



Organic materials & agricultural soil quality

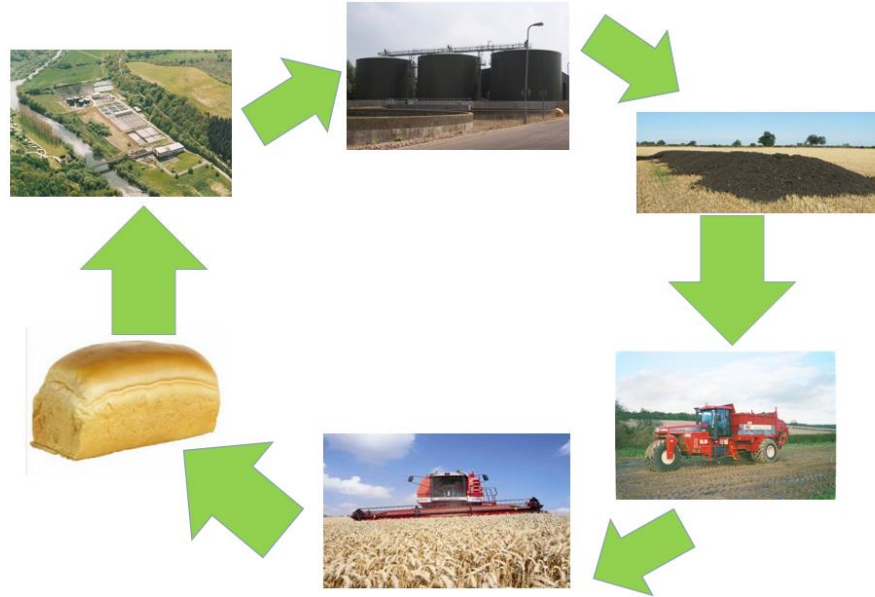
Potential benefits, risks and implications for crop productivity

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ADAS Soils & Nutrients

Why recycle organic materials to land?

- *Nutrients – ‘close loops’*
- **‘Non-nutrient’ benefits:**
 - **Organic matter:**
 - Improve soil ‘health’
 - Store carbon



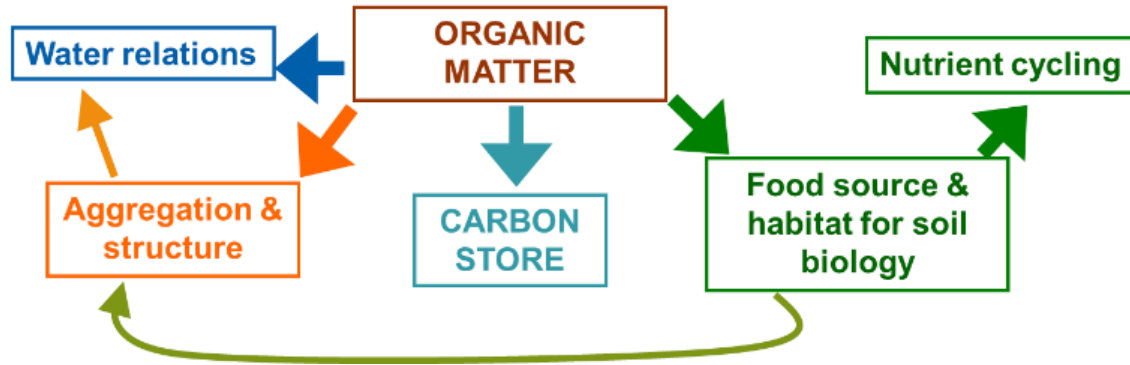
Organic materials - excellent source of organic matter

Organic material	Dry matter	Application rate (t/ha FW) NVZ 250 kg N/ha	Organic matter applied (t/ha)
Cattle FYM	25%	42	5.5
Broiler litter	60%	8	2.5
Biosolids cake	25%	20	3.5
Green compost	60%	33	4.5
Green/food compost	60%	22	5.0

The importance of organic matter

'Soil just isn't soil without organic matter' Brian Chambers

- The majority of soil functions are driven by biological processes, underpinned by SOM decomposition – SOM is the major currency in soil systems.



