LfL

Bavarian State Research Center
for Agriculture

Mitigation potential with crop varieties and cultivation systems

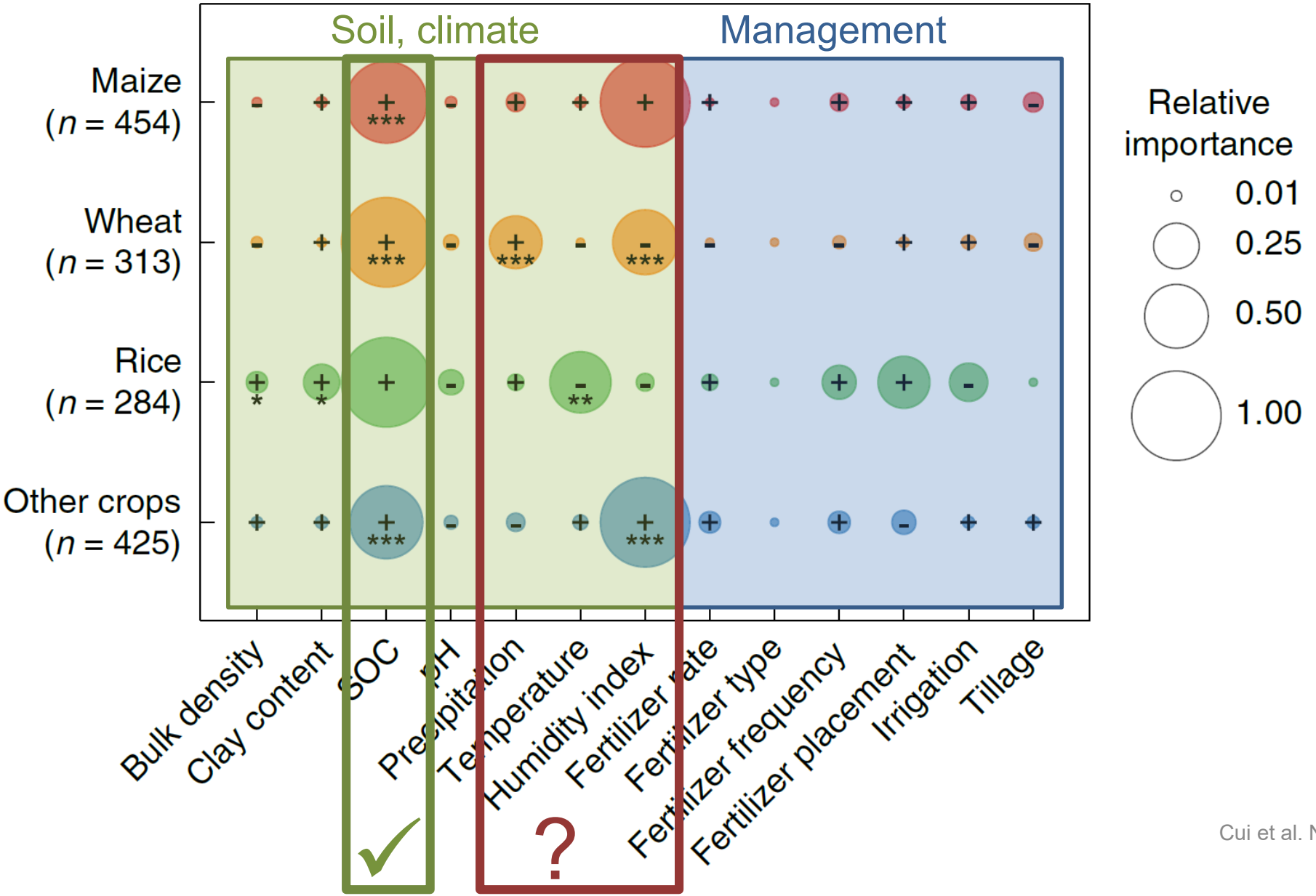
Dr. Annette Freibauer
Institute for Agroecology and Organic Farming

