

# Compost characteristics and compost use, including soil carbon credits

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## Using Compost Wisely and Beneficially

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## Finally – You Have Successfully Navigated Regulatory and Technical Hurdles, Made Compost and its Ready to Use!



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**What? Where? How much? Benefits? Savings?**



Source: <http://managingnutrients.blogspot.com.au/>

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## Some Important Questions

- What type of compost do you have?
- Where and for what purpose do you want to use it?
- What benefits do you want to achieve?



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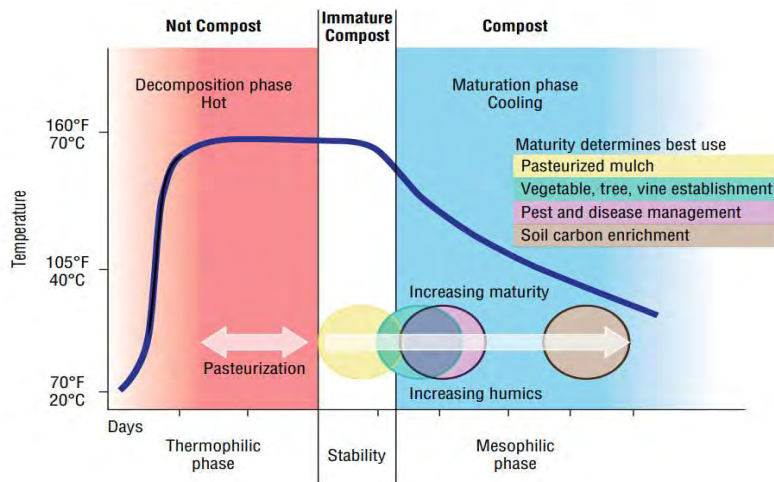
## What Determines Compost Characteristics?

Compost characteristics & the benefits of using compost depend on

- feedstock materials
- processing (duration, temperature, moisture, aeration, **i.e. management**)
- storage (duration, conditions)
- value-adding (e.g. screening, adding lime / gypsum / nutrients / inoculants)

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## Composting Process and Product Quality



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## Compost Characteristics

- Macro nutrients (N, P, K, Mg, Ca) – you need total & available content - often limited N but considerable P and K
- Micro nutrients (S, Zn, Mn, B, Mo....)
- Neutral pH (7 - >8) / Liming Effect
- Both labile and stable carbon compounds
- High cation exchange capacity
- High water holding capacity
- Low bulk density
- Diverse microbial population

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## What to watch out for

- Heavy metals
- High soluble salts (Na & Cl = bad salts, plant nutrients = good salts)
- Biosecurity risks (weeds, animal & human pathogens)
- Herbicide residues (Clopyralid, Picloram, Aminopyralid)
- High C/N ratio
- Impurities (e.g. plastic, metal, rocks, twine)
- Inappropriate particle size
- Moisture content (too high / too low)

## AS 4454 Provides Limited Quality Assurance

### Australian Standard AS 4454 Composts, soil conditioners and mulches

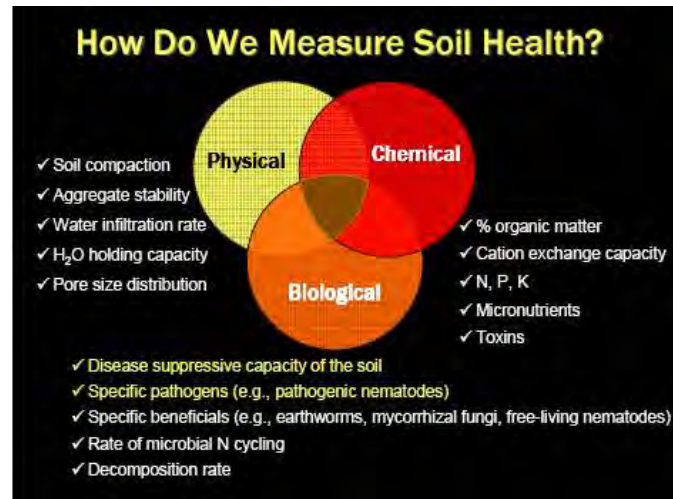
Voluntary Standard that provides  
Minimum quality requirements  
for public health protection and  
to prevent major end-use problems



Australian  
Standard

## Compost Products are Multi-Purpose Products

**Able to improve  
Chemical,  
Physical,  
Biological  
Soil Properties**



Source: Gugino, 2005

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## Benefits of Using Compost