Increasing organic matter will:

- Improve soil structure, workability and rooting
- Increase water holding capacity and infiltration
- Increase biological activity, nutrient retention & turnover

Leading to:

- Improved productivity & lower inputs
- Reduced erosion, runoff and waterlogging
- Reduced emissions to the environment
- Greater resilience

Current literature

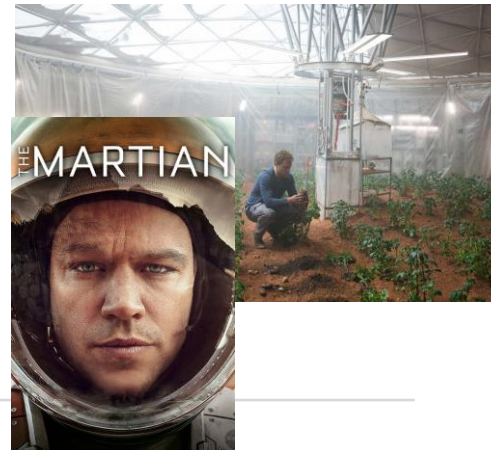
(‘organic manure’ OR ‘organic material’ OR ‘manure’) AND (‘soil fertility’ OR ‘soil health’ OR ‘soil quality’); Last 5 years (2018-2023)

- Soil **‘Fertility’** – chemical properties e.g. nutrient status, pH
- Soil **‘Quality’** – ‘fertility’ + aspects of soil physical condition
- Soil **‘Health’** – all of the above + soil biology

600 research articles; 34 reviews

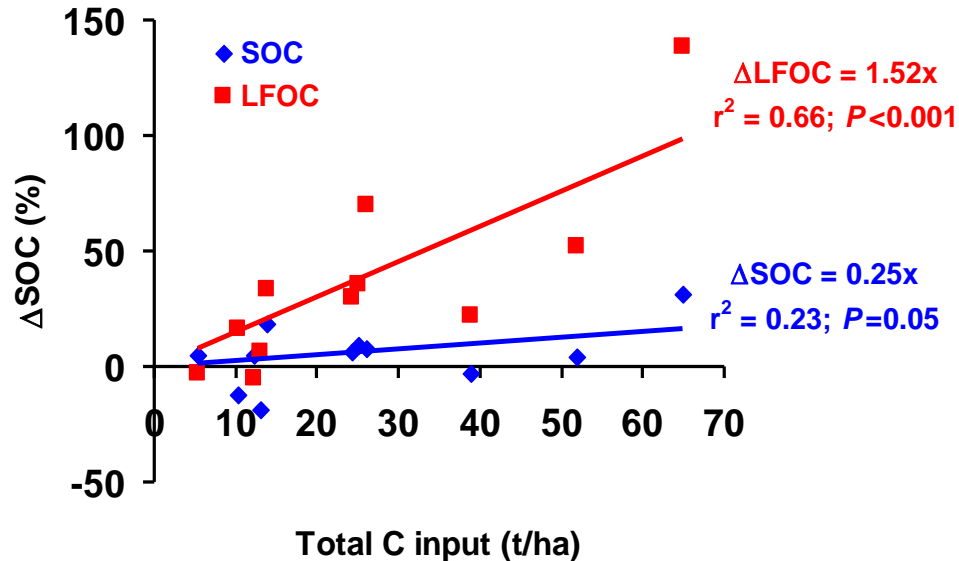
‘How to make the Lunar and Martian soils suitable for food production....’ Caporale et al. (2023) J. Env. Man.

.....ADD MANURE!



Soil 'fertility' (12th RAMIRAN - 2006)

Change in topsoil organic carbon (SOC) and light fraction organic carbon (LFOC) with total carbon input (farm manures)



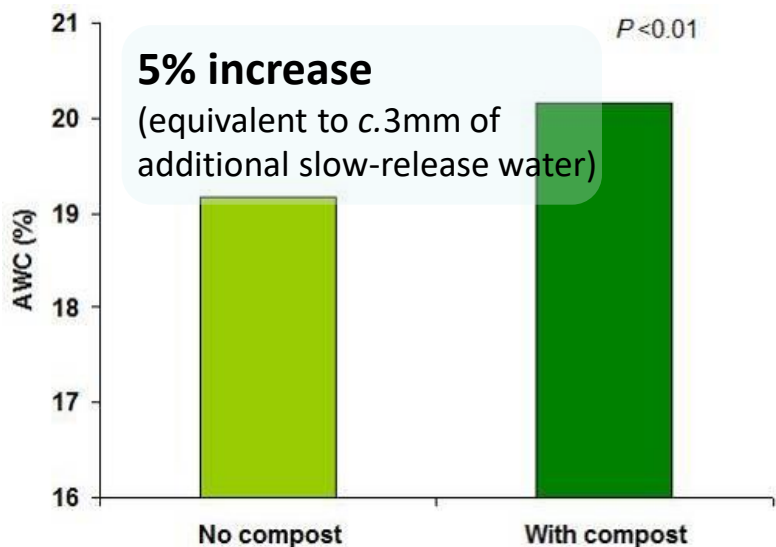
Also increases in:

- Potentially mineralizable N
- Soil extractable P and K

Manures supply organic matter & nutrients; the more you apply the greater the effect!

