Sequestering carbon in arable soils:

- not as easy as you think!

(but good for soil health)

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Soil organic matter (SOM)

Approx 50% C

+ N, P, S

+O, H

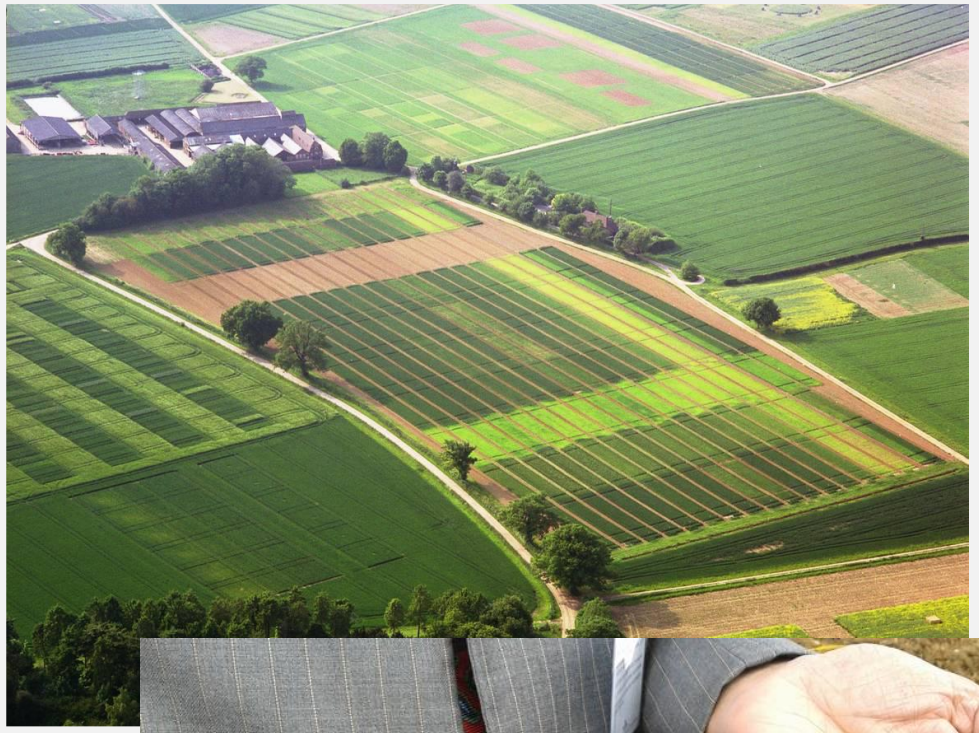
Retains other nutrients: Ca, Mg

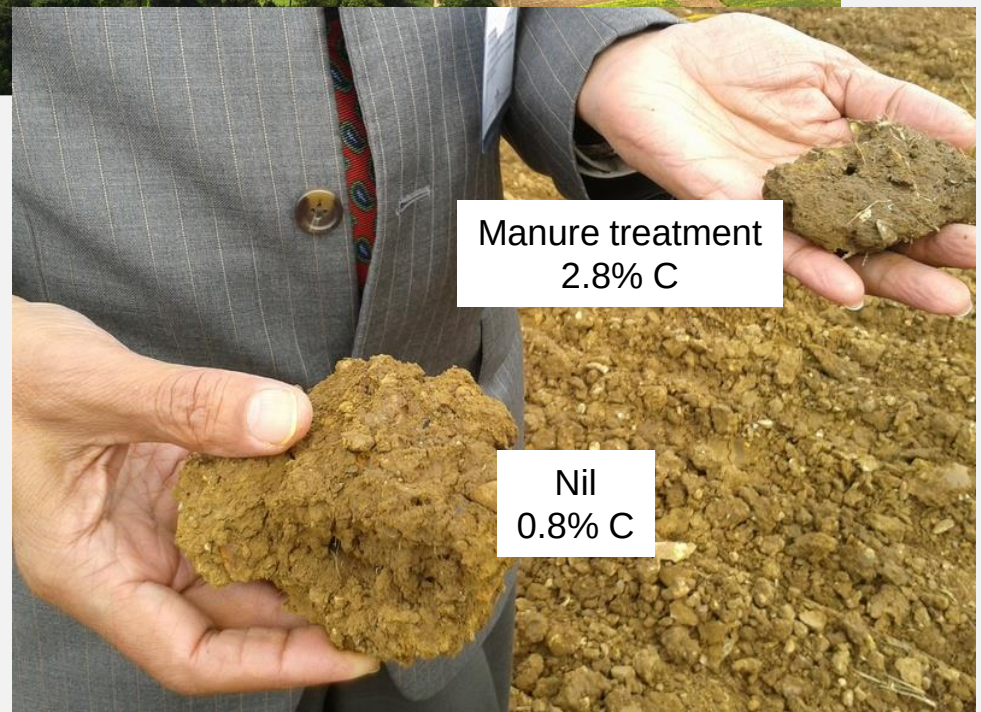
Energy for microbes as they decompose SOM

