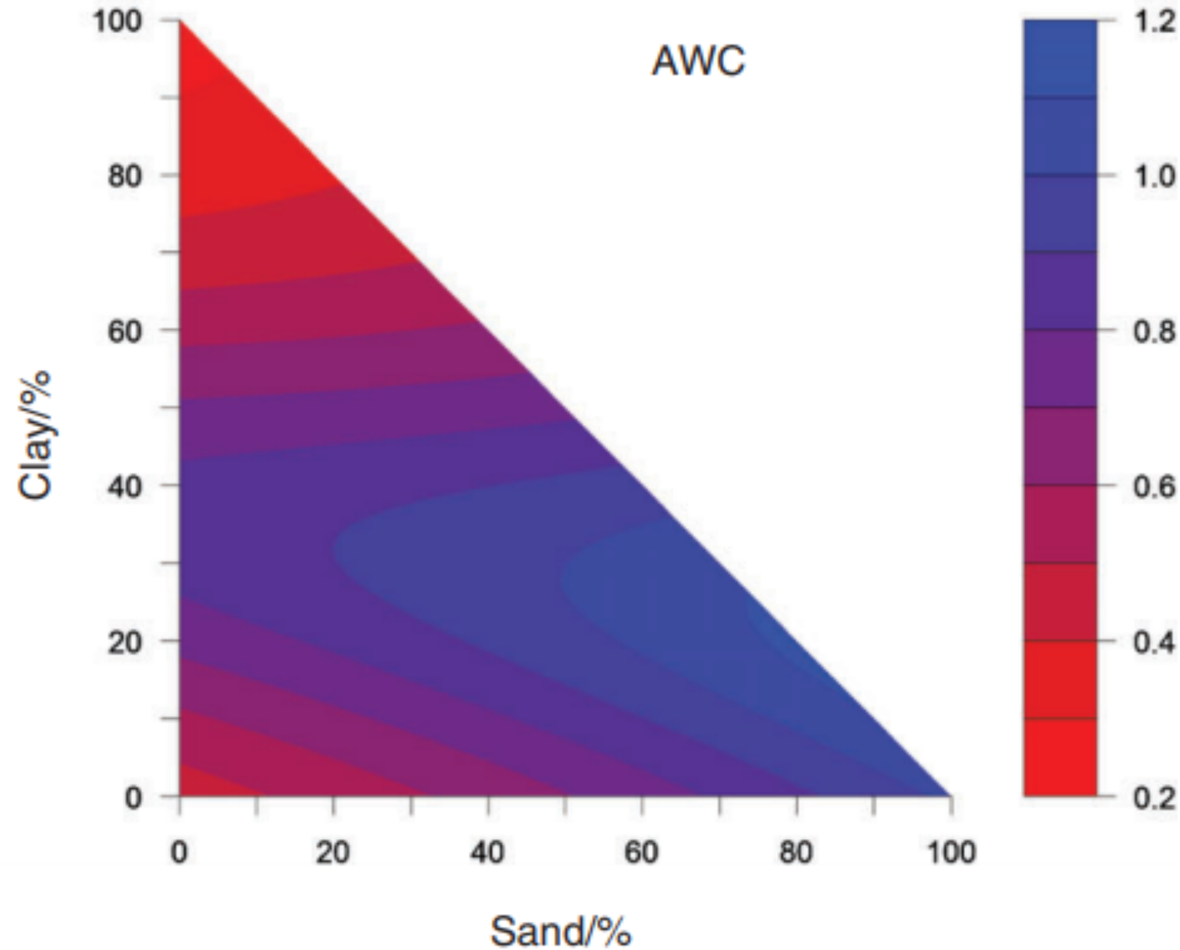
Highlights

- 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



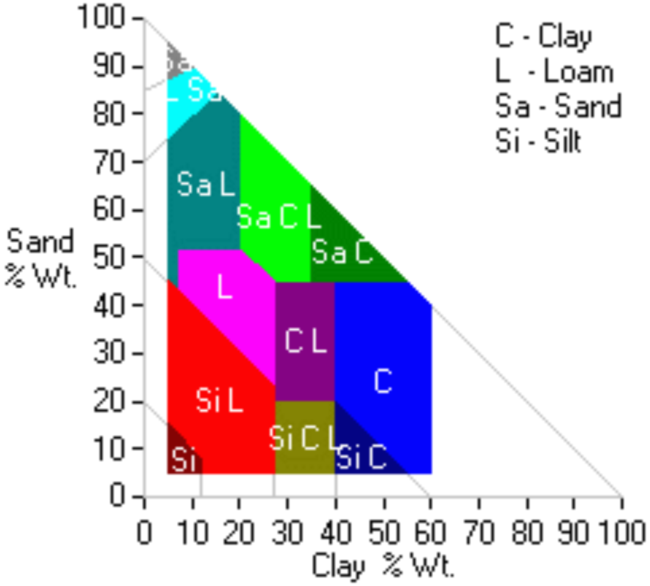
Modelled response of the rate of increase in AWC (mm 100 mm−1) with an increase in OC content from 5 to 15 g kg−1 as a function of sand and clay contents. The model was trained on the NSSC dataset.



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.



Developed By:
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USDA - Agricultural Research Service
and
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in cooperation with