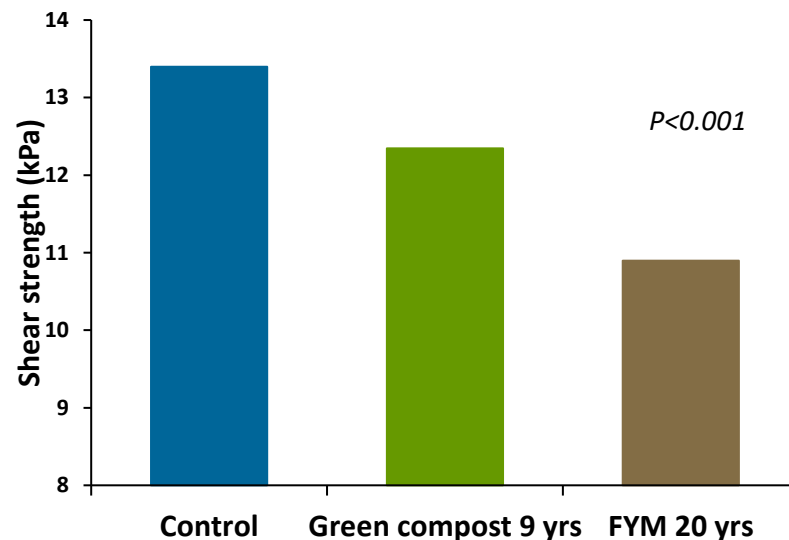
Soil 'quality' – fitness for use

Water retention: Available water capacity



(mean data from 9 sites after 2-10 years of compost additions; Sources Defra SOIL-QC & WRAP OAV023-010; www.compostresearch.com)

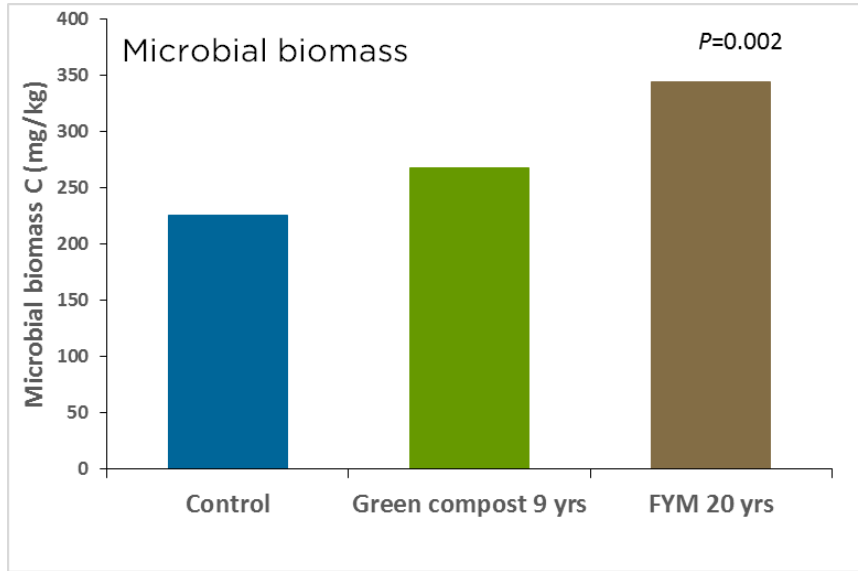
Workability: Shear strength



(mean data from 2 sites; Source: www.wrap.org.uk/dc-agri)

Repeated organic material applications increase available water capacity and improve workability