Hellerup, 4 May 2022

Overview

- N_2O: mitigation is a gamble!
- N_2O emissions and management options
- Attempt for a „code of N_2O-smart cropping practices“
- N_2O in the broader GHG mitigation context

N_2O: Edaphic and climatic conditions overrule management



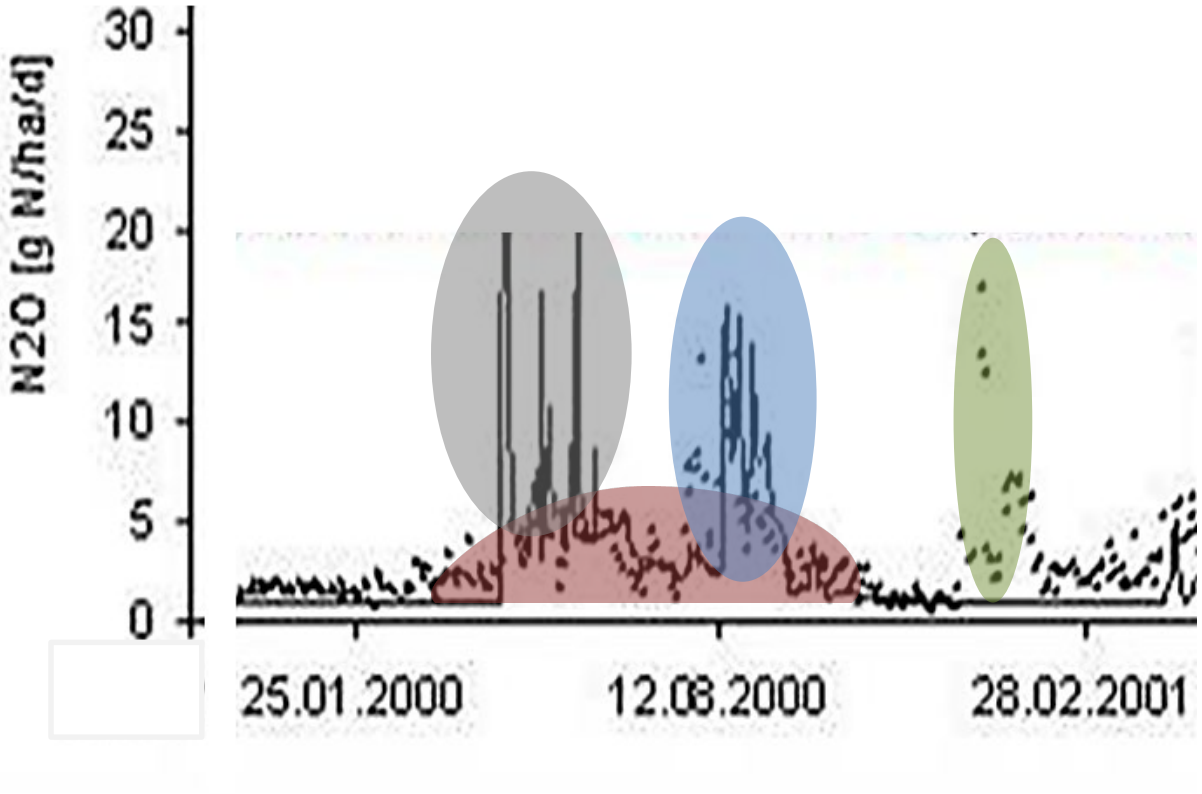
LfL

Cui et al. Nature 2021

nd Resource Management

N_2O mitigation is a gamble!