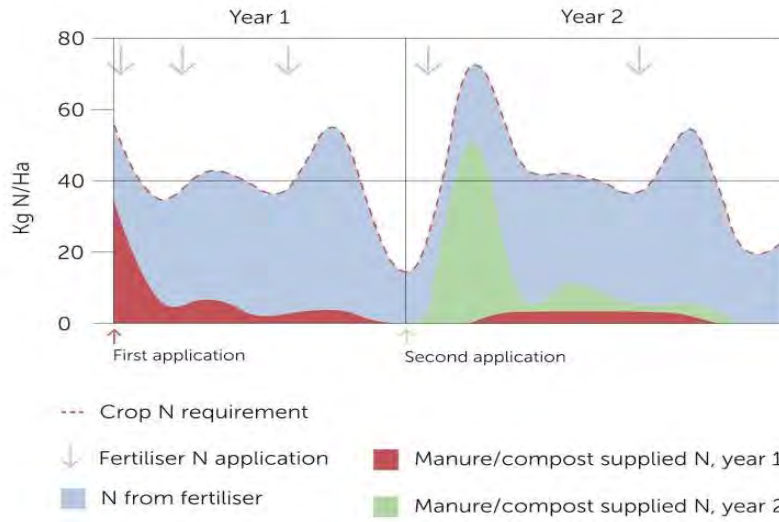
- Many agricultural benefits (e.g. soil properties & crop productivity)
- Many environmental benefits (biosecurity, nutrient management)

Today, focusing on

- Contributions to plant nutrient supply
- Contributions to soil carbon stocks

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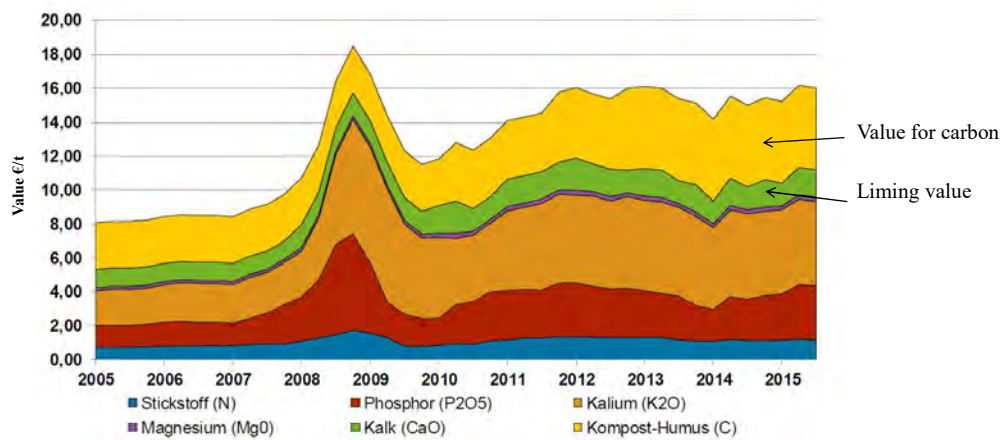
## Integrated Organo-Mineral Nutrient Supply



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## Value of Nutrients, Lime & Carbon in Compost (Germany)



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## Fertiliser Replacement Capacity (Trial Results, Germany)

- Annual use of compost for 9 / 12 years at 5 sites (sandy, loamy, clay soils)
- Urban derived compost made from vegetation + food residues (1.4% N, 0.3% P, 0.9% K, 38% OM, C/N 17)
- Application rates: 0, 5, 10, 20 t DM /ha annually
- + 0, 50%, 100% recommended N
- Rotation: corn / wheat / barley

## Overall Results

Optimum Application Rate  
6 – 10 t DM/ha/year

### Nutrient Balance - *Total Nutrients*

- about balanced for N, P and K
- large surplus for Mg



## Results – P, K & Mg

Compost can replace P, K & Mg fertiliser and substitute liming

### Nutrient Balance – Plant Available Nutrients

- **Phosphorus**
  - 15 – 25% soluble (high fertilising efficiency)
  - increased soil P
  - longer-term: 80 – 100% accountable
- **Potassium**
  - 65 – 70% soluble (high fertilising efficiency)
  - increased soil K
- **Magnesium**
  - 7 – 10% soluble (low fertilising efficiency)
  - no increased soil Mg

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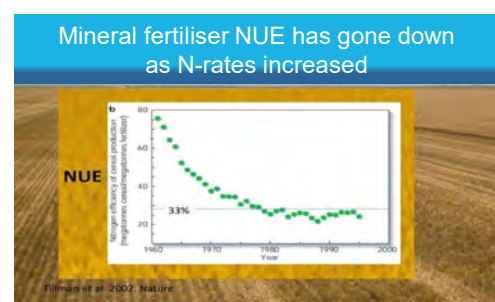
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## Compost Nitrogen Use Efficiency

