Sequestering carbon in soils

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and team from CarboSeq, MaxRoot-C and MIXROOT-C

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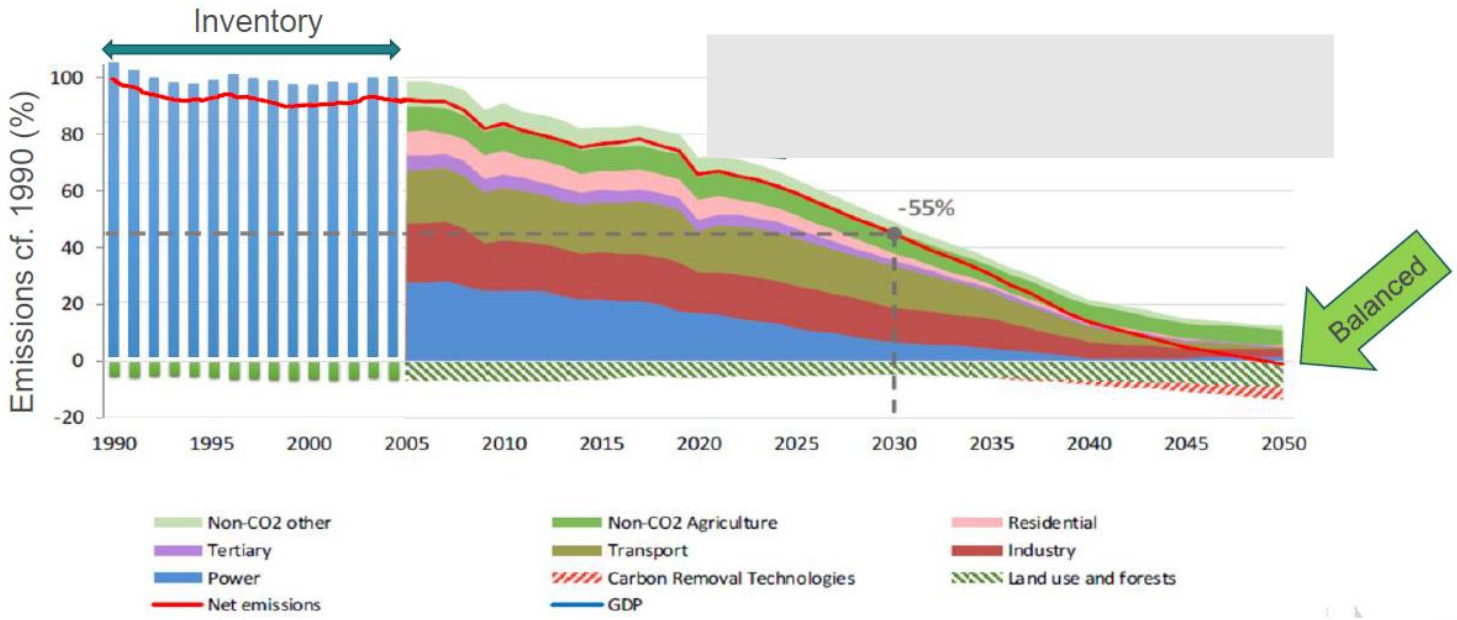
Carbon removal EU



- Sink of 310 Mio. t CO_2 in LULUCF in 2030
- That is almost doubling of the current sink
- C sequestration in soils forstering via the voluntary CO_2 certificates market (C removal directive)

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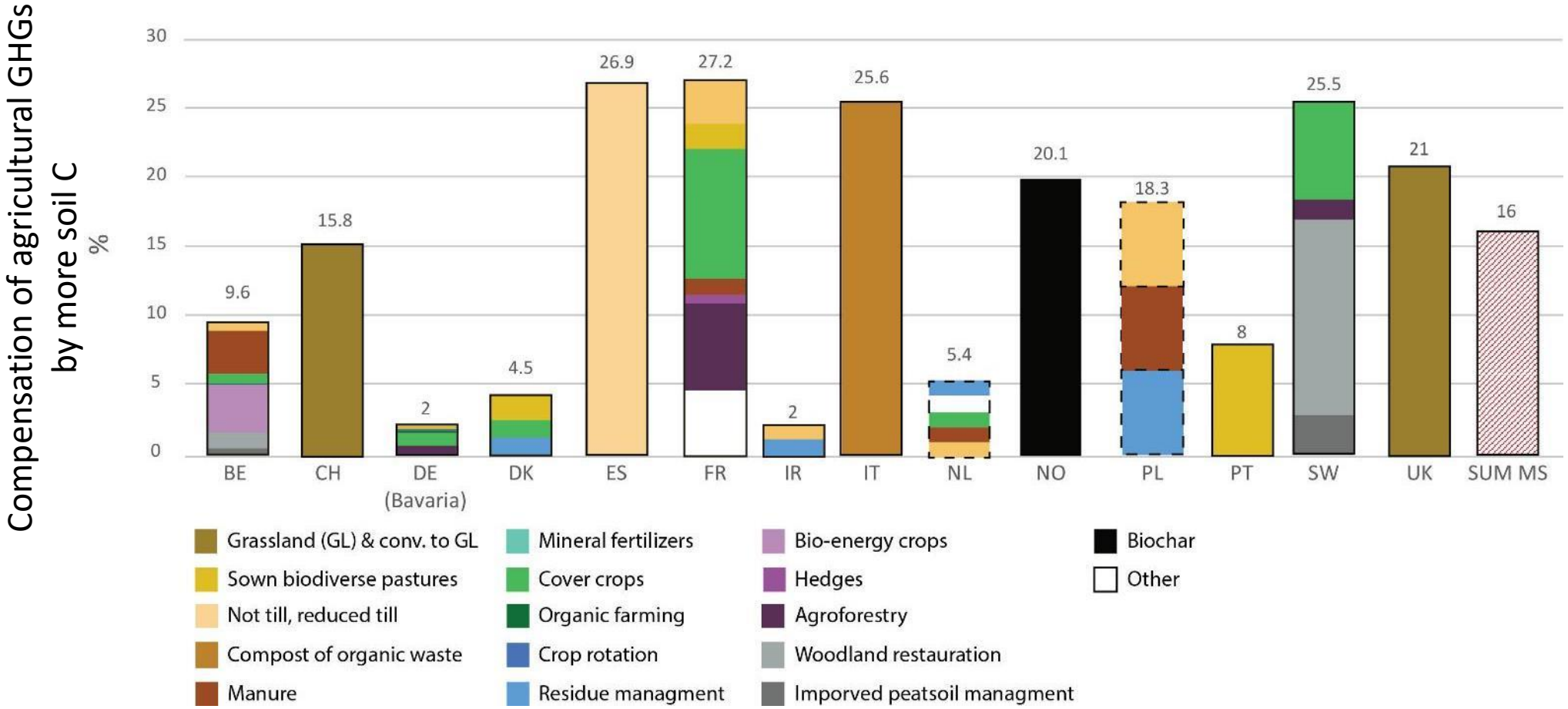
Compensation of GHG emissions via C removal



