Crop residues for soil fertility and greenhouse gas mitigation

The RESIDUEGAS project stakeholder webinar

FACCE ERA-GAS

MONITORING & MITIGATION OF GREENHOUSE GASES FROM AGRI- AND SILVI-CULTURE

RESIDUEGAS

The project receives funding from the European Union's Horizon2020 Research & Innovation Programme under grant agreement No 696356.

Results from ResidueGas

- Overview of the ResidueGas project, Jørgen E. Olesen, AU
- Quality aspects of crop residues, Sylvie Recous, INRAE
- Factors affecting N_2O from crop residues, Maria Ernfors, SLU
- Long-term and legacy effects of crop residues, Klaus Butterbach-Bahl, KIT
- Farmer perspectives on crop residues – questionnaire survey, Chiara De Notaris, AU
- Highlights of the ResidueGas project, Jørgen E. Olesen, AU

Crop residues

- Crop residues contribute carbon (C) and nitrogen (N) to the soil, supporting the soil microorganisms and the soil fauna
- Crop residues contribute to soil fertility by sustaining soil organic matter that provide soil structure, nutrient retention and sustain soil biodiversity
- Crop residues contribute to the greenhouse gas balance of cropping systems in two ways
  - Nitrous oxide (N_2O) from residue management
  - Soil carbon storage in soils

ResidueGas objectives

- Propose a new and improved methodology to estimate N_2O emissions from crop residues.
- Assess the relative importance of crop residue management for total N_2O emissions and the soil carbon balance of agricultural systems, as a basis for the identification and implementation of mitigation strategies.

ResidueGas project components

- Residue quality effects on N_2O emissions
  - Synthesize data on crop residue quality (database)
  - Synthesize data on crop residue N_2O emissions (metaanalysis)
  - Reveal effects of crop residue quality on N_2O emissions (experiments)
- Quantify GHG balance of crop residues
  - Model long term effects on N_2O and soil C
- Assess mitigation of GHG through improved management
  - Synthesize data from experiments (metaanalysis)
  - Questionnaire survey on farmer perceptions

Drivers for N_2O emissions
- Residue nitrogen and carbon
- Soil contact with residues
- Soil environmental conditions

Quantifying and accounting GHG
- Methodology for N_2O
- Hotspots and hot moments
- Temporal aspects

Mitigating GHG
- Soil incorporation
- Residue removal
- Interaction with fertilisation

N_2O emission estimation

In the IPCC Tier 1 methodology, the nature of the plant residues (also called quality) **is taken into account by the quantity of biomass** (AG & BG) **returned and <u>its nitrogen (N) content</u>**

Crop residue N input

EQUATION 11.6 (UPDATED)
N FROM CROP RESIDUES AND FORAGE/PASTURE RENEWAL (TIER 1)

$$F_{CR} = \sum_T \left\{ \left[AGR_{(T)} \bullet N_{AG(T)} \bullet \left(1 - Frac_{Remove(T)} - \left(Frac_{Burnt(T)} \bullet C_f\right)\right)\right] + \left[BGR_{(T)} \bullet N_{BG(T)} \right] \right\}$$

Crop residue above-ground biomass

N content of aboveground residues

Belowground biomass and N

Emission factor (EF) kg N_2O-N /kg added N
standard for all types of crops

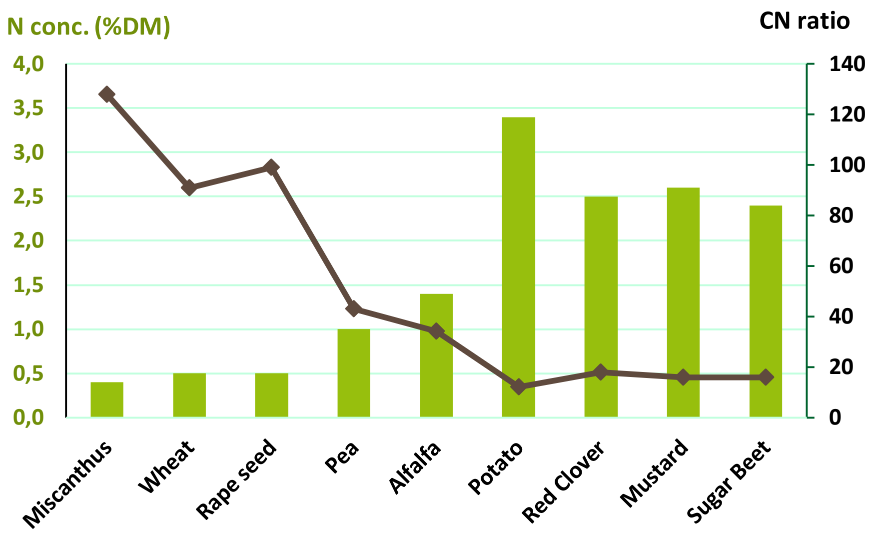
- 0.005 to 0.006

2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories

The chemical residue quality is both the N content and the biochemical composition of the plant tissues