### Generally

- 0 – 10% uptake of added N
- < 5% during initial 3 - 4 years
- 5 – 15% if compost applied > 4 years
- N use efficiency higher (5 – 25%) if no / little use of mineral N
- N use efficiency higher if used for crops with high N demand
- Increase of soil mineral N with some utilised later

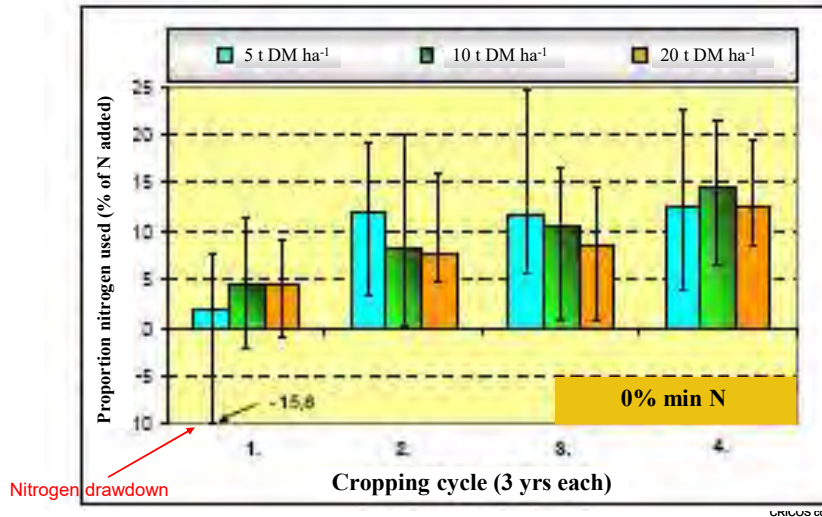


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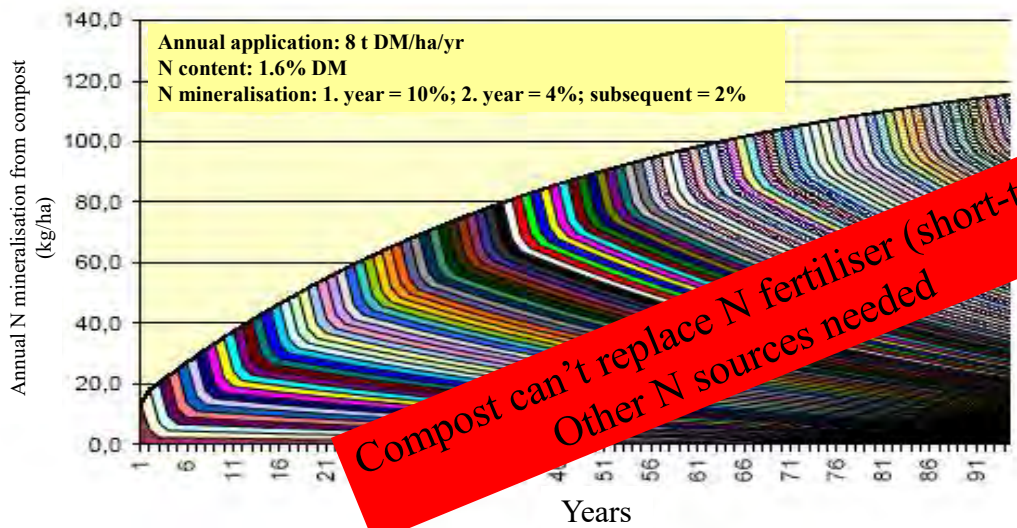
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## Increasing Nitrogen Use Efficiency Over Time (12 years = 4 cropping cycles)



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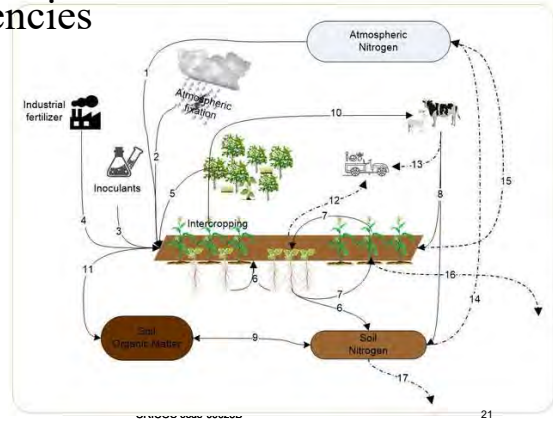
## Annual Compost Use = Long-term Nitrogen Supply



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## Account for Compost Nutrient Supply in Nutrient Budget

- to see and realise mineral fertiliser savings (\$)
- to minimise risks of nutrient deficiencies
- to avert risk of P oversupply
- to prevent environmental problems



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## Nutrient Calculator for Organic Amendments



A decision-support tool for farmers to...