Rodrigues, Leifeld et al. 2022

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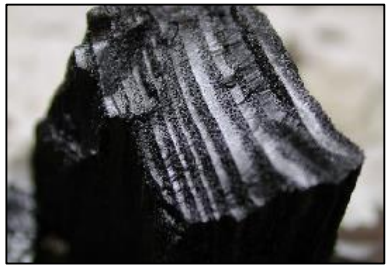
The EJP Soil CarboSeq aim

Estimate the soil carbon sequestration potential of European agricultural soils

- ✓ A economically practicable, feasible potential
- ✓ Based on tested and validated measures for C-Sequestration in agriculture
- ✓ Take into account economic costs
- ✓ Account for non-CO_2 greenhouse gas emissions
- ✓ Considering also subsoils





Joint project of 23 countries and 27 partners

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Potential of soil C sequestration

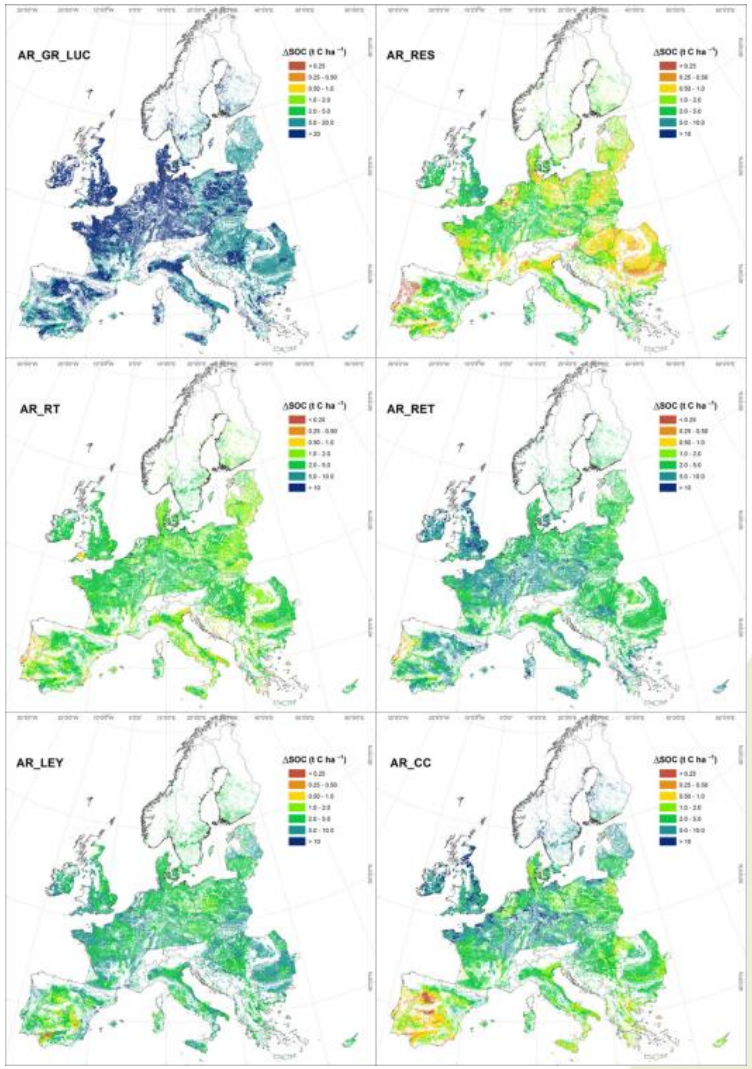
- **Theoretical potential**: Globally 0.9±0.3 Pg C/year, which may offset 20 to 33% of the annual increase in atmospheric CO_2 (Lal, 2004 Geoderma)

- **Technical potential/biophysical potential**

  14-48 Mio t CO_{2e} EU-27 on 12-28% of all arable land (Lugato *et al.* 2015).

  This would compensate 0.3 - 1.1% of the EU-27 GHG emissions.

- **Feasible potential** ???



Lugato *et al*. 2015 GCB

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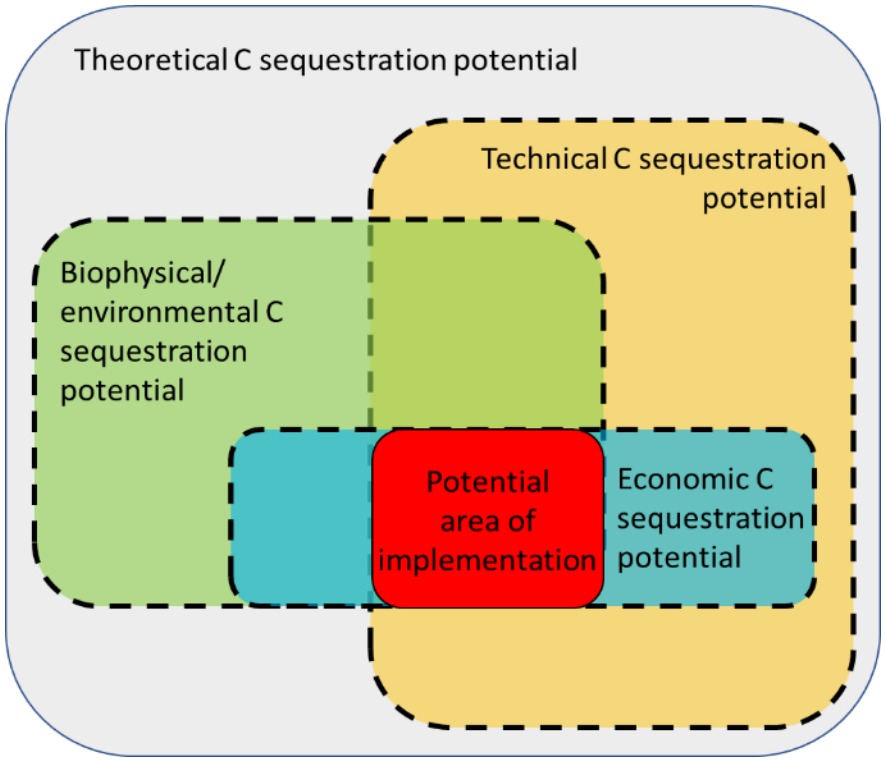
From theory to practice