Department of Biological Systems Engineering
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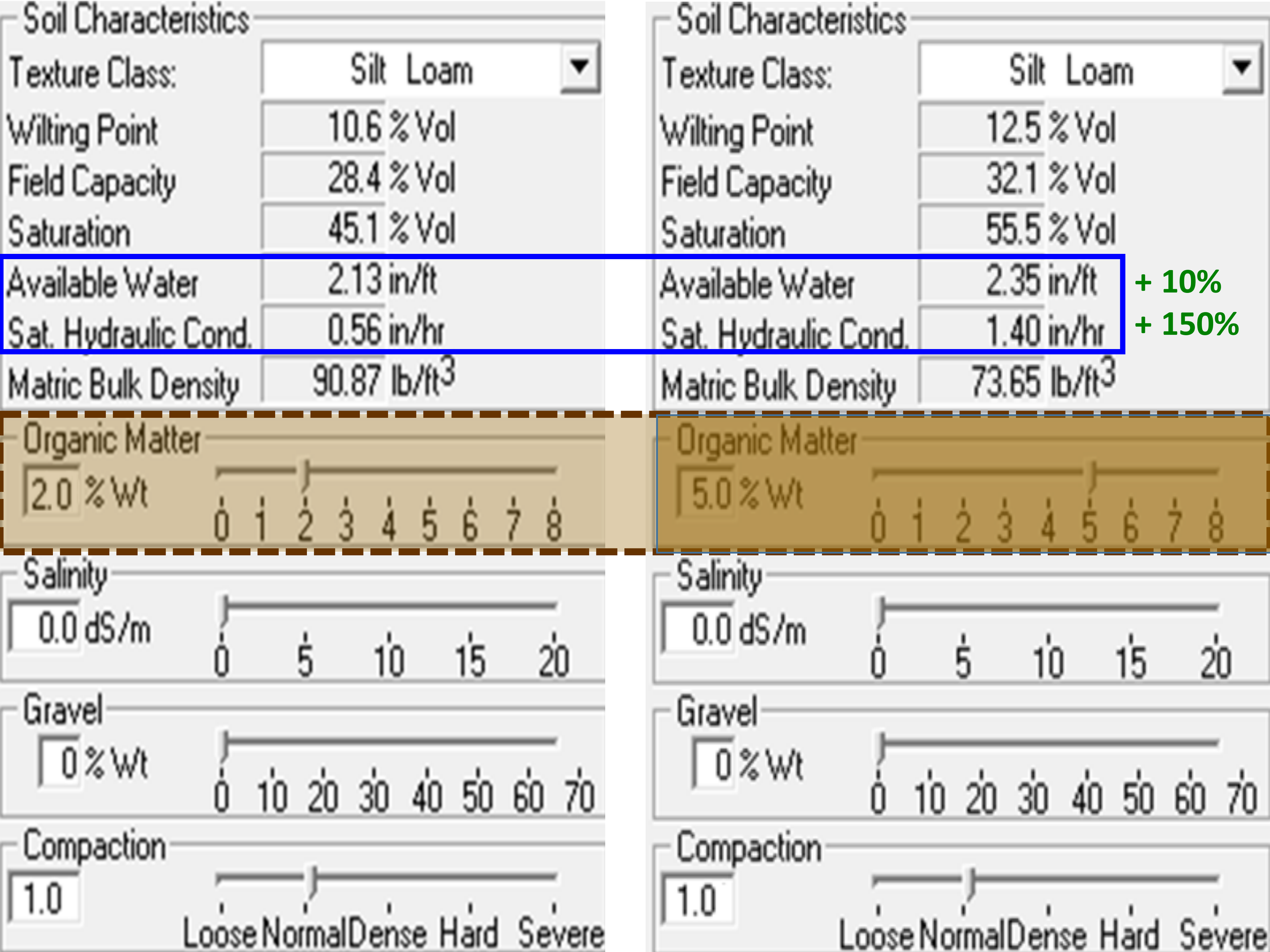

Soil Characteristics
Texture Class: Silt Loam
Wilting Point 10.6 %Vol
Field Capacity 28.4 %Vol
Saturation 45.1 %Vol
Available Water 2.13 in/ft
Sat. Hydraulic Cond. 0.56 in/hr
Matric Bulk Density 90.87 lb/ft3
Organic Matter
2.0 %Wt
0 1 2 3 4 5 6 7 8
Salinity
0.0 dS/m
0 5 10 15 20
Gravel
0 %Wt
0 10 20 30 40 50 60 70
Compaction
1.0
Loose Normal Dense Hard Severe
Soil Characteristics
Texture Class: Silt Loam
Wilting Point 12.5 %Vol
Field Capacity 32.1 %Vol
Saturation 55.5 %Vol
Available Water 2.35 in/ft
Sat. Hydraulic Cond. 1.40 in/hr
Matric Bulk Density 73.65 lb/ft3
Organic Matter
5.0 %Wt
0 1 2 3 4 5 6 7 8
Salinity
0.0 dS/m
0 5 10 15 20
Gravel
0 %Wt
0 10 20 30 40 50 60 70
Compaction
1.0
Loose Normal Dense Hard Severe
+ 10%
+ 150%

Crop rotations for increased soil carbon: perenniality as a guiding principle

Alison E. King and Jennifer Blesh[1]

School for Environment and Sustainability, University of Michigan, 440 Church Street, Ann Arbor, Michigan 48109 USA

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 … s and
functio… ilizer
applicat… rized
crop rot… rops,
and gra… cate-
gories: … . We
compar… onfi-
dence i… ions,
increase… ively.
Within … 6%),
root C … ct of
species … ct of
functio… 5 kg
N·ha^{-1}·yr^{-1}), the decrease in SOC with cereal + legume grain rotations was less than at high N fertilizer rates. Our results show that increasing the functional diversity of crop rotations is more likely to increase SOC concentrations if it is accompanied by an increase in C input. Functionally diverse perennial and cover cropped rotations increased both C input and SOC concentrations, potentially by exploiting niches in time that would otherwise be unproductive, that is, increasing the “perenniality” of crop rotations.

Functionally diverse perennial and cover cropped rotations increased both C input and 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