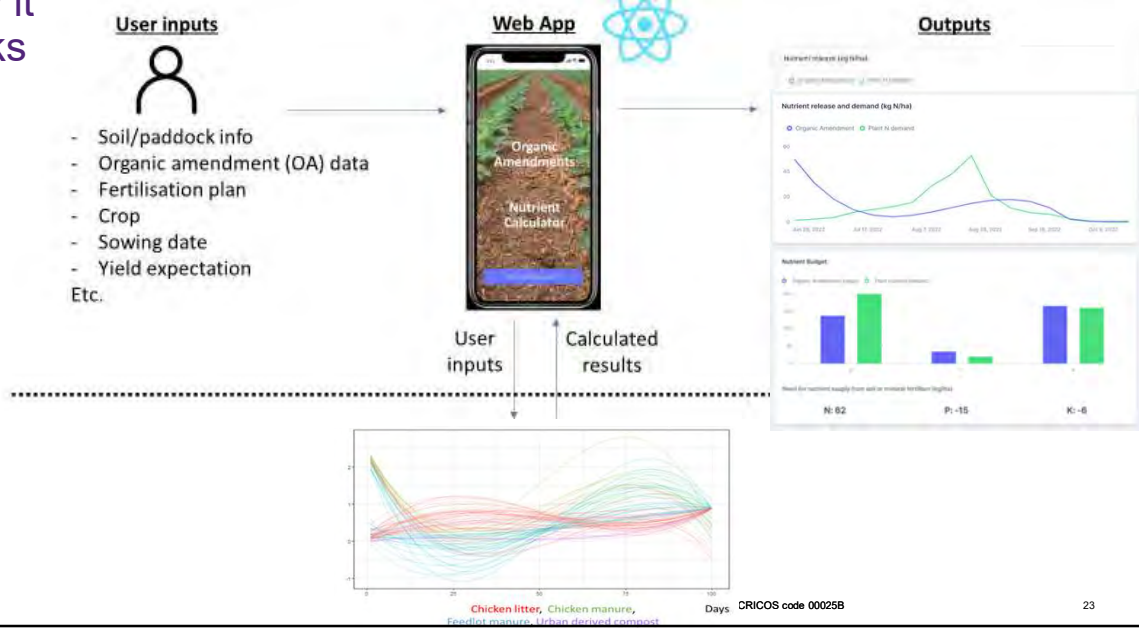
- integrate nutrient supply from organic amendments into farm nutrient budgets, and
- gauge the mineral fertiliser replacement potential of organic amendments



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## How it works

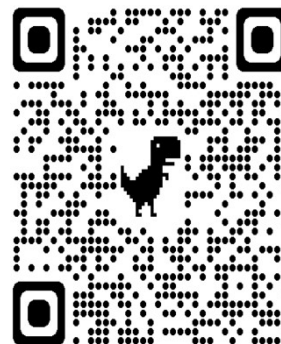


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## Check it Out and Give us Feedback



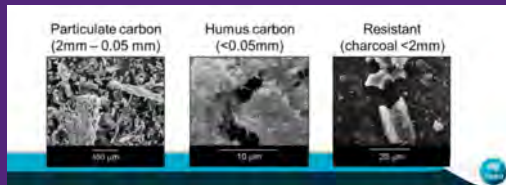
<https://oa-nutrient-calculator.netlify.app/>



<https://docs.google.com/forms/d/1-8xB861sx8mx16ZicZXsrHvNG5pXBflsEuosqdALmg/edit>

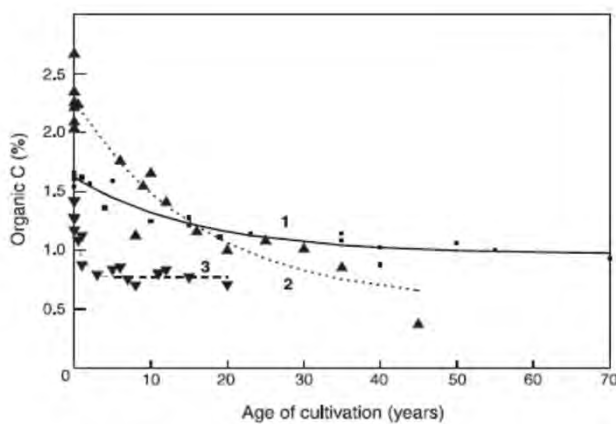
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# Using Compost to Enhance Soil Carbon Levels

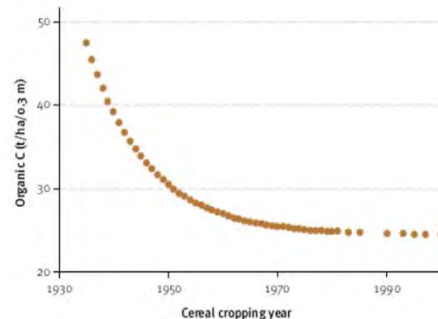


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## Soil Cultivation Results in Declining Soil Carbon Stocks