Soil health – soils as a living system



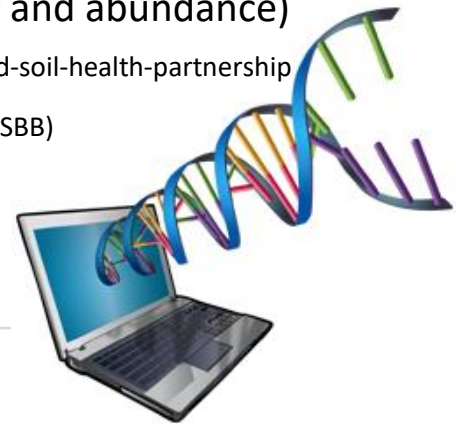
(mean data from 2 sites; Source: www.wrap.org.uk/dc-agri)

- Increase in microbial biomass size and activity (respiration rate)
- Emerging molecular techniques enable us to now look much deeper
 - Community composition (Species richness, diversity and abundance)

<https://ahdb.org.uk/soil-biology-and-soil-health-partnership>

Fernandez-Huarte et al. (SBB)

Microbial biomass size and activity increases following organic material additions, but community doesn't necessarily change





Do all organic materials have the same effect?

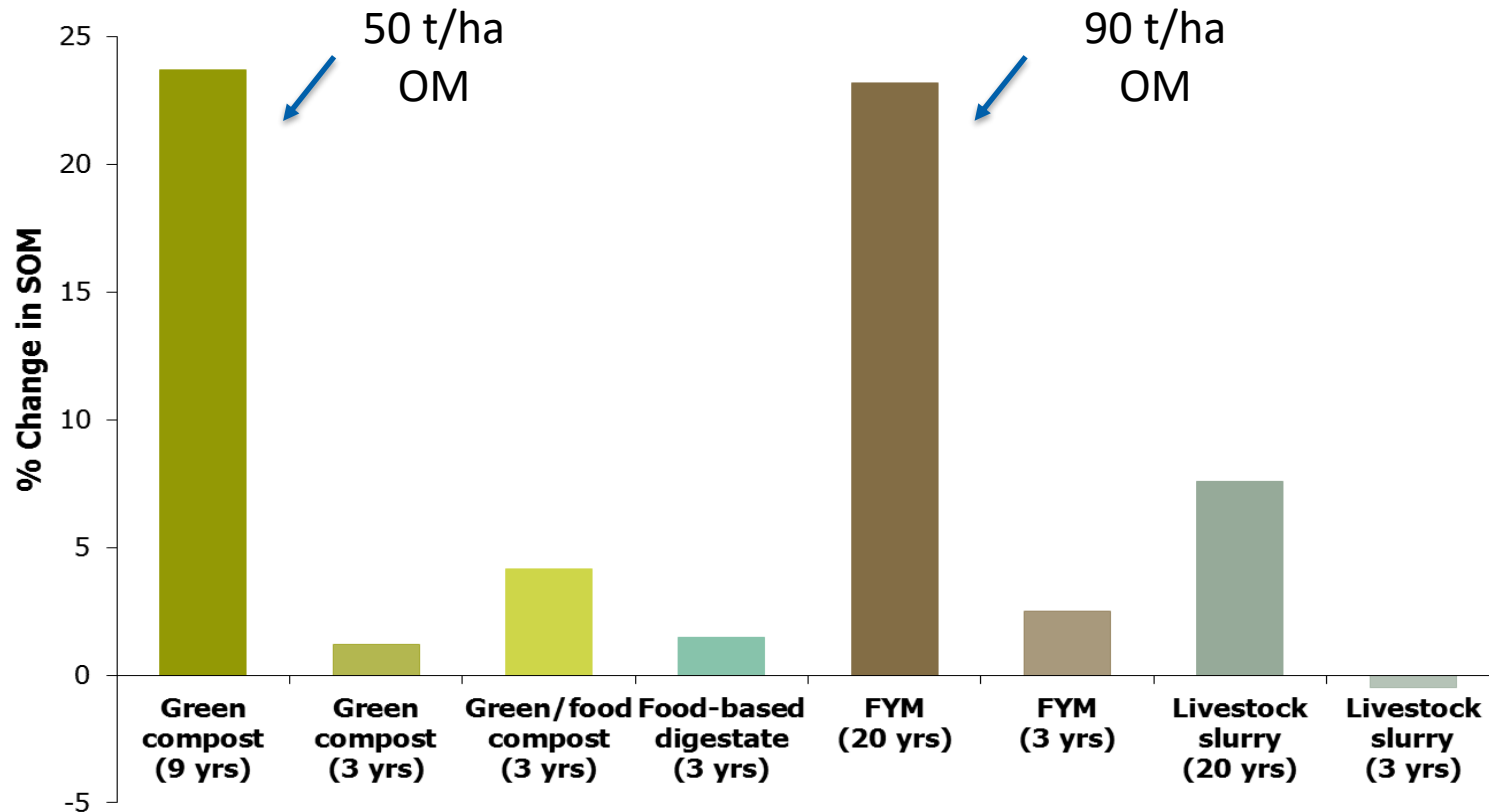
‘Most functions of SOM are promoted by increased quantities, yet we know little about the relationship between these functions and organic matter quality’