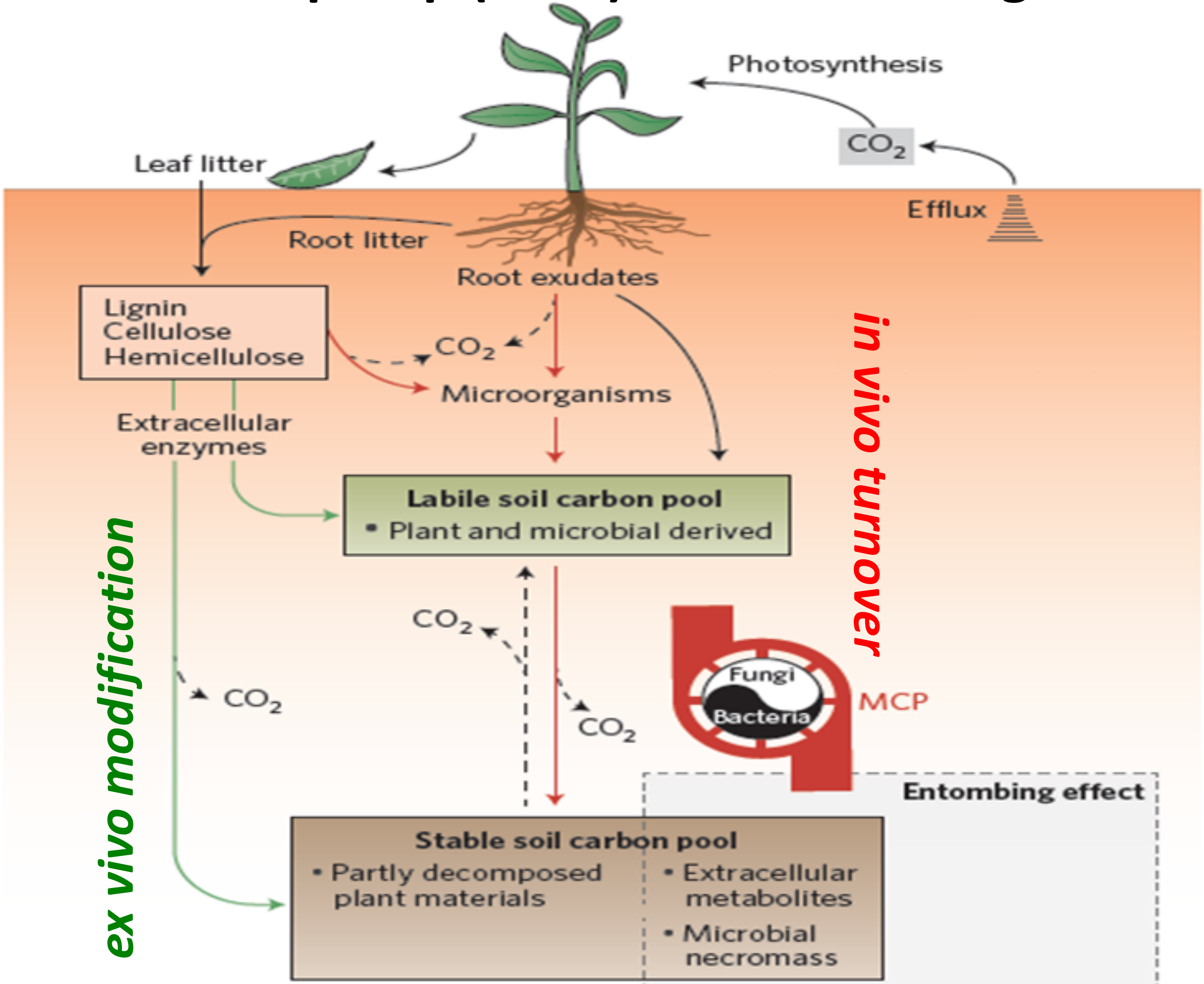
Nature Microbiology - 2017

Chao Liang[1*], Joshua P. Schimel[2] and Julie D. Jastrow[3]

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 ultimatel … ediated processes … jointly explain s … of the soil 'micr … ouples microbial … ct. This integrati … hether via physi … nent of microbial-derived C in soils. We propose a need for increased efforts and seek to inspire new studies that utilize the soil MCP as a conceptual guideline for improving mechanistic understandings of the contributions of soil C dynamics to the responses of the terrestrial C cycle under global change.

…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)



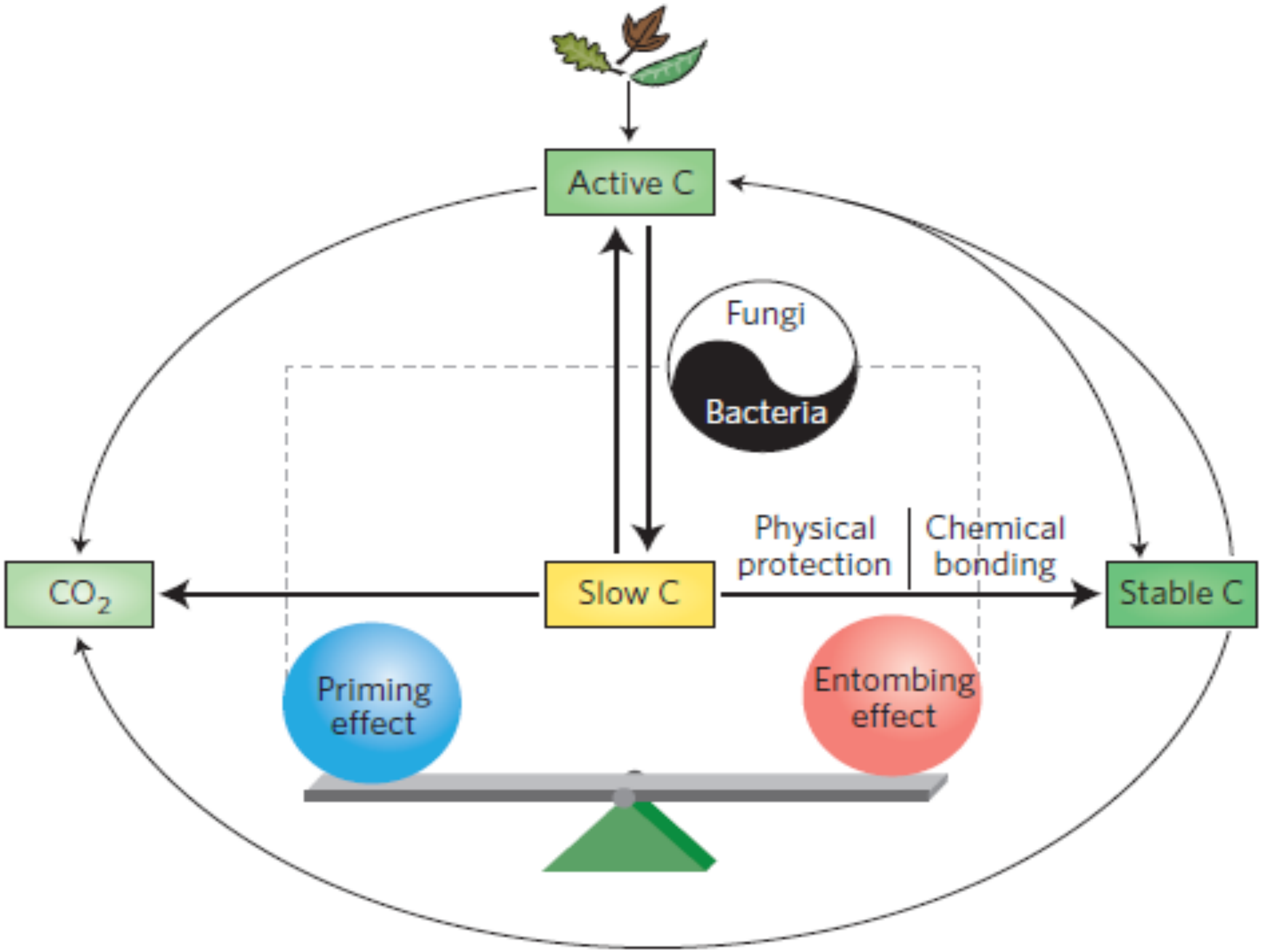
2 major pathways by which microorganisms influence SOM stabilization