Source: Dalal 2001



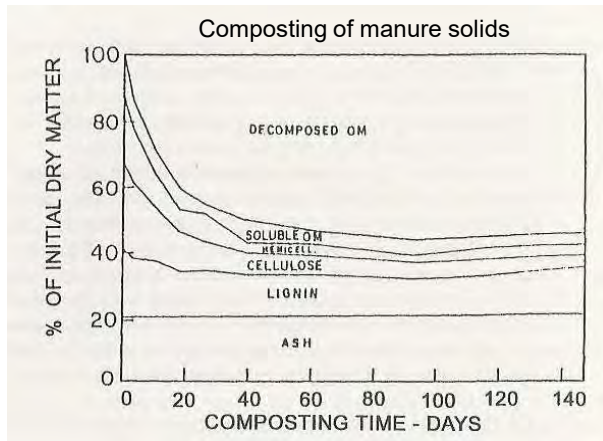
Modelled decline in soil organic carbon since 1935 after land under brigalow was cleared for cereal cropping on the Darling Downs (Dalal et al. 2003)

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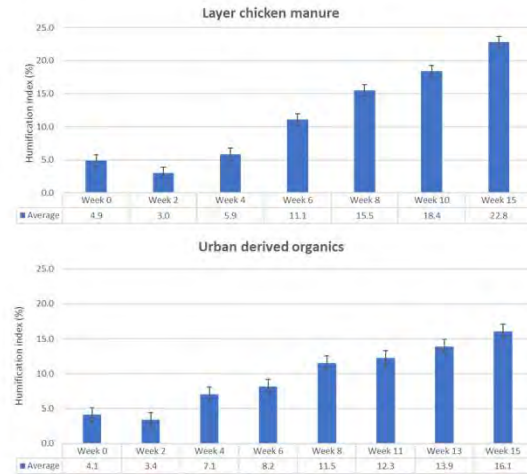
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## Composting = Carbon Transformations



Source: Inbar *et al.* 1989 in Epstein 1997

Production of humic acid as proportion (%) of total organic carbon during composting



Source: Bennett-Jones 2022

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## Soil C sequestration as a Priority for Offsetting Australia's GHG emissions

- Significant government investment delivered major scientific, data and technological advances;
- Great potential for SOC sequestration in existing agricultural systems;
- Development of first approved soil carbon sequestration methodology in 2014 (CFI) included compost use as approved practice;
- New ERF methodology allows use of '**non-synthetic fertilisers**' if generated from a dedicated waste stream and if their use is new or significantly different management practice;

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# Is Compost the Saviour?

26 November 2019

## Compost for Carbon: webinars for farmers to cash in on compost

The naturally deficient in carbon, Australian soils are being depleted further through agriculture. Adding organic matter helps replenish nutrients and improve soil structure. When carbon is added through compost, it is good for the environment, the soil and for now earn ACCUs and cash through the the Emissions Reduction Fund.

### Using compost to build and maintain soil carbon

Bill Grant<sup>1</sup>, Duncan Le Good<sup>2</sup>, Matthew Wilcock<sup>3</sup>  
<sup>1</sup>Australian Organic Recycling Association (AORA)/Blue Environment, [bill@arobf.com.au](mailto:bill@arobf.com.au) or 0437 852 070

As a necessary consequence of increasing agricultural production, organic carbon improves soil structure, health and function. Increasing soil carbon is also seen as a way to achieve carbon abatement (sequestration), but there is some uncertainty about how much soil carbon will remain in the soil under farming systems, particularly if drying climate trends continue. Land management practices, soil types and periodic climate extremes can make it difficult to build and maintain soil carbon levels in many parts of Australia. This is particularly the case on dryland cropping land, lighter soils and in areas with variable rainfall and extended

for organic materials biodegrading at lower temperatures. Matured thermophilic composts typically have organic carbon levels of 30-40% by weight, and in the order of 80% of this can be in more stable forms. This means compost can provide a concentrated source of 'slow' carbon that can be used to build and maintain soil carbon.

#### Degradation rates and accumulation of slow carbon

Stable carbon in composts can build and maintain the levels of 'slow' carbon in soil. With appropriate land

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### Science News

Compost key to sequestering carbon in the soil  
 Study dug deep to uncover which agricultural systems store the most

Date: August 14, 2019  
 Source: University of California | Davis  
 Summary: In a 18-year study, scientists dug roughly 6 feet down to compare soil carbon in different cropping systems. They found that compost is a key to storing carbon strategy for offsetting carbon dioxide emissions.