-> depends on crop species, plant part, and crop maturity

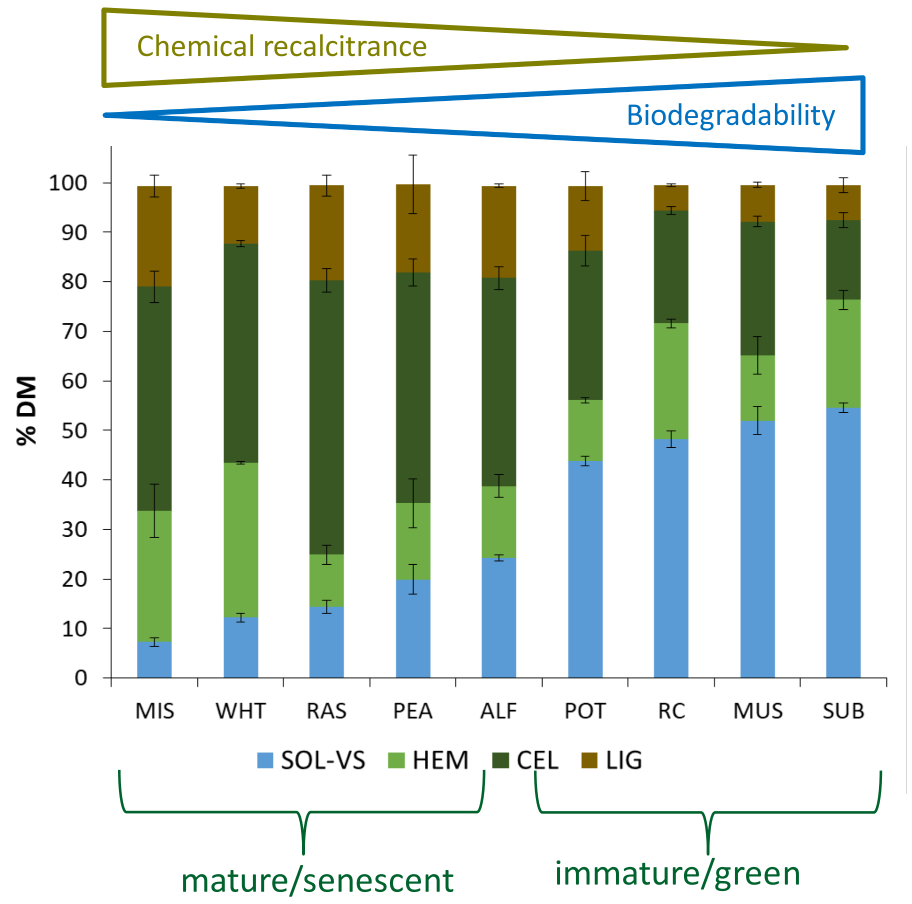
Residue N content



Red Clover and Miscanthus residues (@Lashermes, INRAE)

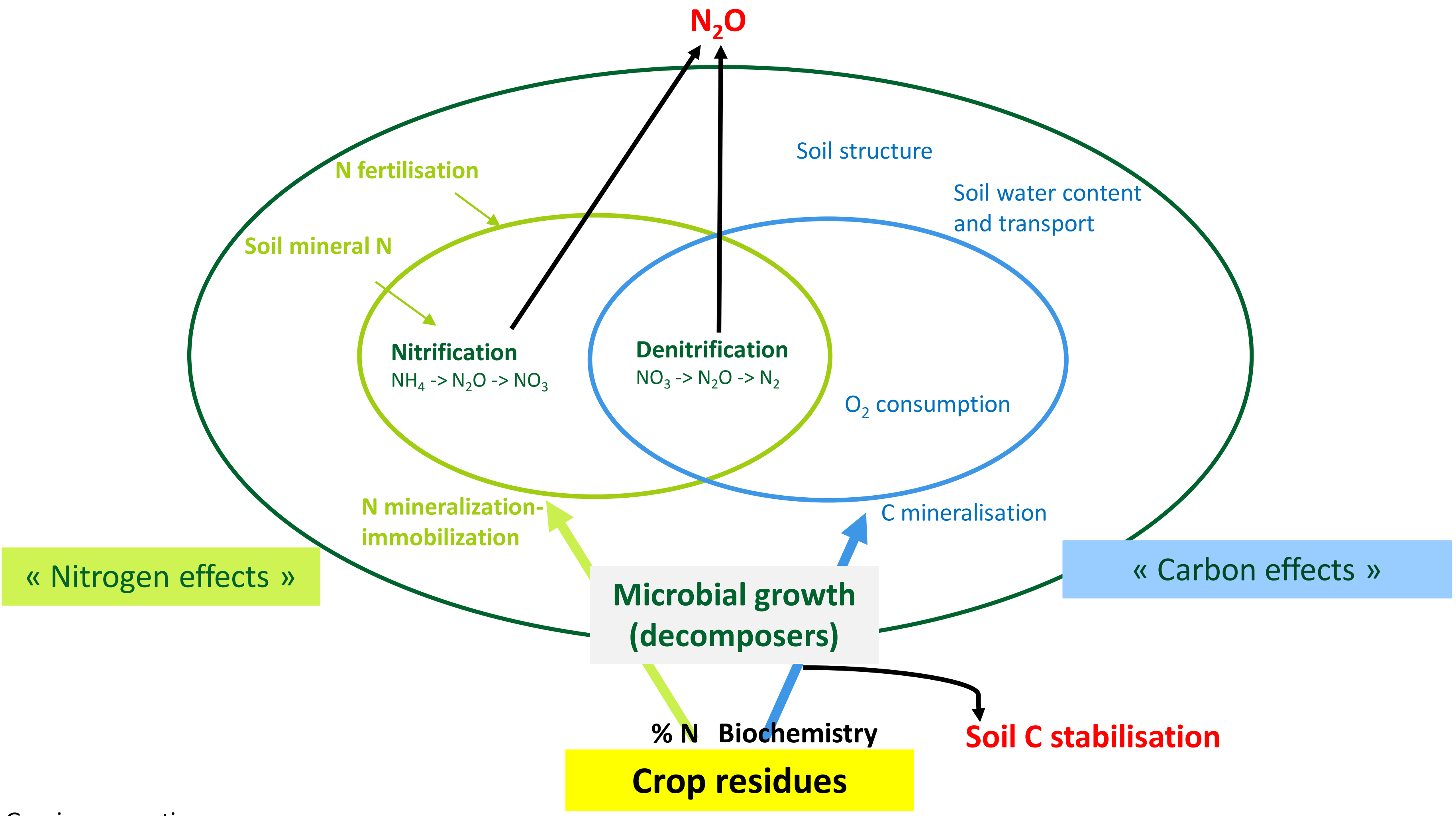
Experimental design for incubations (@Blekken NMBU)