Which agricultural measures can realize this potential?

What is their regional specific contribution?

What are the constraints that limit the adoption and the potential?

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Considered measures in CarboSeq

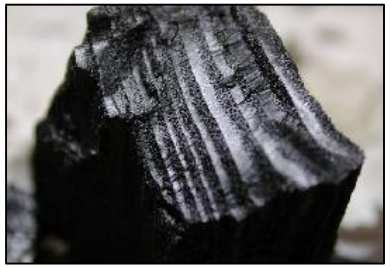
Cover crops
High carbon crops in the rotations
Cover crops
Crop residues
No tillage
Reduced tillage
Irrigation
Agroforestry with hedgerows
Agroforestry with single trees (Alley cropping)
Biochar application
Land-use change to grassland

European SOC effects based on LTE data (Emission factors)

European C input to the soil on a more feasible area

New SOC modelling (RothC based)





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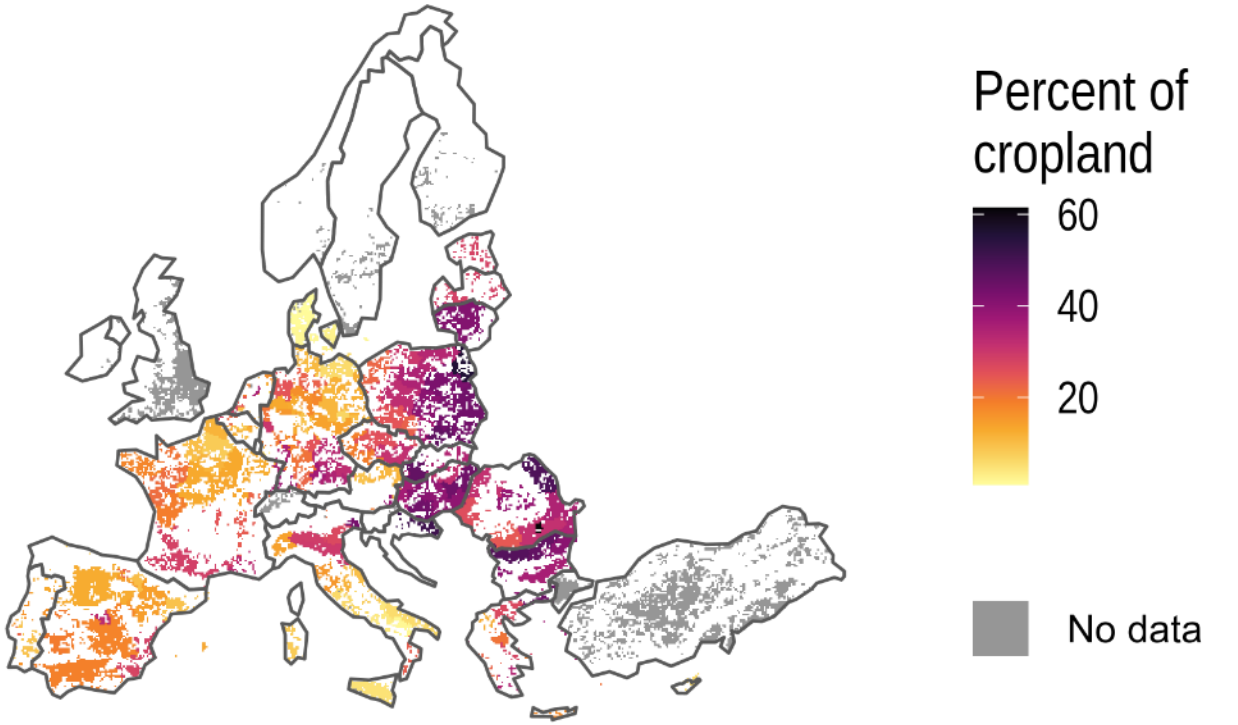
Example cover crops: Potential area of implemenation

Soil cover during winter: Bare soil



Source: Eurostat (ef_mp_soil)

- Additional constraints need to be considered

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Conclusion 1

More soil C can compensate for only a small fraction of the current agricultural GHGs

C sequestration in soils need to be linked to agricultural measures

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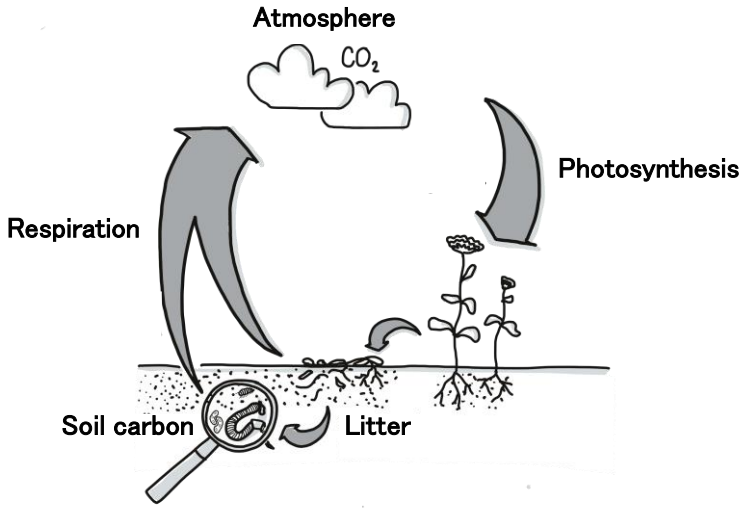
What is C sequestration?