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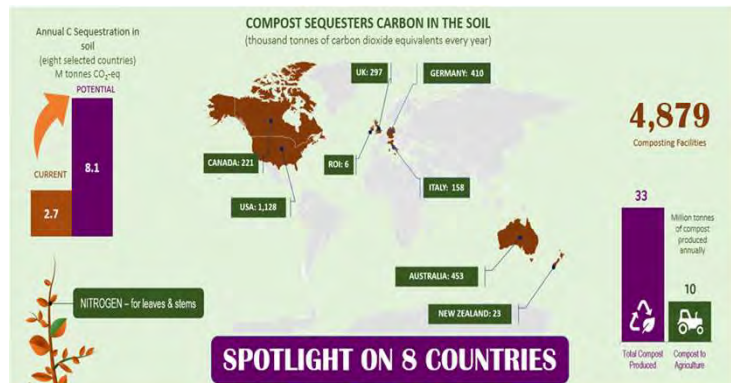
Australian soils are particularly poor, both in terms of general plant nutrients and in terms of organic matter. Undisturbed soils in Australia have been

### The benefits of using compost for mitigating climate change

for Department of Environment, Climate Change and Water NSW

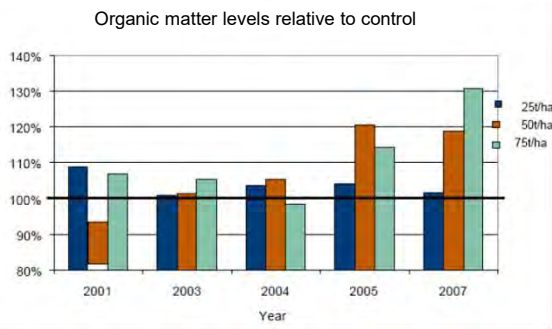
# Many Claims, but where is the Evidence?

No systematic quantitative and qualitative assessment of organic amendments despite their obvious contribution to SOC turnover and stocks



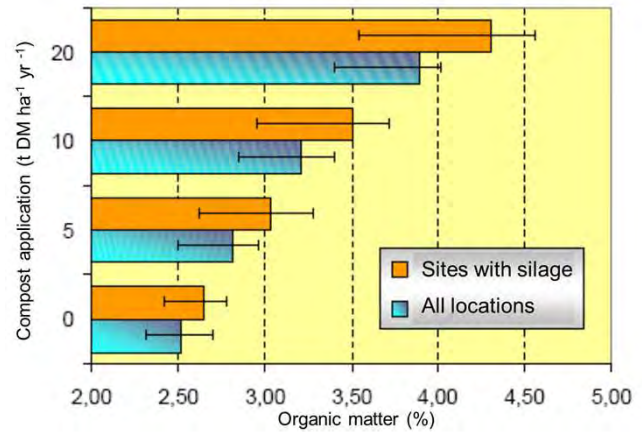
## Effect of Urban-Derived Compost on Soil Organic Matter

Five fields / 2 farms in UK over 7 years



Source: Davison 2008

Five farms in Germany over 9 / 12 years



Source: LTZ 2008

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## Simulating the effects of using manure & compost in QLD

Example:

20 years of continuous sorghum cropping at 3 locations in Queensland with varying soils and climatic conditions.

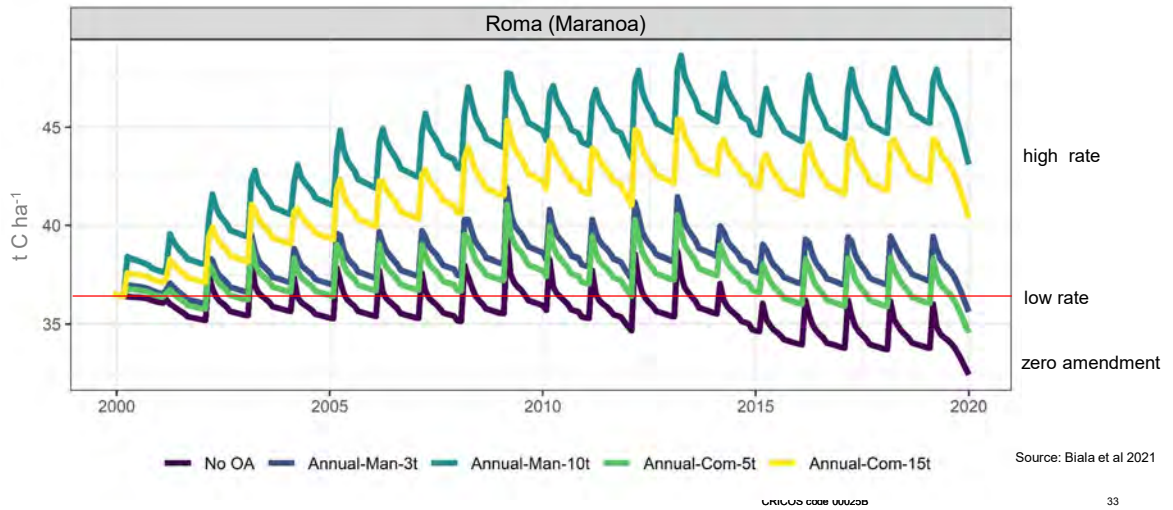
Simulated scenarios (fresh matter application rates):