Residue biochemical quality



Lashermes et al., Janz et al., Laville et al., Bleken et al. , ResidueGas, under submission

Conceptualization of residue quality effects on GHG



Olesen et al. , ResidueGas, in preparation

N_2O emissions from belowground biomass – overestimated?

IPCC methodology:

Same emission factor aboveground and belowground (0.6%)

ResidueGas, grass and clover study:

Belowground emission factor *much lower* (less than half)

- Not explained by biochemical composition alone
  - belowground biomass more protected?
- Low decomposition rate (low CO_2 emission) and not affected by N fertilisation
  - likely C limitation

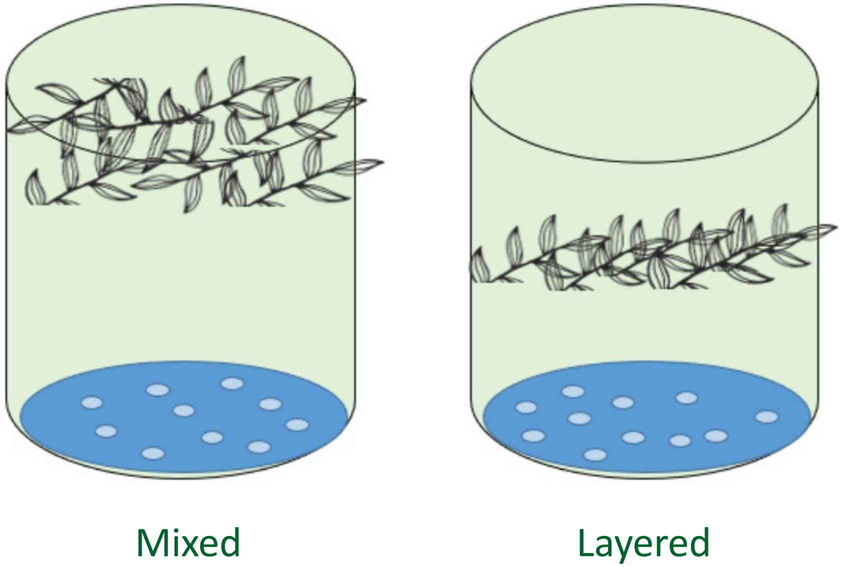
Effects of incorporation method (”cultivator” or ”ploughing”) Interactions with N fertilization

With nitrate

N_2O emissions:
mixing (cultivator) > layering (ploughing)

Without nitrate

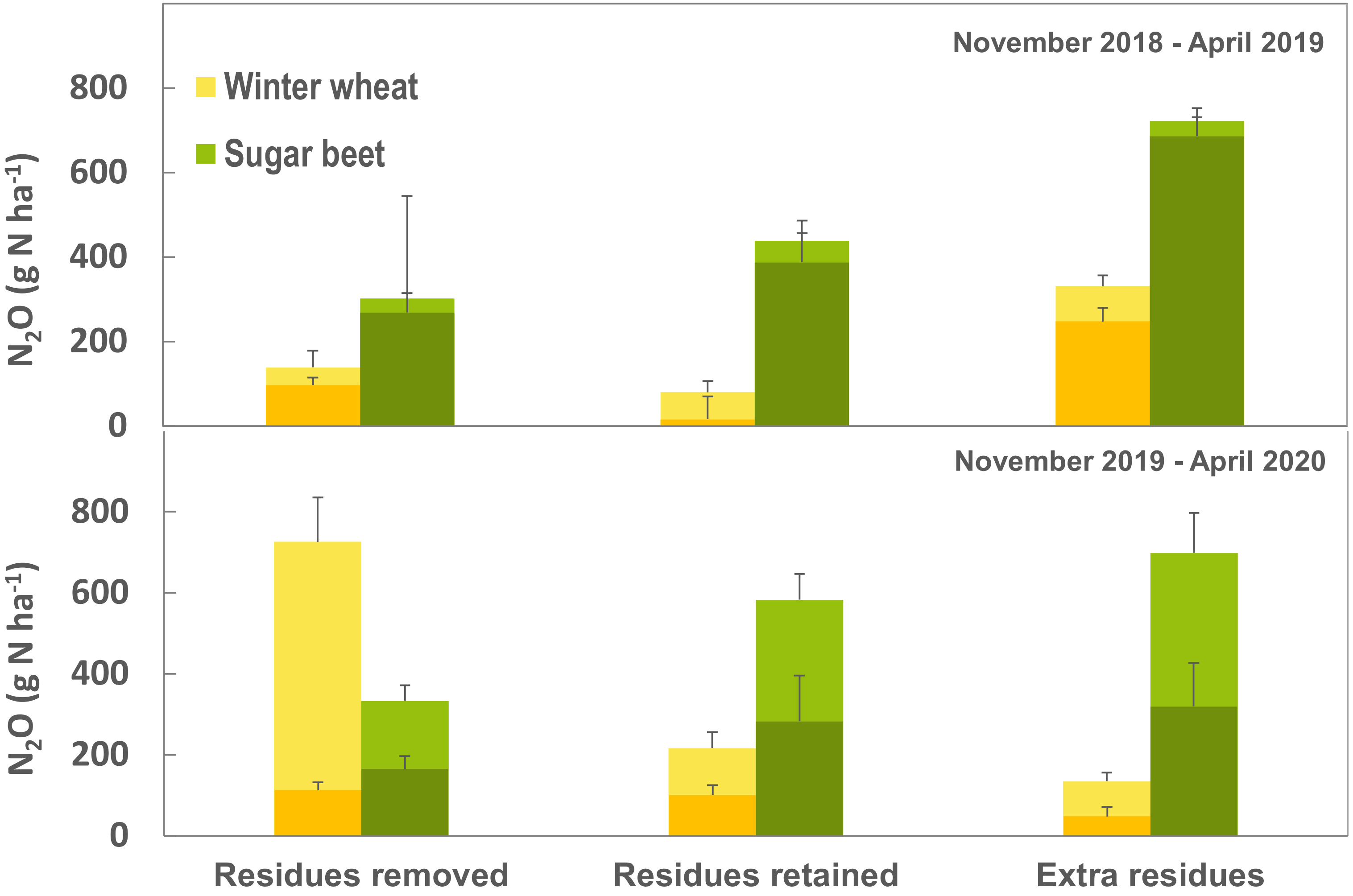
N_2O emissions:
layering (ploughing) > mixing (cultivator)
(or no difference)