Hoffland et al. 2020 (Plant & Soil)

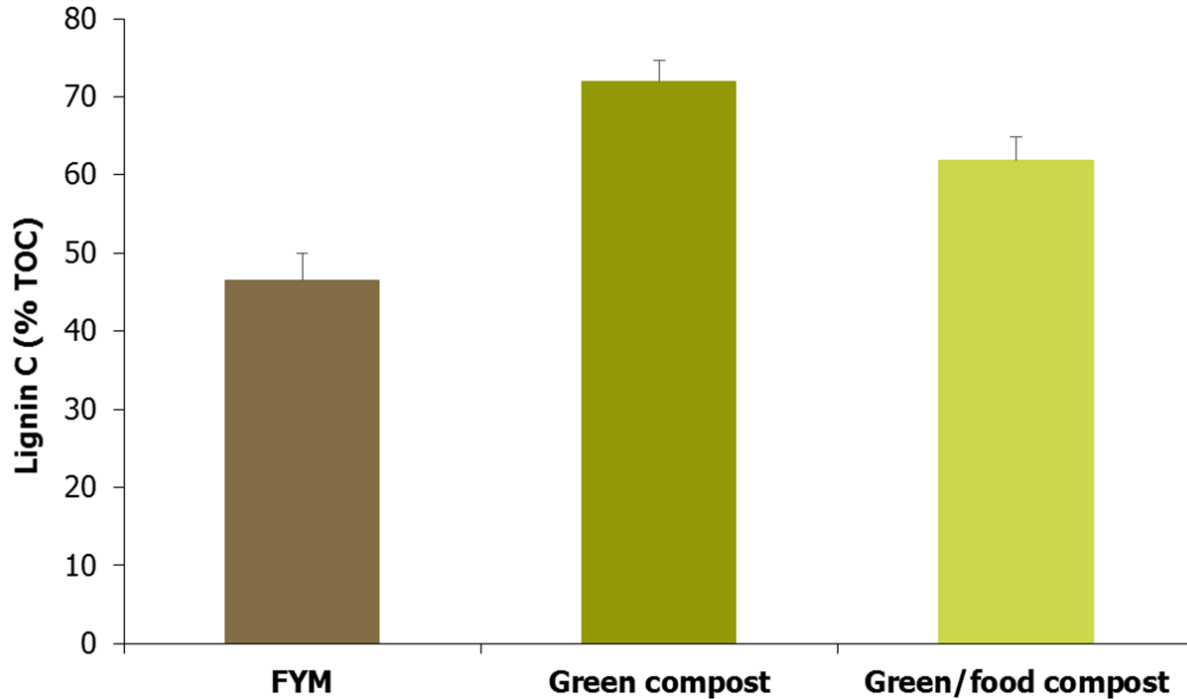
- Do all organic materials behave the same or are some ‘better’ than others?
 - Do they serve different purposes?
 - What characteristics are important?
 - Can we tailor applications to achieve specific goals?
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17th RAMIRAN