Process of transferring **C from the atmosphere into the soil** through plants or other organisms, which is retained as soil organic carbon resulting in a **global C stock increase** of the soil

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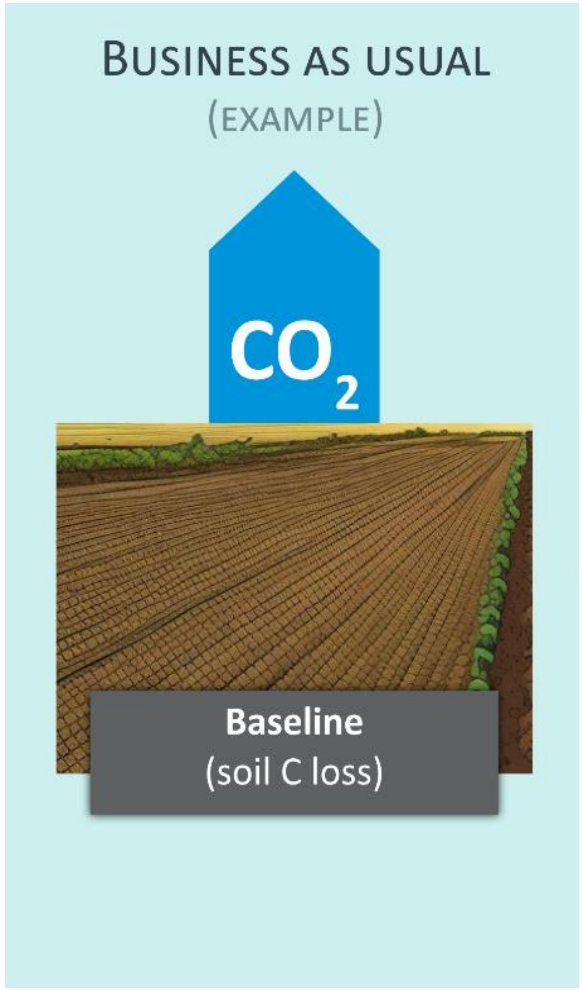
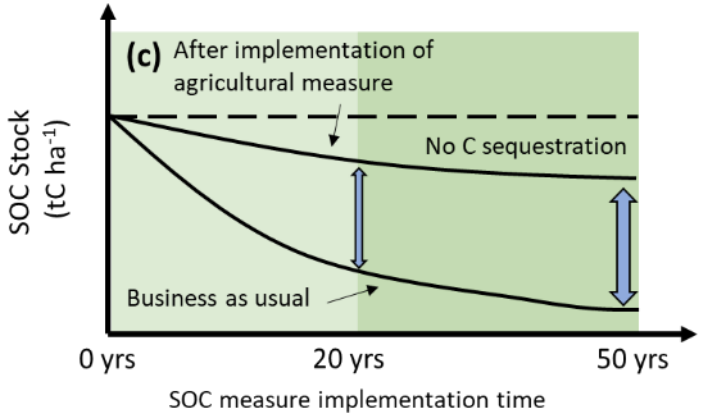
C sequestration or only C loss mitigation?



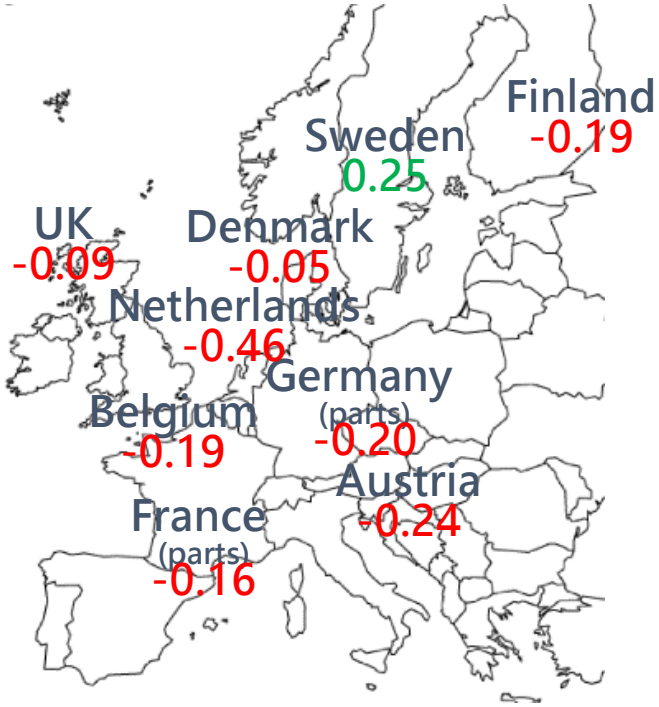
Negative emissions?

- Many croplands in Europe loose C
- Agricultural measures to enhance soil C first need to stop C losses
- Negative emissions and C sequestration may thus be hardly achivable for many cropland soils



Don *et al.* accepted Global Change Biology

Recent soil carbon stock changes in croplands



In t C/ha/yr and based on repeated soil inventories

Sources: Heikkinen et al. 2013, Poeplau et al. 2015, Taghizadeh-Toosi et al. 2014, Lettens et al. 2005, Knotters et al. 2022, Dersch and Böhm 1997, Höper 2021, Antoni et al., 2008