- ➢N abundant: C limits emissions - mixing in residues provides C throughout the soil, increasing emissions
- ➢N limited: enough N-min for high emissions only where residues are concentrated – mixing prevents hotspots

Effects of residue amounts and removal

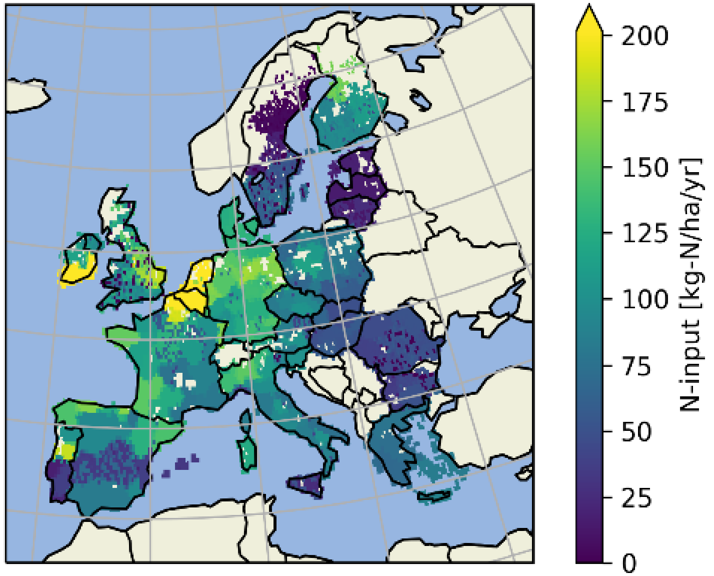
- For ”immature” residues, removal could be a mitigation option
- For ”mature” residues, immobilization effects and interactions with fertilization in the following spring need further study

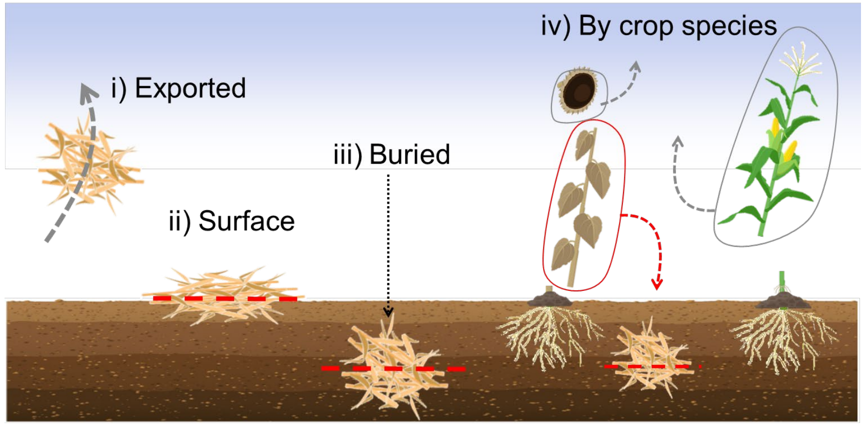


- ”Immature” = green, low C/N
  (e.g. sugar beet, red clover, grass ley)
- ”Mature” = senescent, high C/N
  (e.g. cereals, rapeseed, field peas)