***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



environmental microbiology

sfam society for applied microbiology

Research article

Mineral surface-reactive metabolites secreted during fungal decomposition contribute to the formation of soil organic matter

Tao Wang, Zhaomo Tian, Per Bengtson, Anders Tunlid, Per Persson

First published: 10 November 2017 | https://doi.org/10.1111/1462-2920.13990

SECTIONS PDF TOOLS SHARE

Summary

Soil organic matter (SOM) constitutes the largest terrestrial C pool. An emerging, untested, view is that oxidation and depolymerization of SOM by microorganisms
promot … M stabilization.
To test … ving one
ectomy … or functional
groups … nposition
enhanc … nodifications of
organic … tial amounts
(> 10% … n enhanced
mineral … n mineral-
stabilize … ynthesizing
mineral … decomposers can
play a yet overlooked role in the formation and stabilization of SOM.

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

Decrease of soil organic matter stabilization with increasing inputs: Mechanisms and controls

Geoderma - 2016

Muhammad Shahbaz [a,c,*], Yakov Kuzyakov [b,c], Felix Heitkamp [a]

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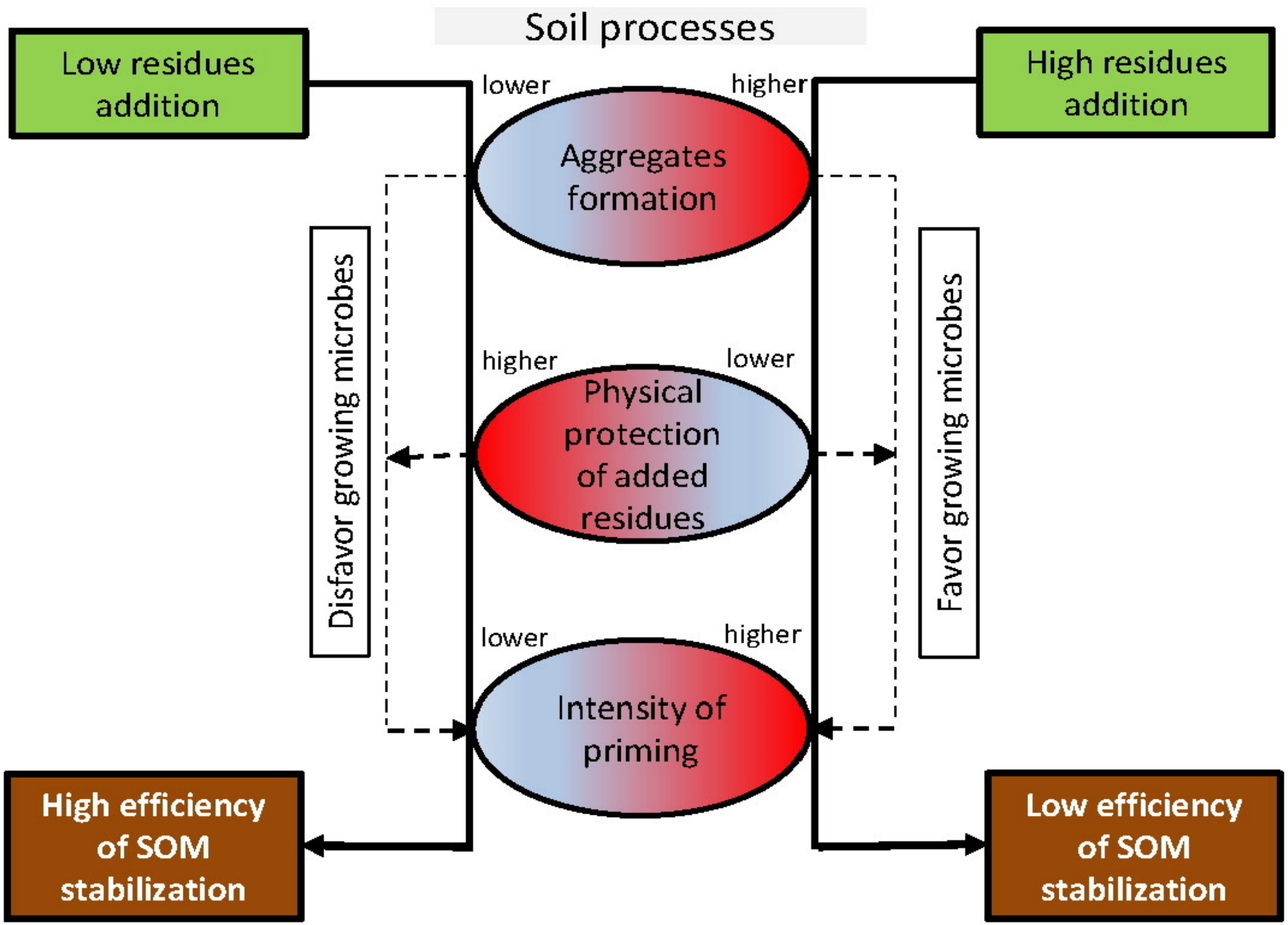
Straw residue
Soil organic matter
Carbon sequestration
Priming effect
Water stable aggregates

ABSTRACT

Crop residue addition is a way to increase soil organic matter (SOM) level in croplands. However, organic matter input and SOM stocks are not linearly related. Consequently, adding high amounts of residues, such as straw, may increase SOM to only a small extent, and an alternative use of the residues may be justified. The objective of this
study was to ... bilization.
We hypothe ... ggregate
formation w ... ing, with
the magnitu ... s (leaves,
stalks, roots) ... 13C signa-
ture were m ... ates (53–
250 μm) and ... was quan-
tified in each ... t, but the
proportion o ... on of res-
idues from ... Residue
mineralisati ... talks and
leaves. Prim ... unt: SOM
mineralisation increased by 50% and 90% at low and high addition levels, respectively. 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.