- ❖ Manure application at 3 t/ha and 10 t/ha annually and at 3-year intervals
- ❖ Compost application at 5 t/ha and 15 t/ha annually and at 3-year intervals
- ❖ No compost or manure application



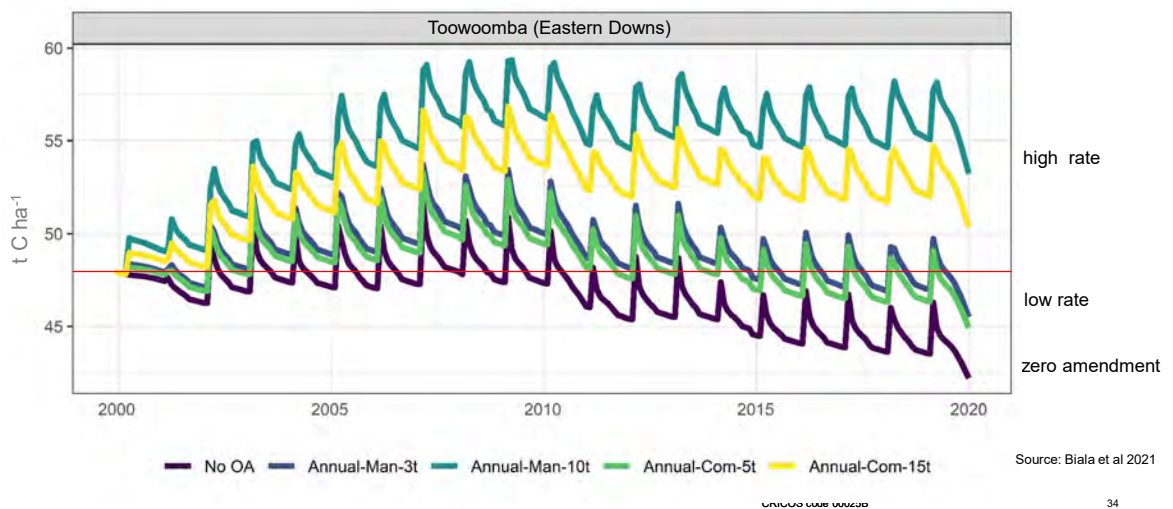
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## Results – Simulated effects of annual manure & compost use (I)



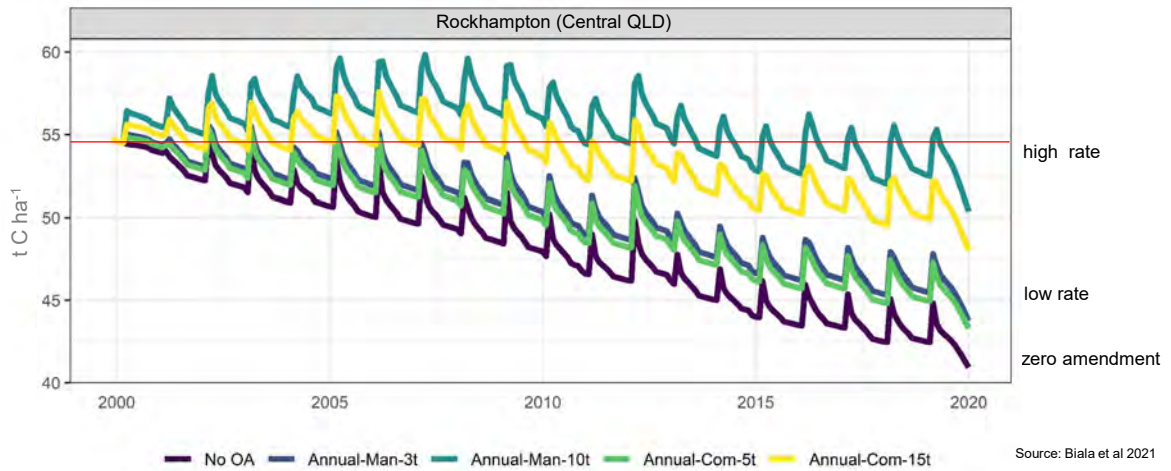
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## Results – Simulated effects of annual manure & compost use (II)