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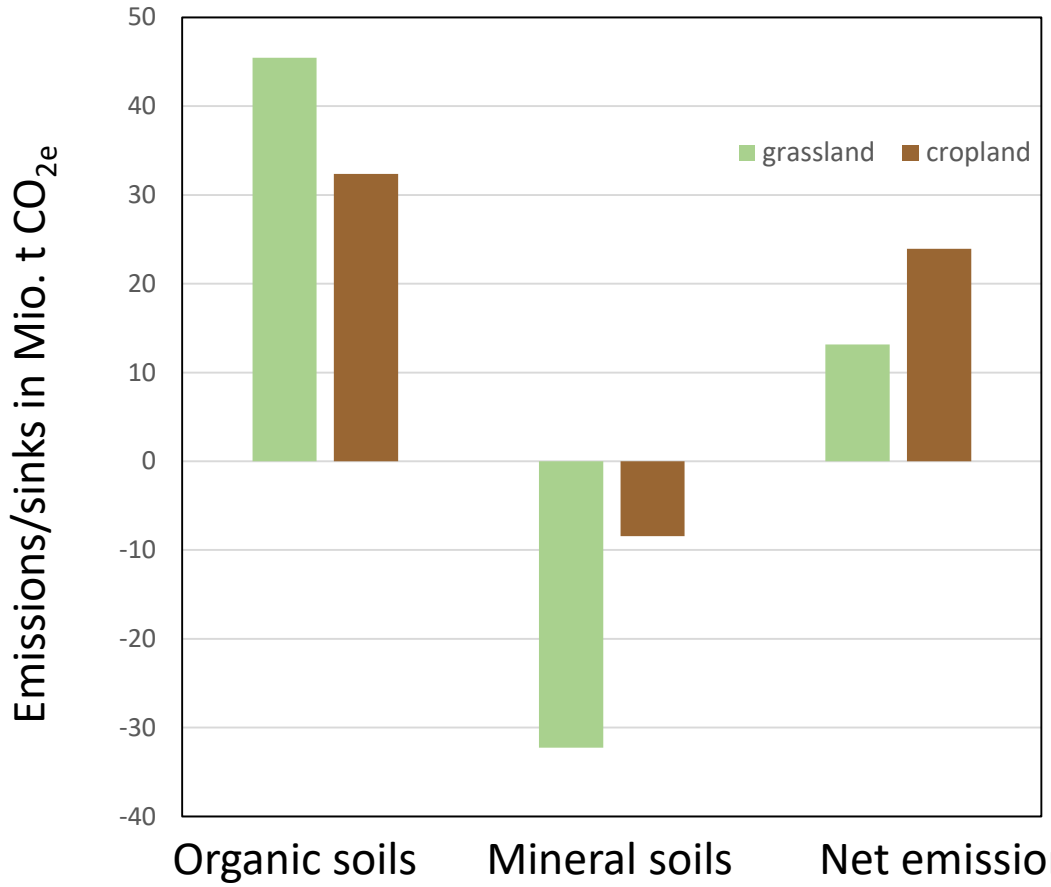
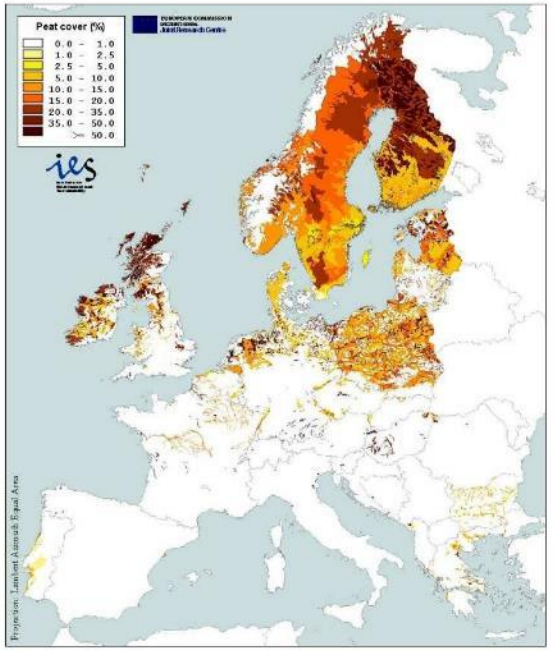
EU Emission reporting LULUCF



EU CRF report
to UNFCCC for 2021

Organic soils (peat cover)



- C gains in grasslands mainly due to land use change cropland to grassland
- Average reported C loss in croplands: 0.03 t C/ha

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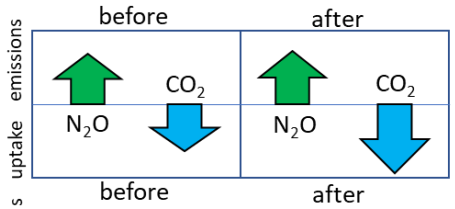
Agricultural management examples: Climate impacts

(a) Cropland management change to more cover crops



SOC loss mitigation	Climate change mitigation	C sequestration / SOC accrual	Negative emissions
——	✓	✓	✓

Don *et al.* accepted in Global Change Biology

- C sequestration is not equal to negative emissions

Conclusion 2

C sequestration is a net removal of C from the atmophere.

In some soils ist only possible with agricultural measures to reduce C losses.

Be careful with the terms around C sequestration and negative emissions.