Modelling residue management on N_2O and soil carbon

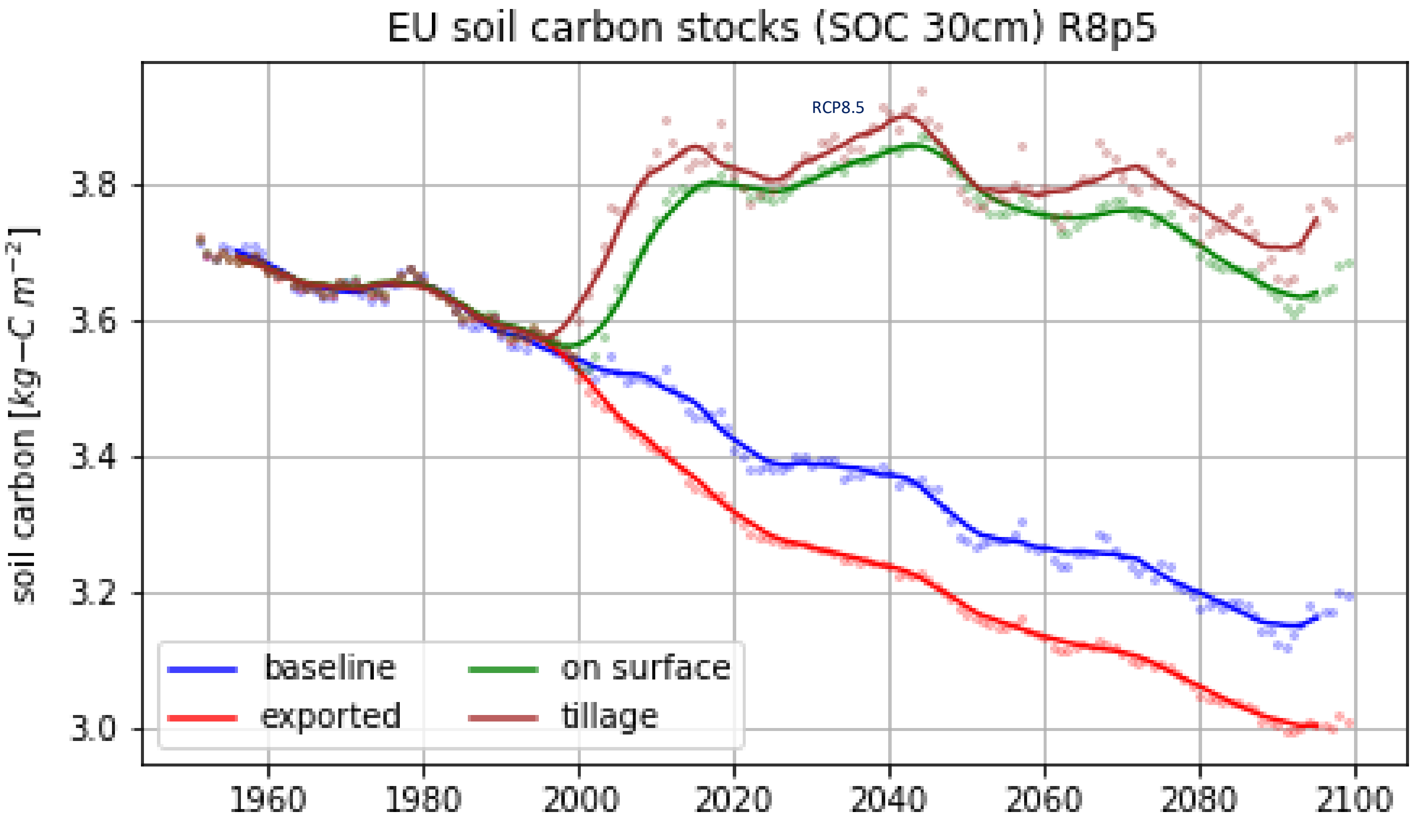
a) Development of a EU wide database on soil, field management and (simplified) crop rotations
b) Use of historical climate information and future climate scenarios
c) Assuming scenarios of residue management
d) Use of information for driving biogeochemical model LDNDC

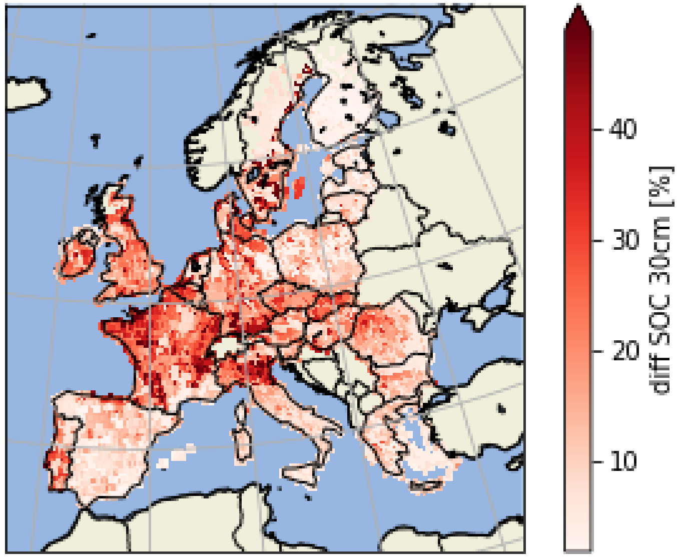




a. Base scenario: residues (% left versus exported) as observed in 2000 (FAO)
b. Surface: 100% residues on surface and reduced tillage
c. Incorporated: 100% residues tilled into 20cm