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)

Journal of Soils and Sediments
https://doi.org/10.1007/s11368-018-1916-4

HUMIC SUBSTANCES IN THE ENVIRONMENT

CrossMark

Humic products in agriculture: potential benefits and research challenges—a review

Daniel C. Olk[1] · Dana L. Dinnes[1] · J. Rene Scoresby[2] · Chad R. Callaway[3] · Jerald W. Darlington[2]

Received: 4 October 2017 / Accepted: 5 January 2018

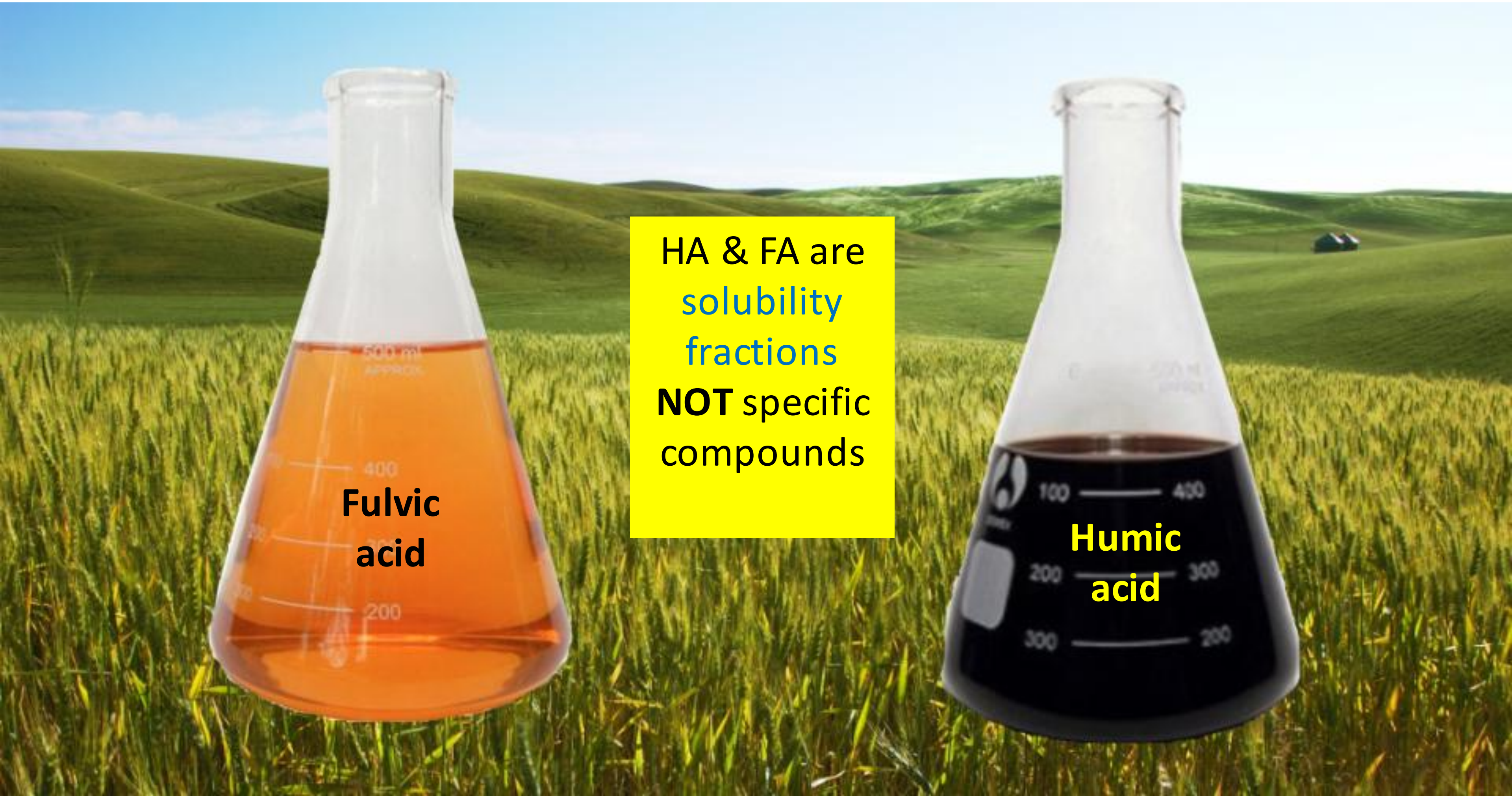
Abstract
Humic products have been used in cropland agriculture for several decades, but lack of widespread credibility has restricted their use to small proportions of farmers. To improve the credibility of humic products, we identify four knowledge gaps and propose pathways of future action to close these gaps. First, while the capacity of humic products to improve plant growth has been proven in greenhouse and growth chambers, more such work is needed in field conditions, especially to determine the modifying effects o [illegible] s, soil type, anc [illegible] nce of humic p [illegible] ducts. Some re [illegible] itions. Industry [illegible] robial-based ex [illegible] lustry-wide me [illegible] their humic a [illegible] inally, humic p [illegible] ts and thereby [illegible] long-term fie [illegible] more knowled [illegible] t of a global r [illegible] ducts, crop types, soil types, and climates. Plant and soil samples would be analyzed by cooperating specialists in advanced laboratories to identify mechanistic processes and benefits to both plant production and soil health. 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.