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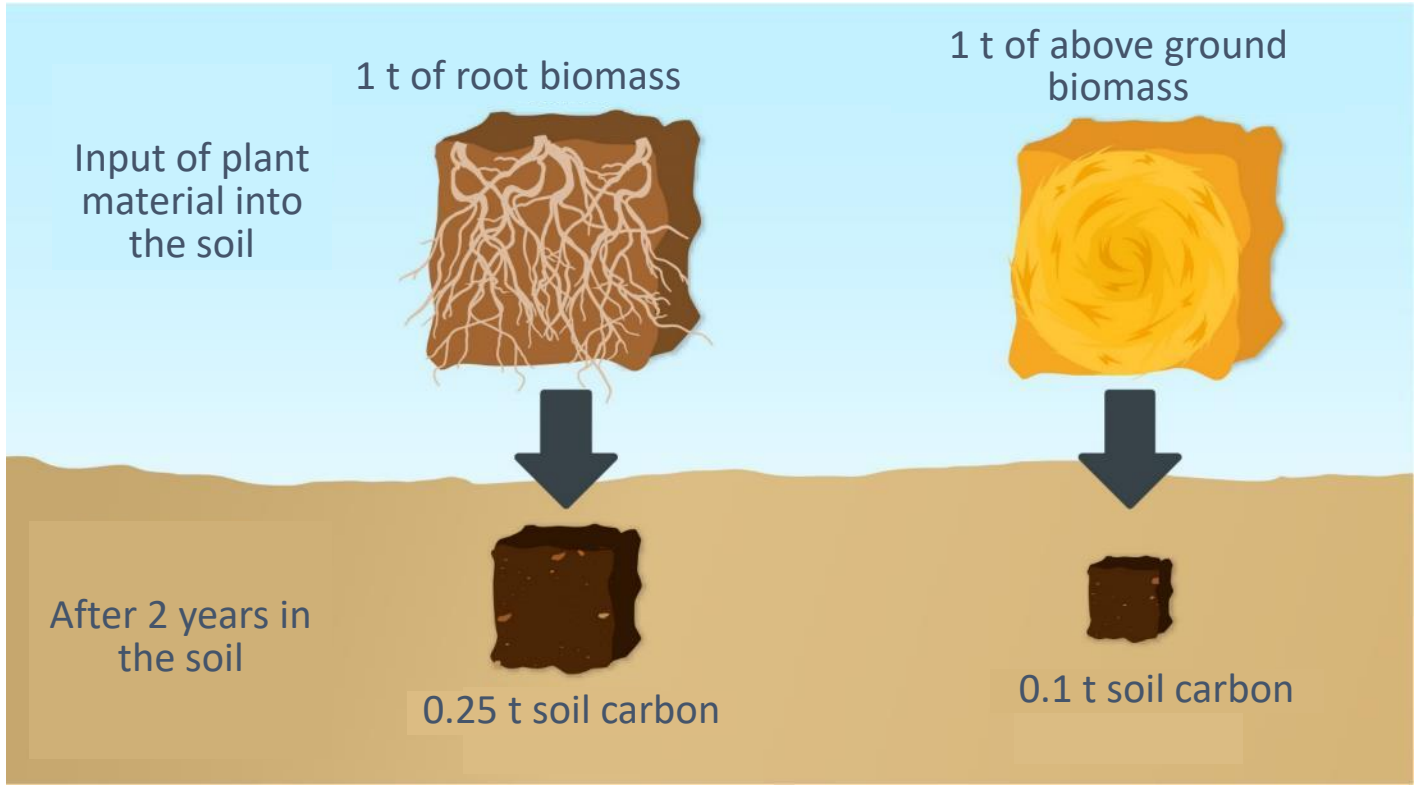
Roots built up soil carbon



after Kätterer et al. 2011

- Roots are 2 to 3 times as effective in building up soil C compared to straw and other above ground biomass

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EJP soil research on roots

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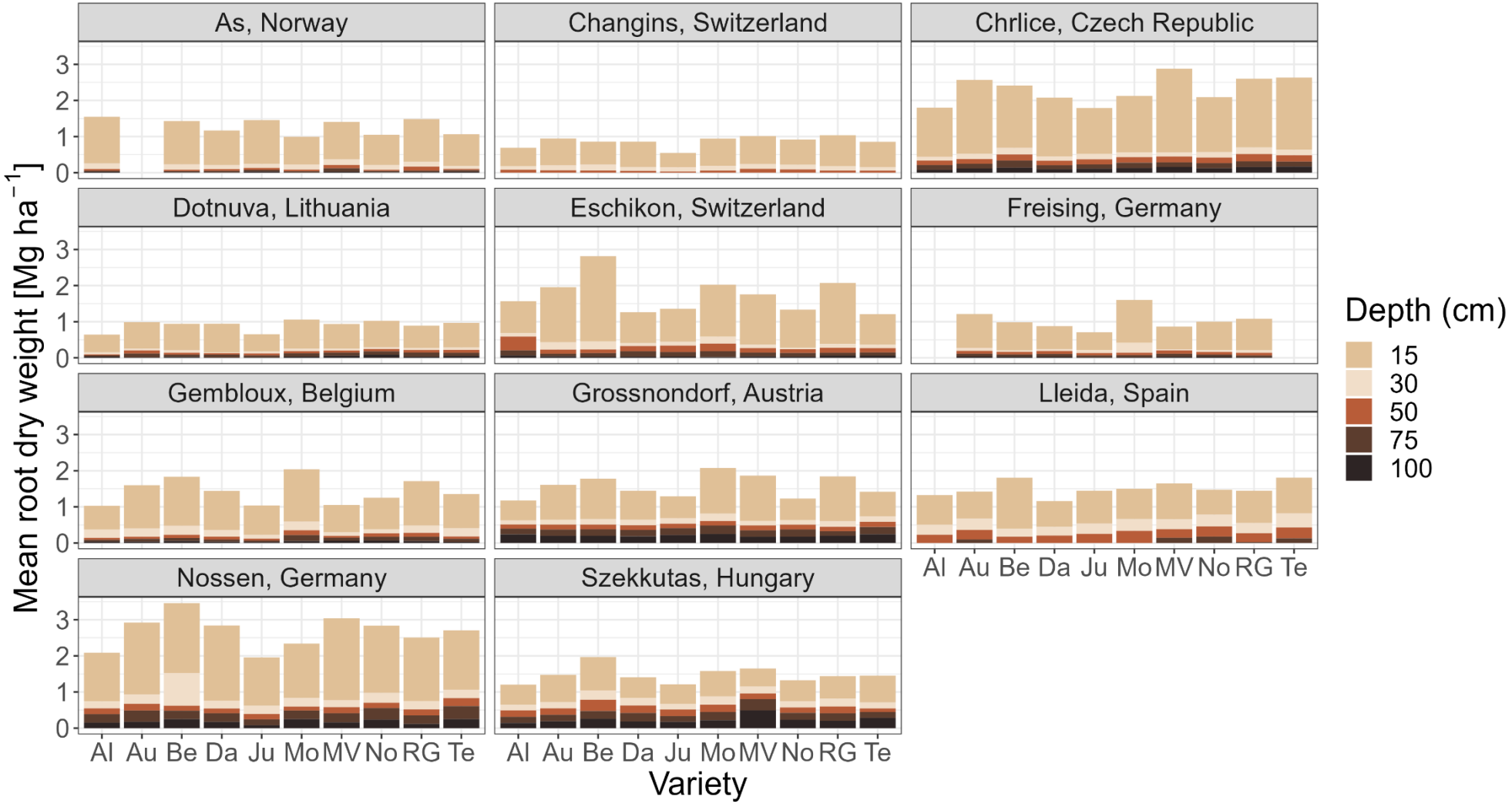
Genotype effect on root biomass at 11 sites



Heinemann et al. in prep.