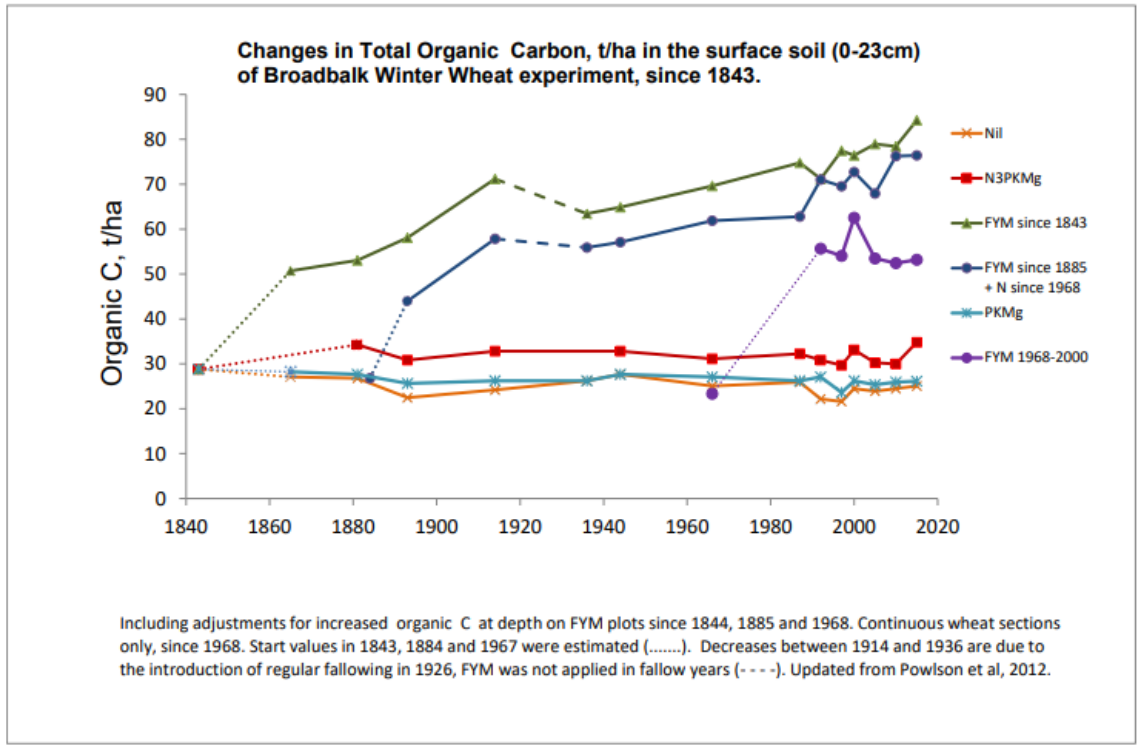
Improves soil physical structure:

- water infiltration & retention
- pores
- aeration
- root growth

Broadbalk Experiment, Rothamsted started 1843







Soil organic matter (approx. 50% C)

Soil health

- Crop growth
- Sustainability
- Ecosystem services

- Atmospheric CO_2 : 750 Gt C
- SOC to 1m depth : 1500 Gt C

Global carbon cycle

Climate change:

- Mitigation

(C sequestration)

OR

- Worsening

(extra C release)

Agriculture: CH_4 + N_2O

Soil health

- Probably *(wrongly)* downplayed since WW2
- Small C increases - very beneficial for soil functioning
- Increased soil C *does not guarantee increased crop yield*
  - but numerous benefits, including :

Aggregates & pores

Biology

Year-to-year yield stability (adverse weather)

Decreased fertilizer requirement

Sustainability

Climate change **adaptation**

For climate change **MITIGATION**

- Must be ***additional transfer of C from atmosphere to soil*** – not just redistribution within soil or landscape, e.g.
- *manure – spatial redistribution*
- *reduced tillage – depth redistribution (some net accumulation over time)*
- **Increase in absolute quantity (stock)** of C – *tricky measurements!*