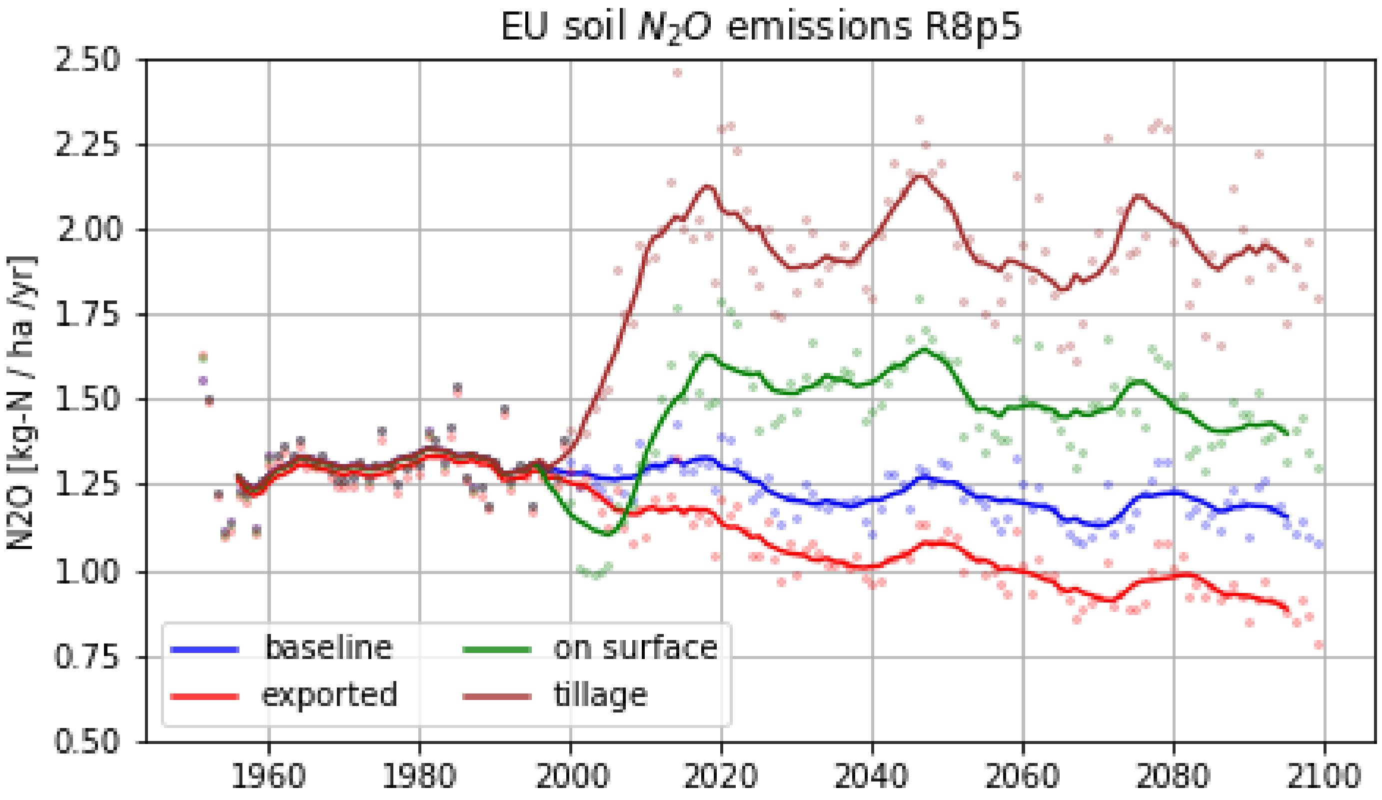
Residue management effects on SOC stocks

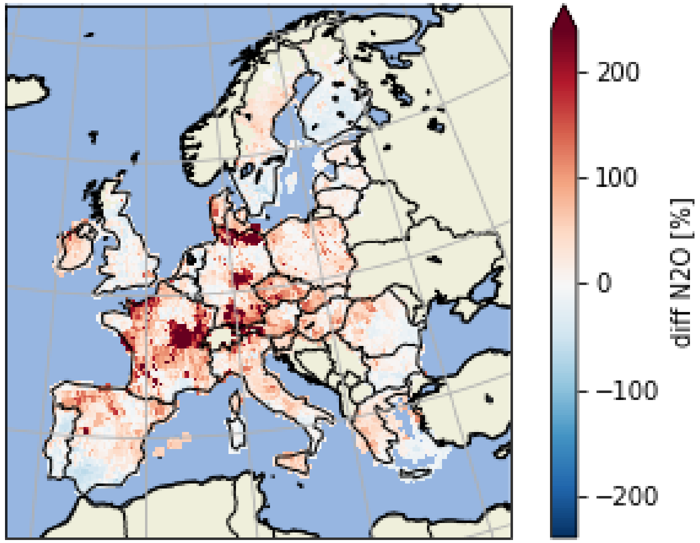




%-change of topsoil C stock (0-30 cm) comparing two scenarios: business as usual versus residue incorporation (year 2050)

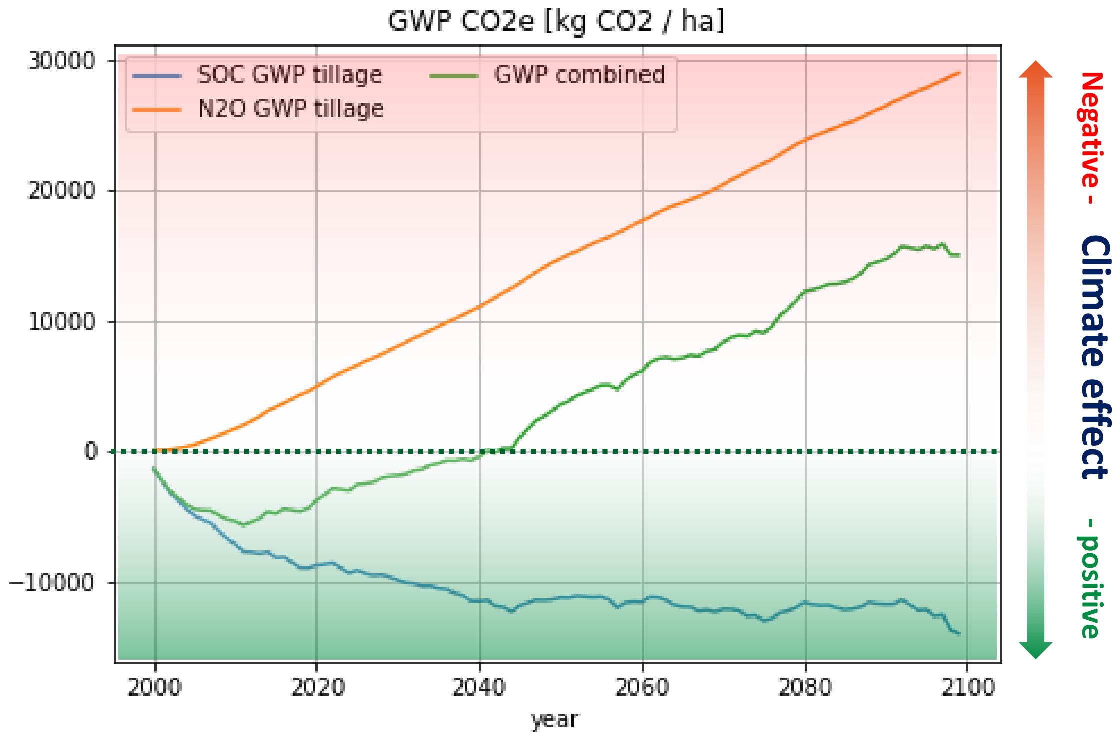
Residue management effects on soil N_2O emissions