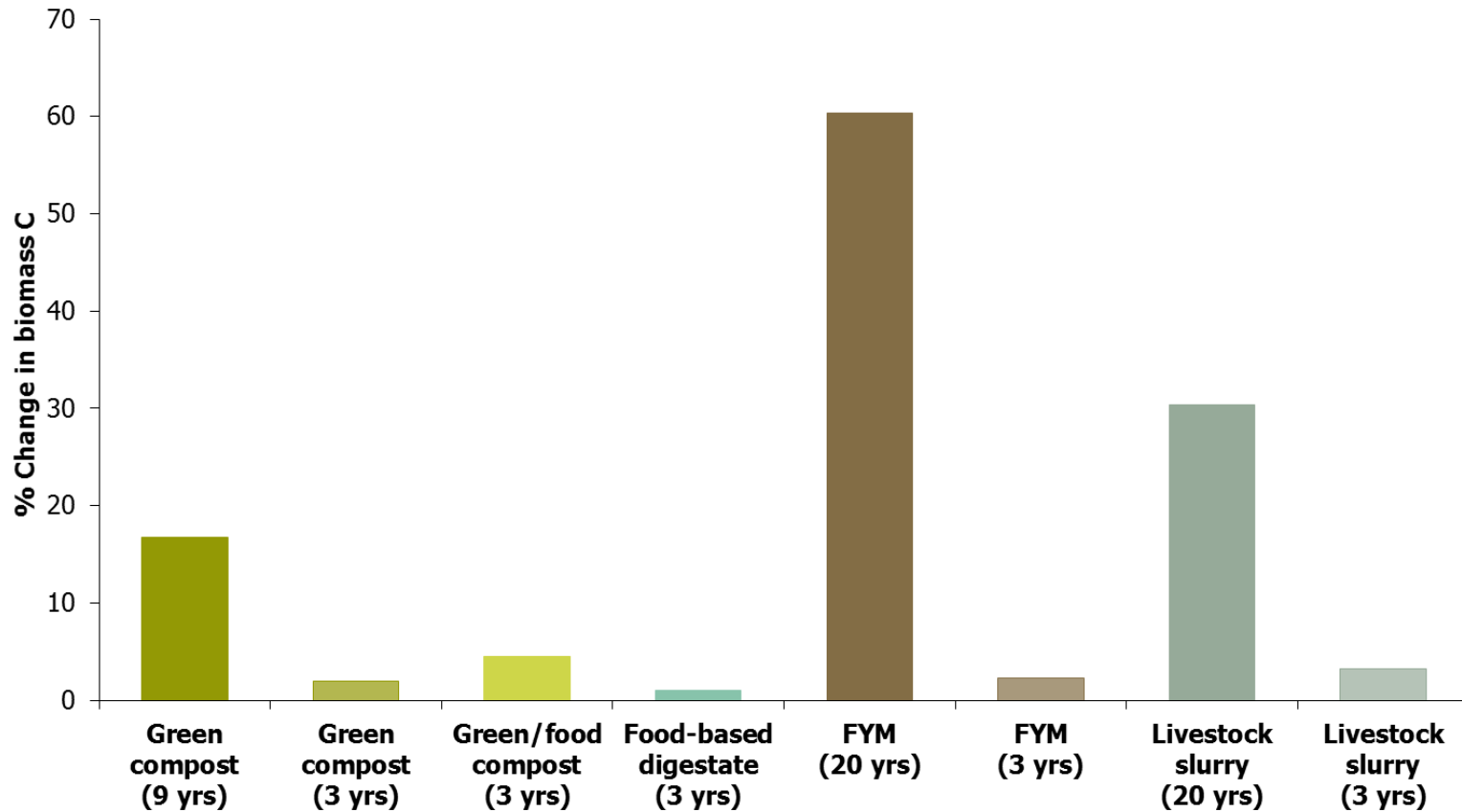
Organic materials increase soil organic matter