- **Remember:**
  - Soil C does not increase indefinitely

    Highest accumulation rate in early years – careful of extrapolating
  - Reversible

Carbon farming

Natural climate solutions

Regenerative agriculture

Holistic grazing management

“4 per 1000” initiative

Cautions about soil C sequestration for climate change mitigation

Beware of exaggerated claims

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OPINION

WILEY Global Change Biology

Managing for soil carbon sequestration: Let's get realistic

William H. Schlesinger[1] | Ronald Amundson[2]

Global Change Biology **25**, 386-389 (2019)

In ***agricultural*** soils, realistically possible C increases are:

- Usually small
- Difficult to measure
- *But good for soil health*

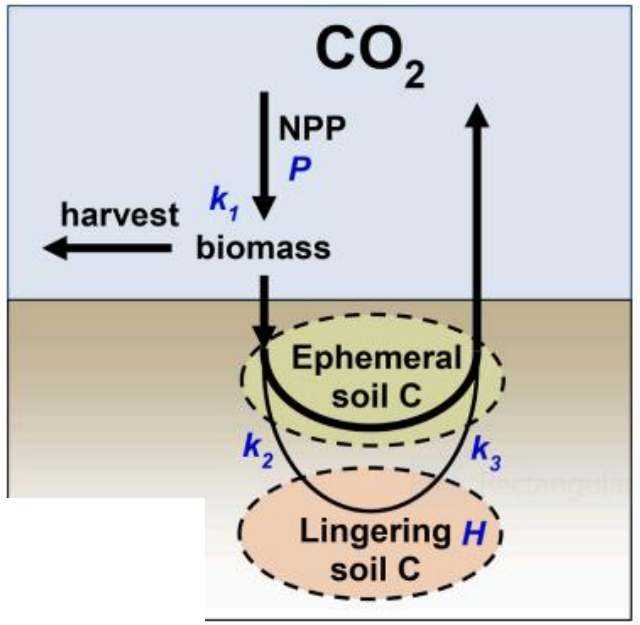
Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Photosynthetic limits on carbon sequestration in croplands

H. Henry Janzen [a], Kees Jan van Groenigen [b], David S. Powlson [c], Timothy Schwinghamer [a], Jan Willem van Groenigen [d,*]



of carbon flows in agroecosystems, depicting pools
r approach to estimate annual change in global
ils, as presented in Equation [3].

- Estimated current C input from photosynthesis in global croplands entering "lingering" C = 0.44 Pg C yr^{-1}
- Taking account of decomposition of existing "lingering" C,

max sequestration in croplands = **0.14 Pg C yr^{-1}**

= 1.5% of current anthropogenic C emissions

Janzen *et al* (2022) *Geoderma* **416**, 115810

David Jenkinson FRS
1928 - 2011

Measuring soil C changes

“Weighing the captain of the ship”

Ship without captain

Ship + captain

Small change, large background

Some issues associated with paying for soil C sequestration

- Measurement difficulties:
  - slow changes after change of management (>5yrs)
  - spatial variability – need many samples – expensive!
- Sandy soil can never sequester as much as C as soil higher in clay or silt – an equity issue
- If a farmer has already achieved high SOC, as a result of past/continuing practices, little scope for further increase

Payments for increased soil C ?

NO!

Instead, I suggest - payments for *sustainable food security & soil health*

- ***Climate change mitigation – a welcome co-benefit***
- Practices good in long-term may have costs or practical or barriers in short-term
- Many C offset schemes are dubious!

Payments for ***quantity of C sequestered ?***

- Many difficulties – measurement, validation, soil types, initial value from past practices

But if you insist on C payments :-

1. "Ground truth" with ***benchmark sites***
   - use SOC models – test predictions – experiments & "real fields"
   - test ***new predictors of SOC change***
   - focus for ***farmer/researcher interaction*** – 'KE'
   - Be led by evidence, not financiers!
2. Continually **improve *N management*** (N_2O ↑ direct + indirect)

Priority

Priorities – climate change

1. Cut GHG emissions from fossil fuels

2. Cut C losses from large natural stocks globally
   - Deforestation, peat & wetland drainage
3. Increase carbon-friendly practices in agriculture
   - Priority: ***sustainable food production***
   - Climate change mitigation: ***a welcome co-benefit***
   - *Don't forget:* food production, profitability
4. Improve N use efficiency (fertilizers, manures)
   - CO_2 from N fertilizer manufacture
   - Decrease N_2O emissions, direct + indirect
   - ***"For C, think N"***