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



TIDIC acid production system ☺

A New Standardized Method for Quantification of Humic and Fulvic Acids in Humic Ores and Commercial Products

Richard T. Lamar
Horizon Ag Products, 1450 Infinite Dr, Louisville, CO 80037
Daniel C. Olk
U.S. Department of Agriculture, Agricultural Research Service, National Laboratory for Agriculture and the Environment, 2110 University Blvd, Ames, IA 50011
Lawrence Mayhew
EAM Consulting, 3899 Schreiner Rd, Spring Green, WI 53588
Paul R. Bloom
University of Minnesota, Department of Soil, Water, and Climate, 1919 Upper Buford Circle, Suite 439, St. Paul, MN 55108

Increased use of humic substances in agriculture has generated intense interest among producers, consumers, and regulators for an accurate and reliable method to quantify humic acid (HA) and fulvic acid (FA) in … present a thorou… standardized met… contents in raw h… products produc… preparation of HA and FA were adapted according to the guidelines of the International Humic Substances Society involving alkaline extraction followed by acidification to separate HA from the fulvic fraction. This is followed by separation of FA from the fulvic fraction by adsorption on a nonionic macroporous acrylic ester resin at acid pH. It differs from previous methods in that it determines HA and FA

quantification of humic and fulvic acids in humic ores and commercial products. This single-laboratory validation (SLV) study was conducted under the guidance of the Association of American Plant Food Control Officials (AAPFCO) to validate …nalysis of HA and FA in …s work, there has been no …ining the quantity of HA

…to quantify HA and FA in solid and liquid commercial humic products, peat, soil, and humate-containing geological deposits. This method is based on a procedure for extracting HA and FA from natural materials. Like the method of Swift (2), the proposed method is a modified form of the "classical" technique described in detail by Stevenson (3). The classical method of extracting HA and FA from soil humus utilizes a strong base to extract the alkaline-soluble materials, and then, after removal of

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

Comparison of Permanganate-Oxidizable Carbon and Mineralizable Carbon for Assessment of Organic Matter Stabilization and Mineralization

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School of Environment and Natural Resources
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William R. Horwath
Jordon Wade
Deandra Cass
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Joshua W. Beniston
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Permanganate-oxidizable C (POXC) and mineralizable C (as determined by short-term aerobic incubation of rewetted soil) are measures of active organic matter that may provide early indication of soil C stabilization and …

… biomass, and tomato (Solanum lycopersicum L.) fruit yield than other soil C fractions evaluated here. Thus, the integrated use of POXC and mineralizable C can provide a complementary framework to assess the relative dynamics of soil C stabilization and nutrient mineralization functions in agroecosystems.

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.

SituResp®: A time- and cost-effective method to assess basal soil respiration in the field

Alexis Thoumazeau[a,b,c,d,*], Frédéric Gay[b,c,**], Pascal Alonso[d,e], Nopmanee Suvannang[d], Audjima Phongjinda[d], Phantip Panklang[d,f], Tiphaine Chevallier[b], Cécile Bessou[a], Alain Brauman[b,d]

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[c] HRPP, Kasetsart University, 10900, Bangkok, Thailand
[d] LMI LUSES, Land Development Department, 10900, Bangkok, Thailand
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Basal soil respiration
SituResp®
Solvita®
Indicator
Soil microbial activity
Soil quality

ABSTRACT

The soil microbial activity is a key parameter in numerous studies aiming to assess soil quality in agricultural plots. Basal Soil Respiration (BSR) has been extensively used as an indicator of this soil microbial activity. However, available methods to measure BSR remain time- and labor- consuming and must be performed in the
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field test on 9 agricultural-plots, the SituResp® method yielded similar results to the Solvita® tool. The SituResp® method is therefore a reliable method for performing a cheap, rapid but efficient assessment of soil microbial activity in the field which could be included in soil quality monitoring.