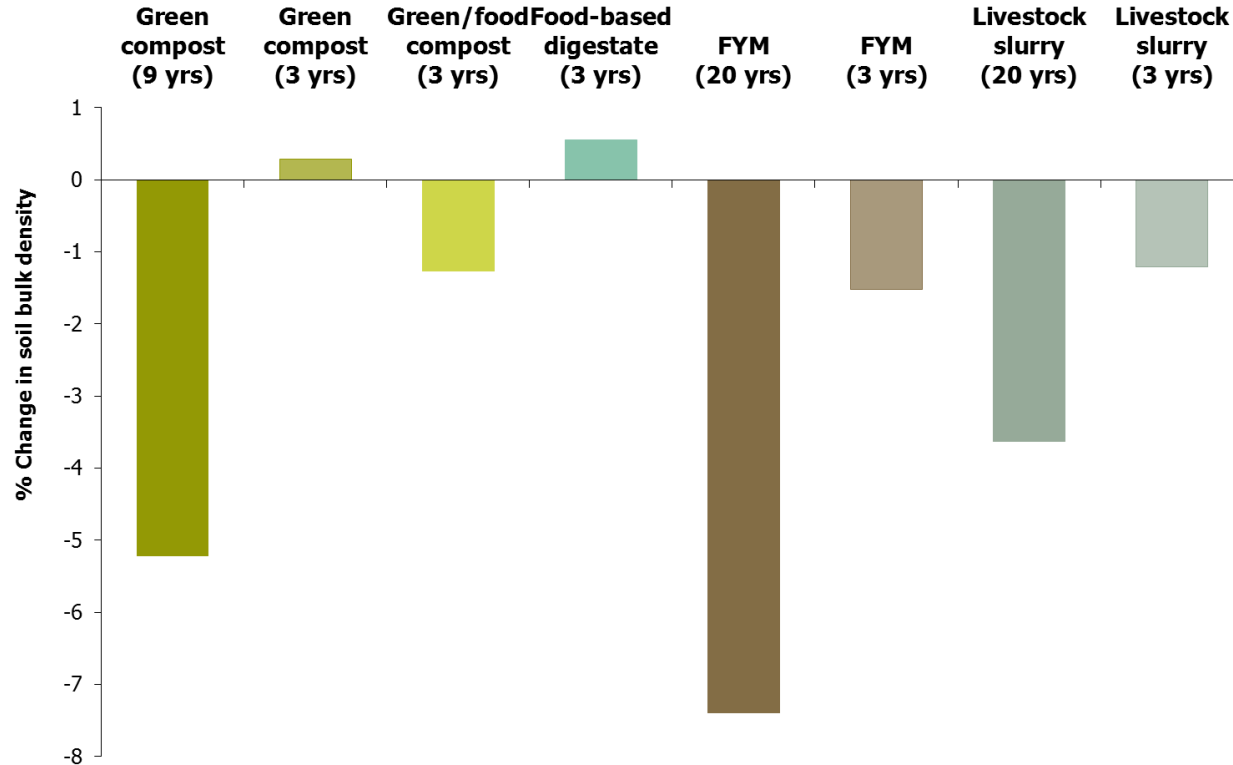
Compost supplies 'stable' (lignin-based) organic matter



Organic materials - effect on topsoil microbial biomass



Organic materials – effects on soil structure



Do all organic materials have the same effect?

Quantity **and** quality matter

Decomposable OM (FYM): Higher turnover rates, lower retention; More needed over a longer timescale; BUT supports higher biomass and has greater impact on soil physical functioning

Resistant OM (Compost): lower turnover rates, higher retention, greater impact on bulk soil OM over shorter timescale; does improve soil biological and physical functioning, but to a lesser degree.

Impact on soil properties depends on chemical characteristics, rate of application and nature of the receiving soil

Risks to soil quality

- Heavy metals (Zn, Cu, Cd, Pb etc)
- Organic contaminants (e.g. PCBs, Dioxins & Furans etc)
- Pathogens (e.g. E Coli, Salmonella)



‘Emerging’ contaminants:

- Micro and nano plastics
- Antibiotic resistance genetic material



What's in it for farmers?

- Nutrients have ££ (fertilizer replacement):

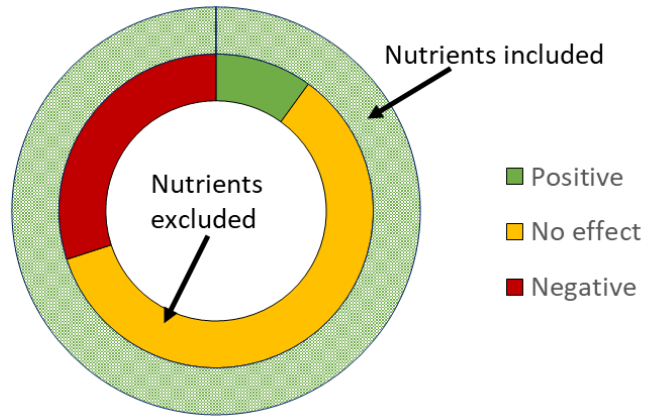
Manure type	Rate	Crop available N	Total P ₂ O ₅	Total K ₂ O	Value 2022
	t/ha	kg/ha			£/ha
Cattle FYM	40	24	128	376	524
Pig slurry	35	45	53	77	210
Poultry manure	8	90	136	168	466
Biosolids	20	33	220	18	326

- Value of the additional organic matter & improvements in soil health?
 - Yield? NUE? Input costs – fuel/water use?

Organic manures – effects on crop yields

- What is the benefit of the additional organic matter (apart from nutrient supply)?