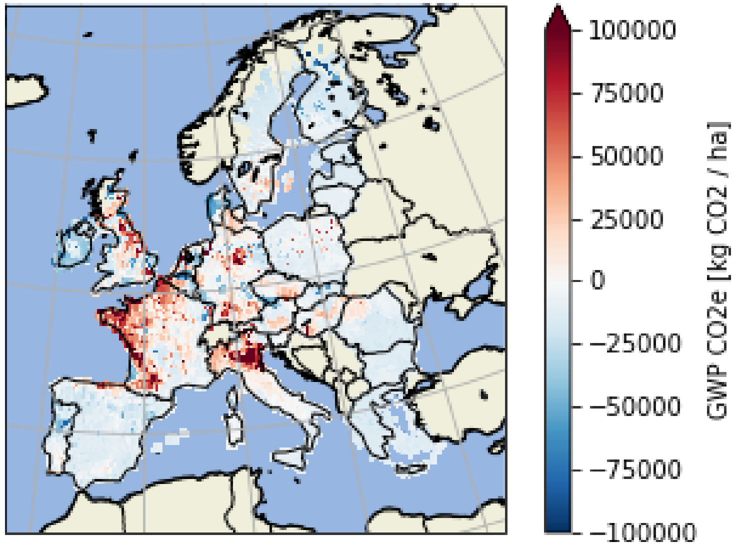




%-change in soil N_2O fluxes comparing two scenarios: business as usual versus residue incorporation (year 2050)

Residue management effects on net GHG emissions





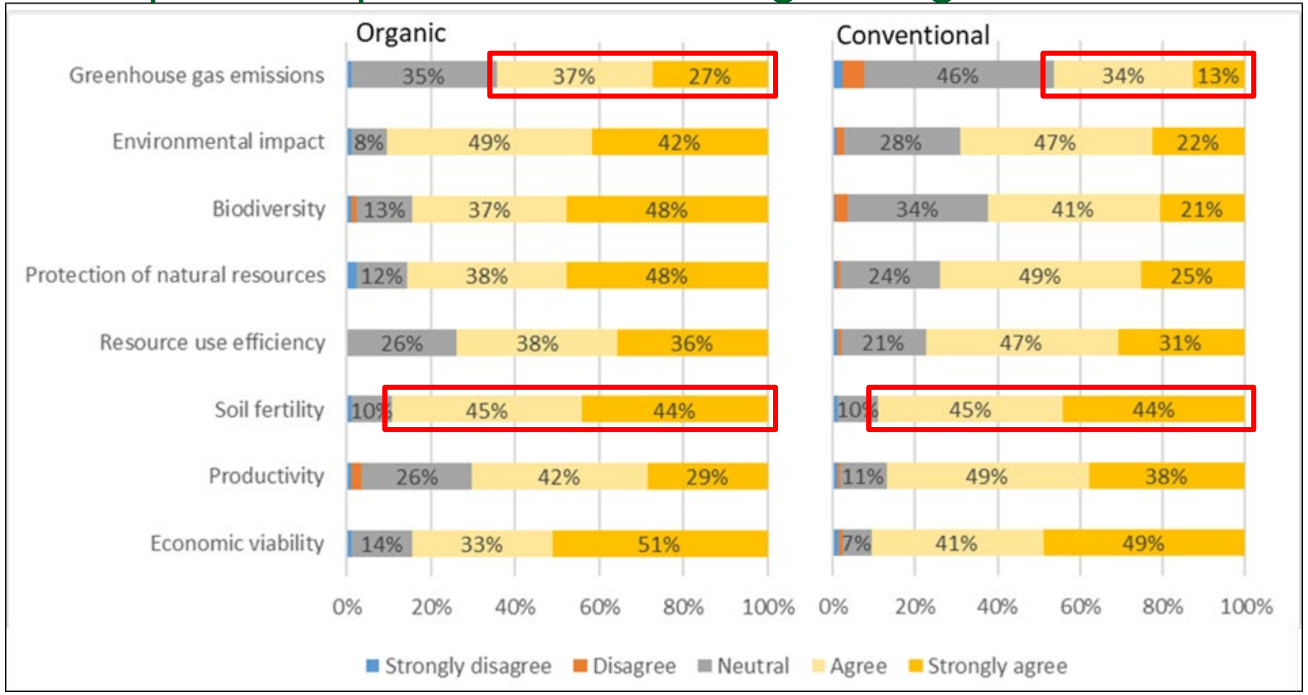
Change of the cumulative GHG balance (CO_2+N_2O) over a 100-year period comparing two scenarios:
business as usual versus residue incorporation