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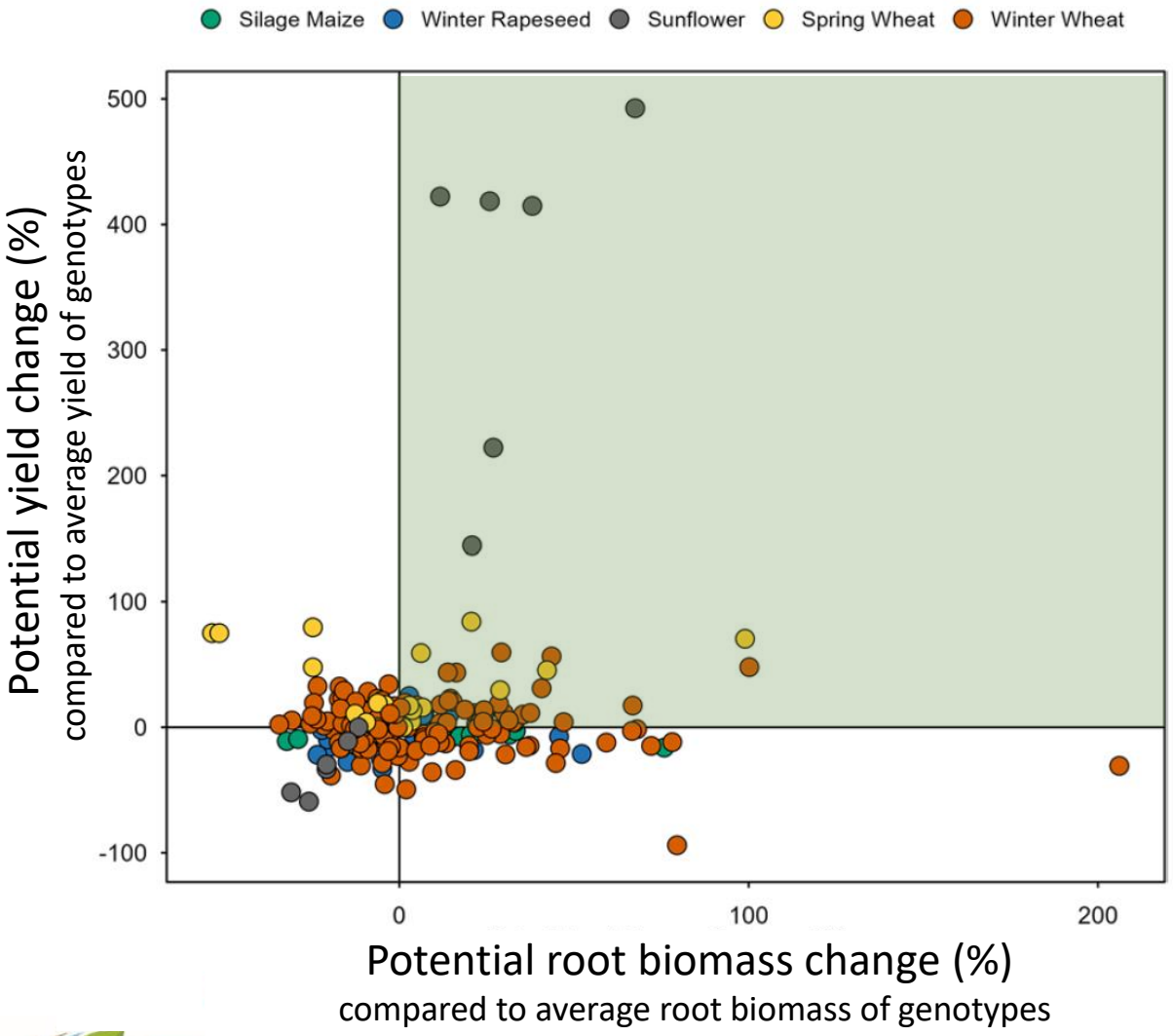
Do we get roots only at the expense of yield?



- Many genotypes enhance roots and yield at the same time compared to average genotypes
- Breeders hardly know root traits