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## Results – Simulated effects of annual manure & compost use (III)



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## Results – Simulated changes in soil organic carbon

Scenario	Application (t fm ha <sup>-1</sup> )	Modelled change in SOC		
		Maranoa	Eastern Downs	Central QLD
No Amendments	0	-11%	-12%	-25%
Annual-Manure-3t	3	-2%	-5%	-20%
Annual-Manure-10t	10	18%	11%	-8%
Annual-Compost-5t	5	-5%	-6%	-21%
Annual-Compost-15t	15	11%	5%	-12%
3Year-Manure-3t	3	-8%	-10%	-24%
3Year-Manure-10t	10	-1%	-4%	-19%
3Year-Compost-5t	5	-9%	-10%	-24%
3Year-Compost-15t	15	-4%	-6%	-21%

Source: Biala et al 2021

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# However, the Current Humus Formation, Stable Organic Carbon Input Model is Being Challenged.....

## PERSPECTIVE

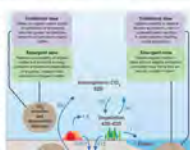
### The contentious nature of soil organic matter

Johannes Lehmann<sup>1,2\*</sup> & Markon Kleber<sup>1,2\*</sup>

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 complex components. Here we argue that the available evidence does not support the formation of large, undecomposable and persistent "humic substances" in soils. Instead, soil organic matter is a continuum of progressively decomposing organic components. 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 increases in the atmospheric concentration of these greenhouse gases<sup>1</sup>. Moreover, organic matter retains nutrients as well as pesticides in the soil, which improve plant growth and pesticide water quality. Nitrates are also an important source of aquatic systems, with implications for biogeochemistry of rivers, lakes and estuaries<sup>2</sup>. Despite its recognized importance, there is a widely divergent view of the nature of soil organic matter.

Biological, physical and chemical transformation processes convert dead plant material into organic products that are able to have intimate associations with soil minerals, making it difficult to study the nature of soil organic matter. Early research based on an extraction method assumed that a humification process occurred and produced humic substances, and large "humic substances" to make up the majority of soil humus (see Box 1). However, these humic substances have not been



Applied Soil Ecology  
Volume 134, October 2020, 105055



Review

### The spontaneous secondary synthesis of soil organic matter components: A critical examination of the soil continuum model theory

Matia De Nobili<sup>1\*</sup>, Carlo Broso<sup>1,2\*</sup>, Yoni Chen<sup>1,3</sup>

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<https://doi.org/10.1016/j.apsoil.2020.105055>

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#### Highlights

- Secondary synthesis of humic substances does not require energy investments.
- Non pre-existing complex molecules are produced by phenoloxidases and peroxidases.

## CHAPTER ONE

### Soil organic matter formation, persistence, and functioning: A synthesis of current understanding to inform its conservation and regeneration

M. Francesca Cotrufo<sup>1</sup> and Jocelyn M. Lavallee

<sup>1</sup>Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO, USA; <sup>2</sup>University of Connecticut, Storrs, CT, USA; <sup>3</sup>University of California, Davis, CA, USA

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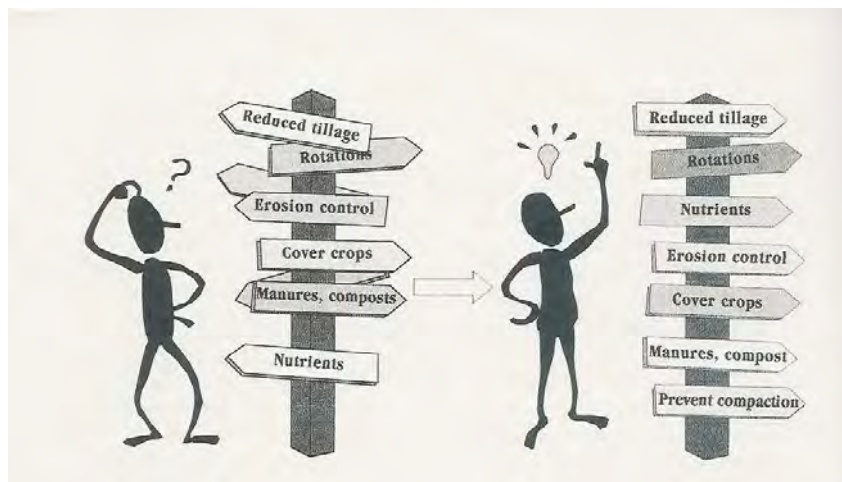
1. Introduction
2. Soil organic matter formation
  - 2.1 Organic matter inputs
  - 2.2 The SOM formation process
  - 2.3 Controls of SOM formation
3. The persistence of soil organic matter

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# Compost Use can Help Achieve Sustainable Soil and Farm Management!



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