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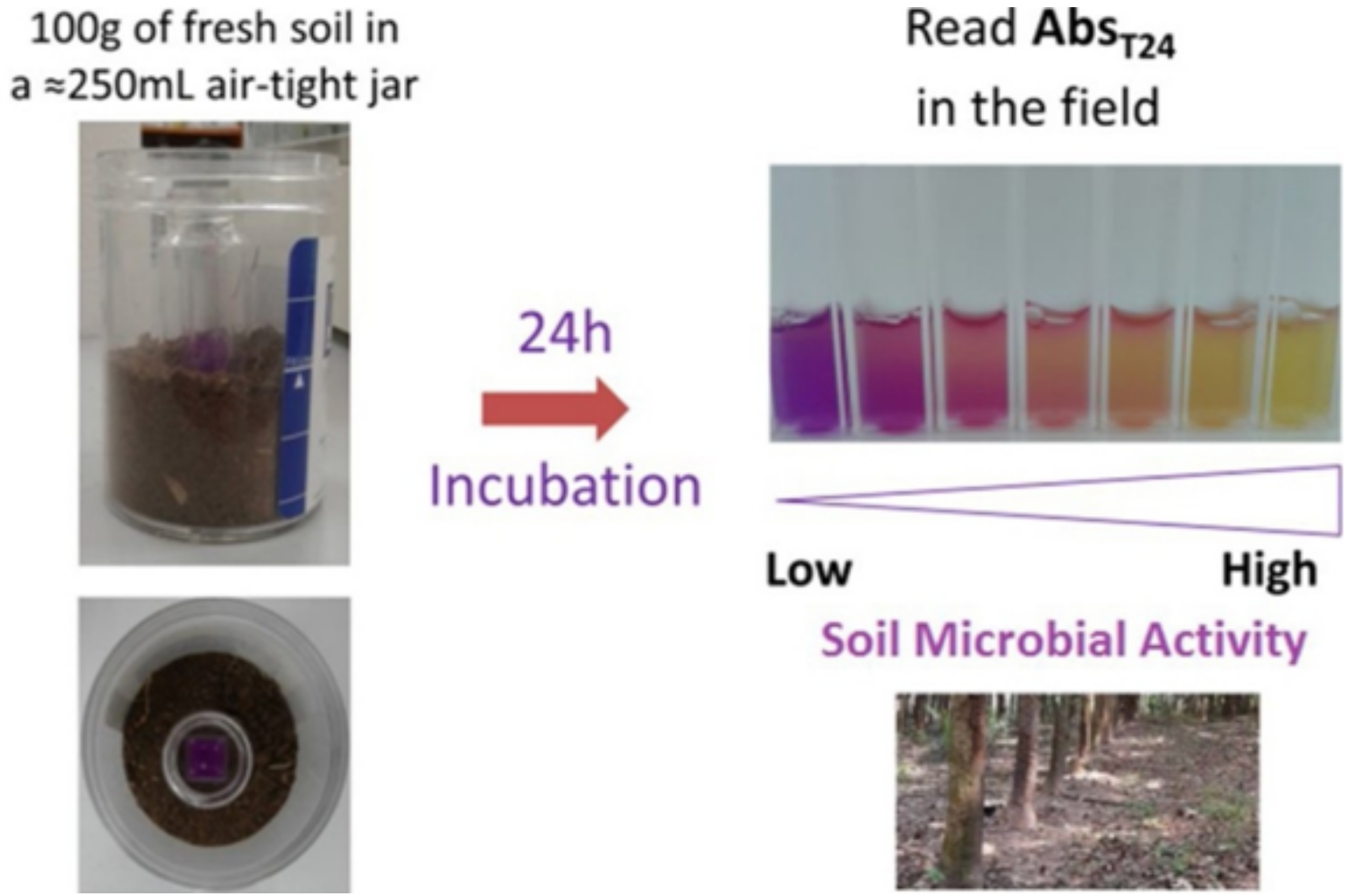
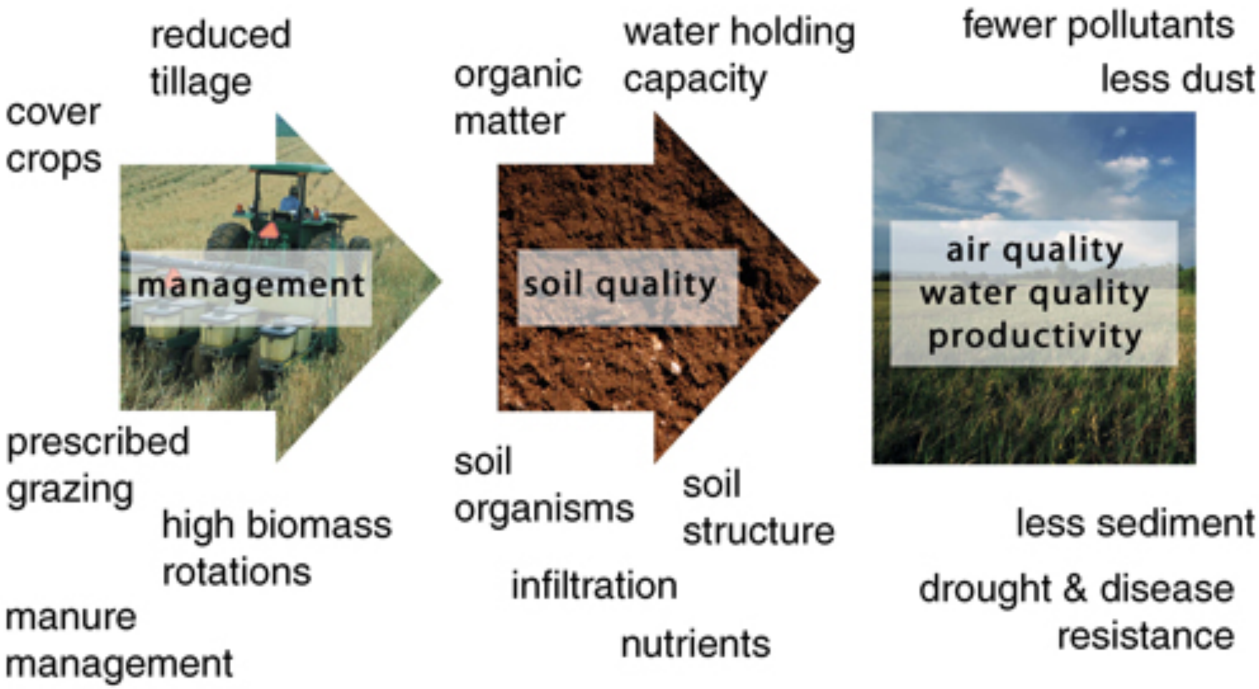
Cuvettes containing pH indicator Cresol Red in agar gel provide a cheap sensitive measurement of respiration



(Thoumazeau et al, 2017)

Go beyond T - Manage for C!

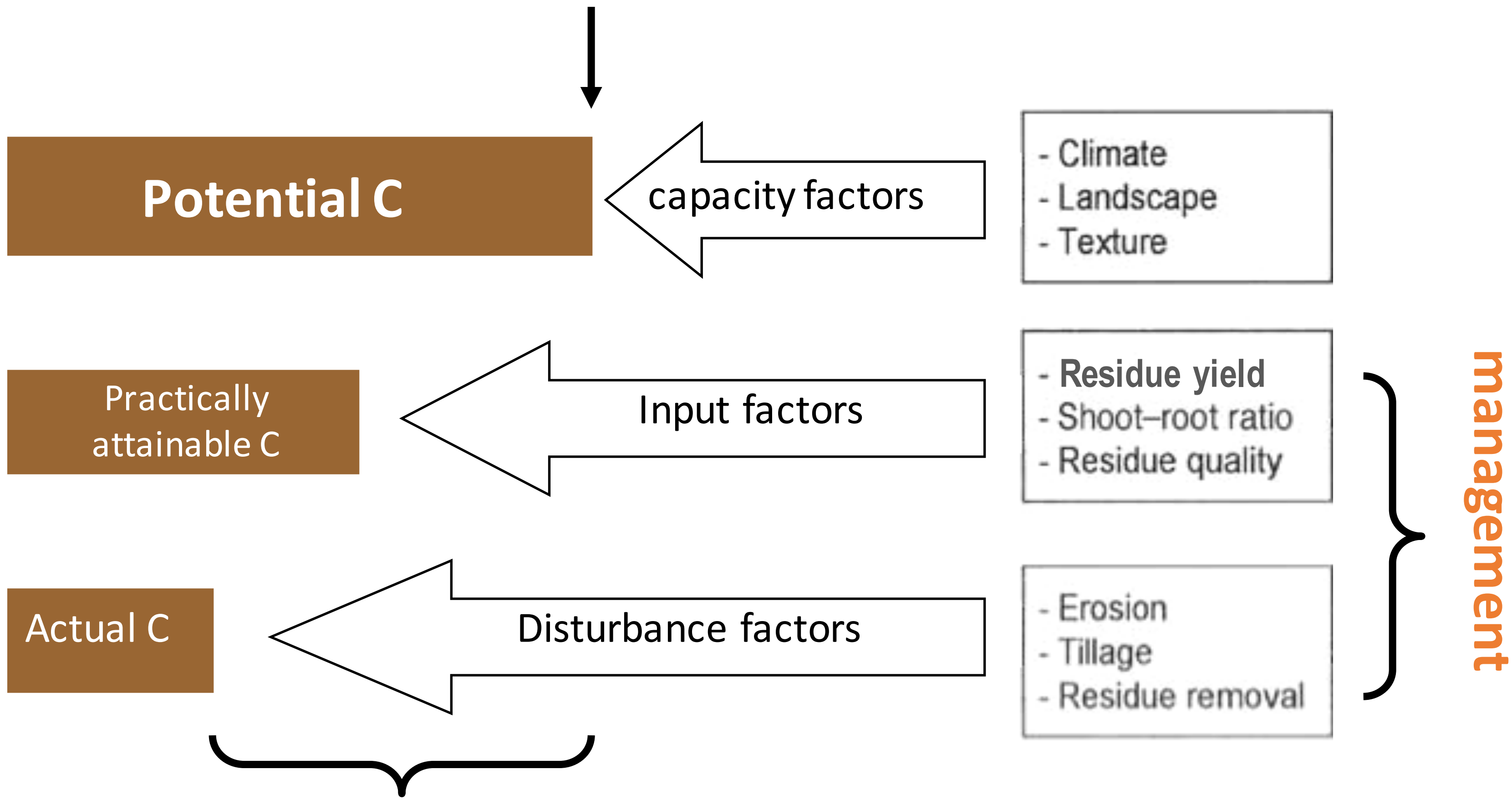
Managing soil organic matter is the key to air and water quality.