Heinemann *et al.* 2023 Plant and Soil

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Conclusion 3

Roots matter!
We need crops with deeper and more roots

This would be climate adaptation and climate mitigation

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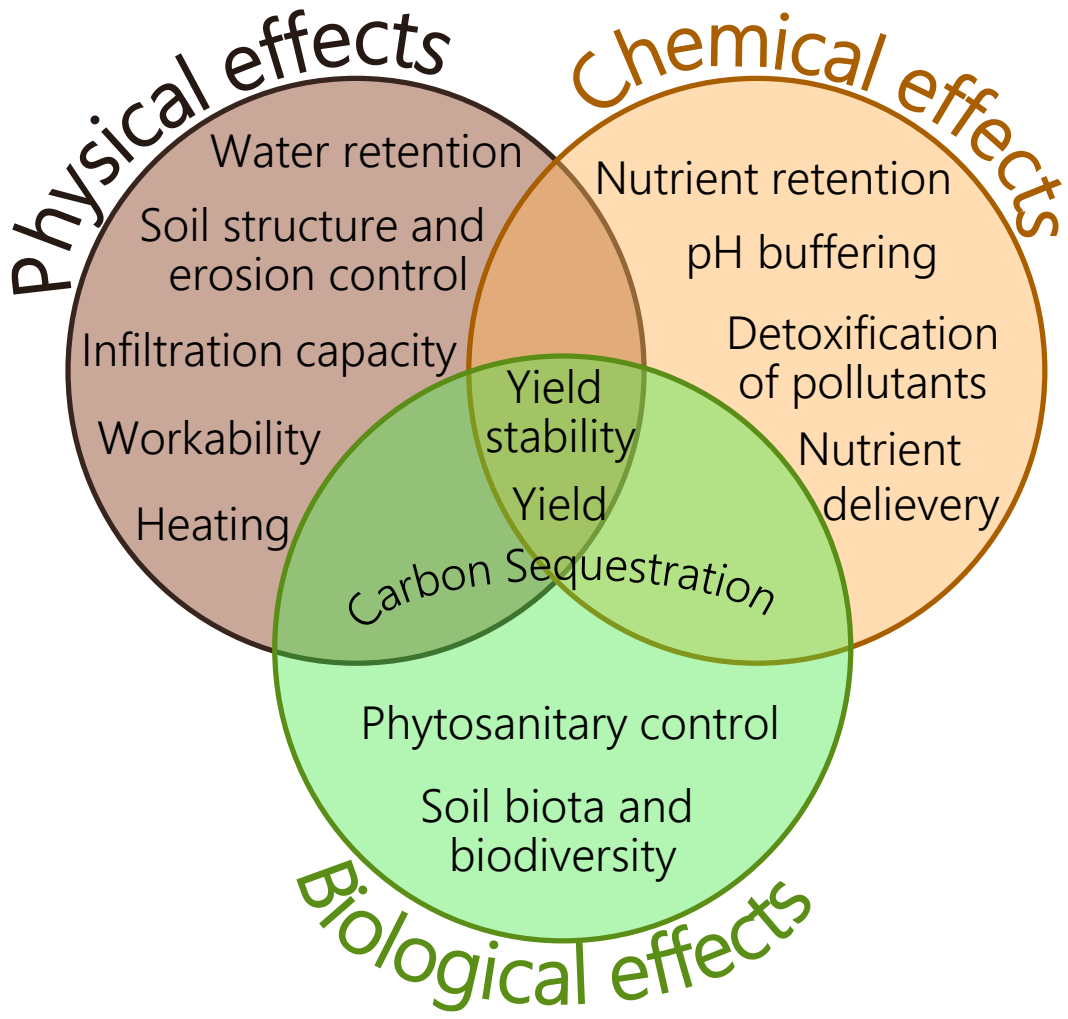
Soil organic matter – More than for C sequestration!



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Thank you for your attention

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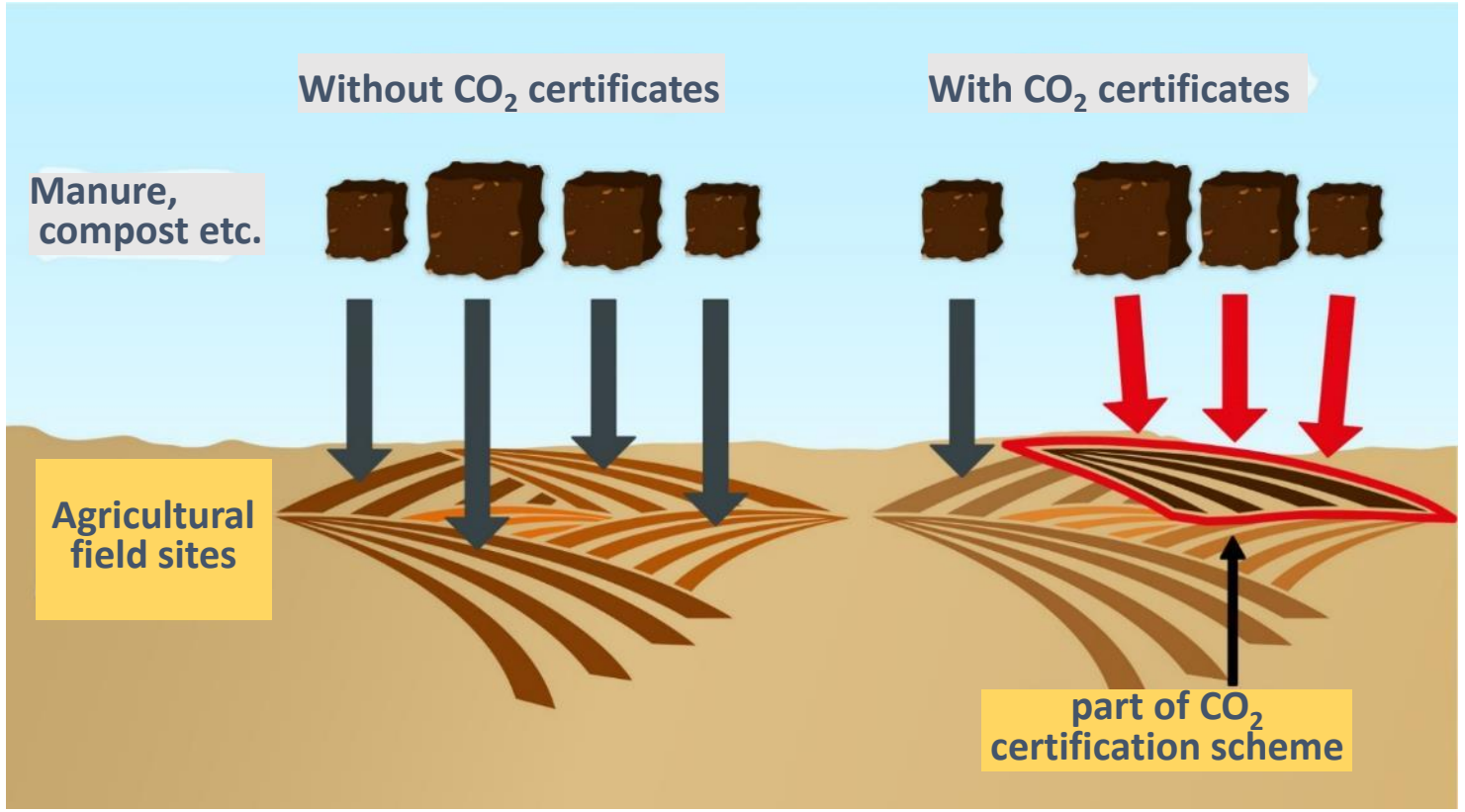
Leakage with organic fertilisation



- **Transfer of C with manure** but no enhanced soil C stock at large scale
- Leakage instead of climate mitigation

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