Farmer perspectives of crop residues

- Survey conducted in Northern European countries
- 592 complete responses collected in Denmark

Priorities and current management

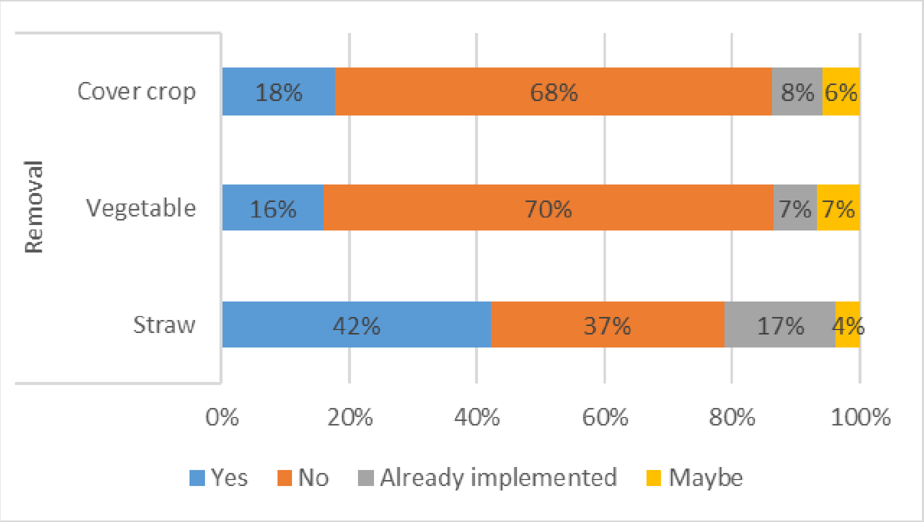
This aspect is important when taking management decisions:

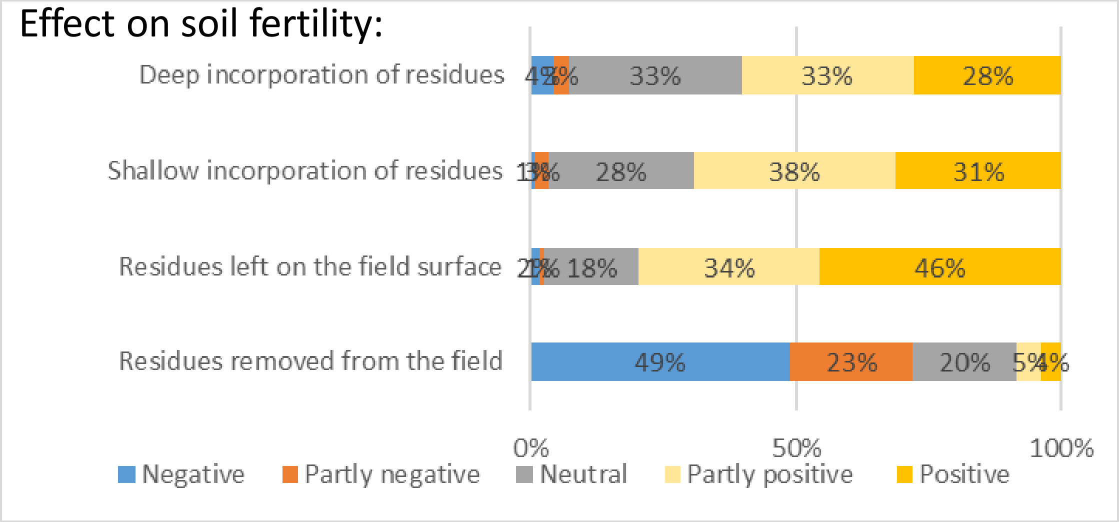


88 % of Danish farmers are concerned about the Soil Organic Matter (SOM) status in their farm
→ 74 % retain plant residues in the field to maintain or increase SOM

Acceptability of alternative management options

- Even surface spreading and deep incorporation of crop residues were mostly accepted as alternative methods by Danish farmers
- Removal of “green” residues (cover crops and vegetables) was not accepted
  → perceived as having negative effects on crop production and soil fertility





Barriers and incentives

Lack of knowledge about which option is most effective
→ main barrier to the adoption of alternative methods for residue management

Main incentives:

- Indicators and tools for farmers to measure progress in reducing farm emissions
- Strengthening of farm advisory services (knowledge and advice)
- Financial support

ResidueGas highlights on crop residues

Drivers of GHG emissions

- N_2O emissions are driven by residue quality (available N and degradable C)
- N_2O emission levels are distinguished by mature and immature crop residue
- Crop residues enhance soil carbon, but the effects are not lasting (and are outweighed by N_2O effects)
- Long-term GHG benefits of crop residues may only be expected for C-poor soils

Management

- Distribute immature crop residues evenly in the field and avoid contact between soil and residues
- Avoid applying mineral N fertilizers with the incorporation of immature residues
- Removal of residues is primarily relevant for immature residues
- Farmers are concerned with crop residues for soil fertility, but lack knowledge

ResidueGas outputs

Databases

- Crop residue quality
- Field N_2O emissions from crop residues

Scientific documentation

- Special issue of Science of the Total Environment (in preparation)

Other materials

- Website: https://projects.au.dk/residuegas/

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