Mean yield effect of increasing SOM



Yield benefits most often observed:

- Tropics (cf. temperate)
- Roots & maize (cf. cereals)
- Light textured soils (cf. heavy textures)

Re-drawn from: Hijbeek et al 2018 (IFS Proc. 826)

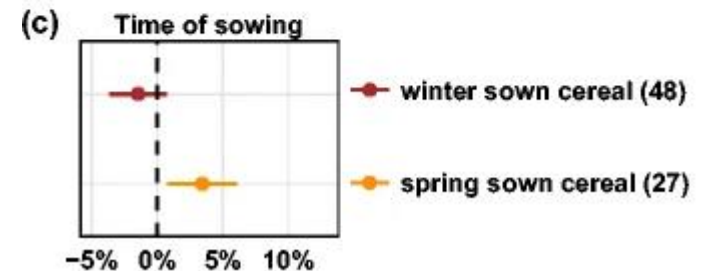
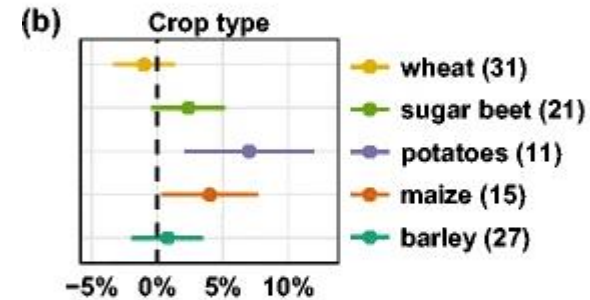
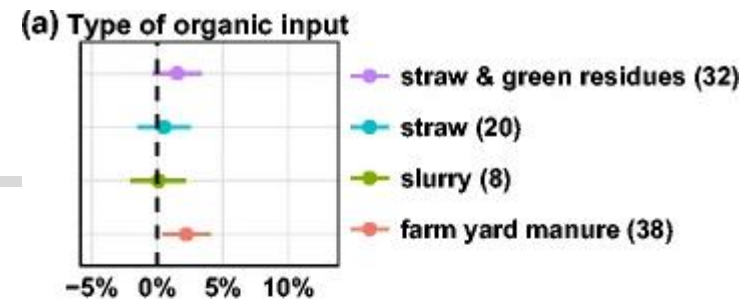
(7 studies not controlled for nutrients; 10 studies where nutrients controlled)

'Additional' yield benefit

- 20 long-term European experiments

Hijbeek et al (2016) Plant & Soil

Only see an additional yield benefit
if there is another constraint to yield
e.g water



Additional yield effect of organic input

Organic materials and soil carbon storage

- Soil organic carbon stocks increase with organic material applications
 - e.g. 203-1310 kg C/ha/yr (Bolinder et al., 2020; 200 comparisons)
- Rate of increase dependent on the type of material applied

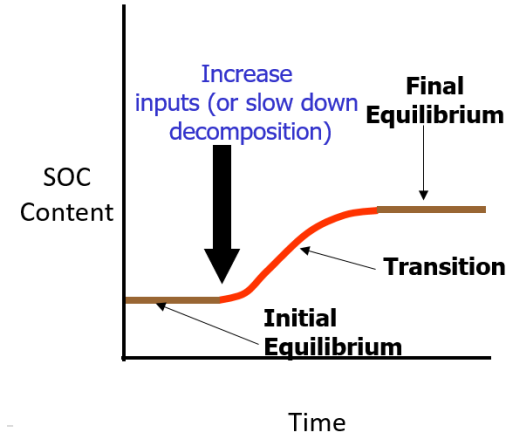
Manure type	SOC increase (kg/ha/yr/t ds)	% C applied retained
Farm manure	60 (20-100)	23
Biosolids	180 (130-230)	56
Compost	60 (40-80)	43

Powlson et al., 2012

But is it genuine C sequestration???

Organic materials and soil carbon storage

- Reliability of estimates?
 - what is the control (+/- fertiliser); how long was the study; what was the soil depth?
- Limitations
 - Finite capacity & reversible
 - Potential for pollution swapping (do other GHG increase?)
 - What was the alternative fate of the materials? (aren't we already achieving this?)





Conclusions

- Organic manures are a valuable source of organic matter and nutrients, which lead to improvements in soil health and crop yields
 - *But not all materials are the same & need to manage risks*
 - *Benefits to crop yields often only seen where other constraints present*
 - Significant changes in soil biological & physical functioning are dependent on supplying sufficient OM that is biologically available.
 - Increased soil C storage can be achieved by applying organic materials
 - *But it has its limitations*
 - Need to consider the wider implications of applying organic materials to minimize environmental impacts
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Thank you