http://soils.usda.gov/sqi/concepts/soil_organic_matter/som.html


Is this really possible?
Marengo silt loam
Ap1
Ap2
AB
Bg1
Bg2
Bg3
Bg4
Bg5

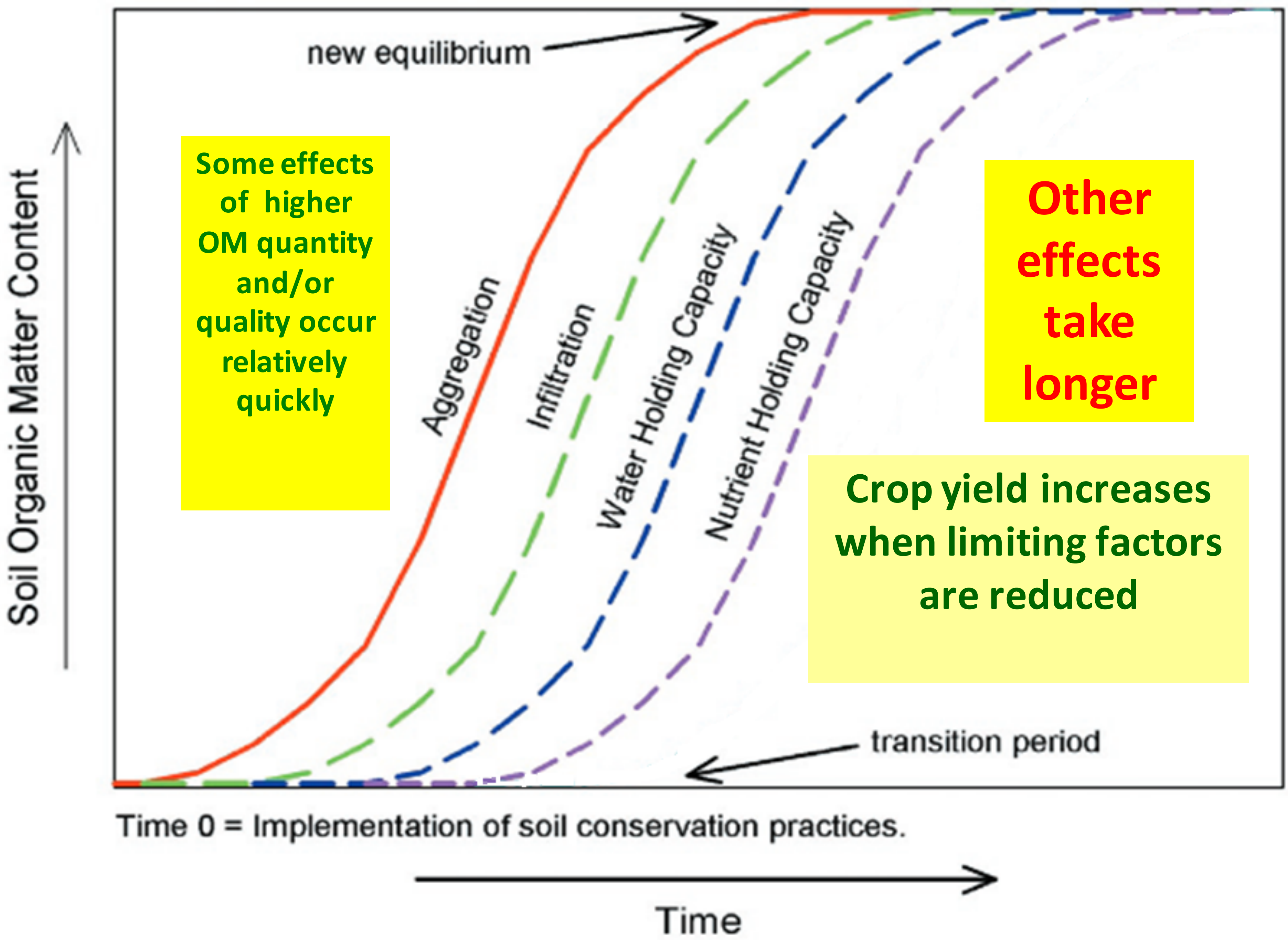
Saturation of capacity



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.



Soil Organic Matter Content
new equilibrium
Some effects of higher OM quantity and/or quality occur relatively quickly
Aggregation
Infiltration
Water Holding Capacity
Nutrient Holding Capacity
Other effects take longer
Crop yield increases when limiting factors are reduced
transition period
Time 0 = Implementation of soil conservation practices.
Time