Emission patterns of N_2O from an East German cropland



Temperature: seasonal base fluxes

Events:

Fertilization

Drying-rewetting

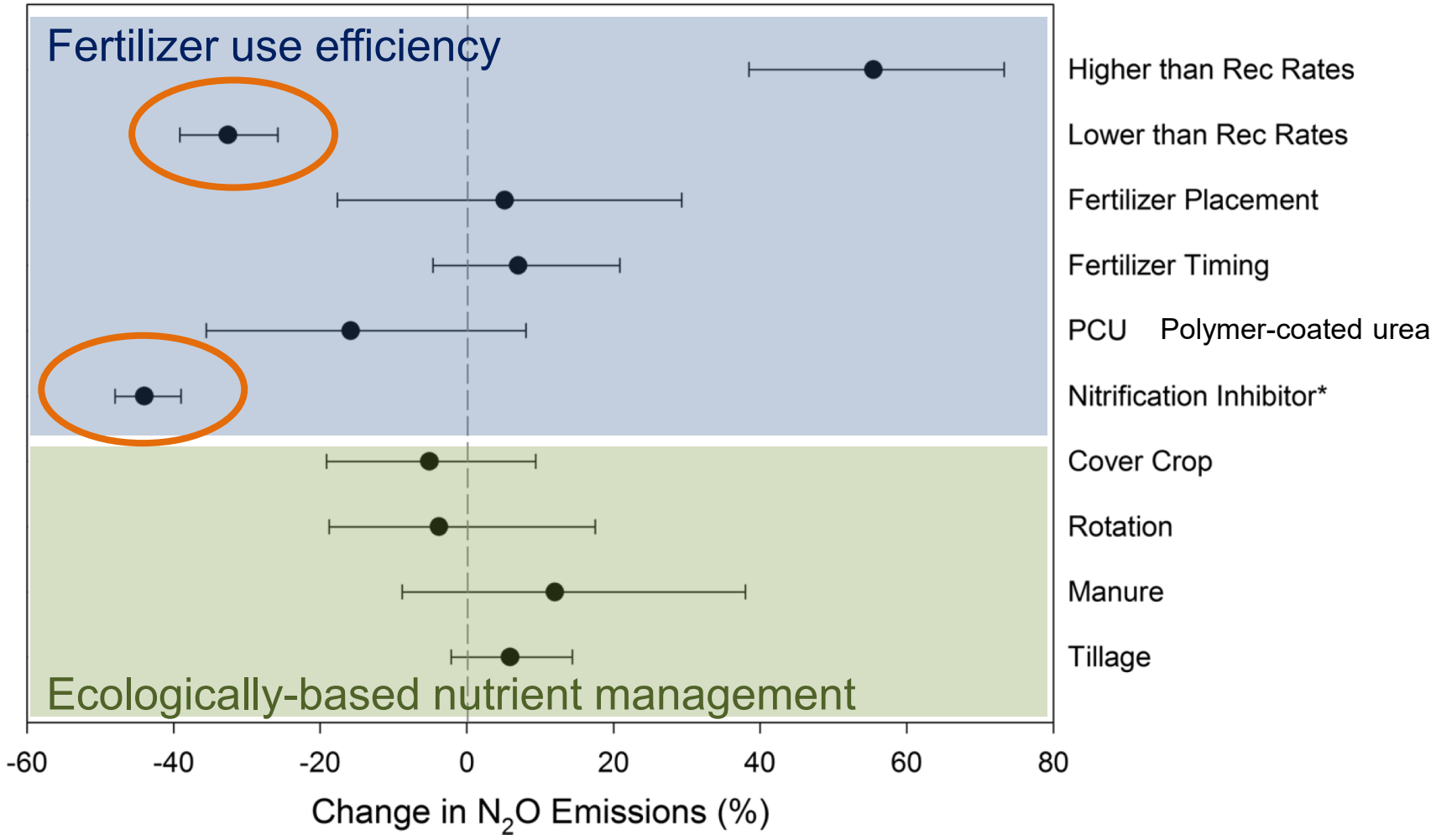
Freeze-thaw

→ **We can manage the risk, not the real emission**

LfL

Crop management strategies for N_2O mitigation: what will savely work?

Fig. 1 Effect of management practices on area-scaled N_2O emissions reported as percent change from the control. Mean values and 95% confidence intervals of the back-transformed response ratios are shown. The result for nitrification inhibitors was from Qiao et al. (2015) and was shown for comparison



N_2O risk management = nitrogen management

- IPCC Tier 1: $E(N_2O)_{direct}$ =

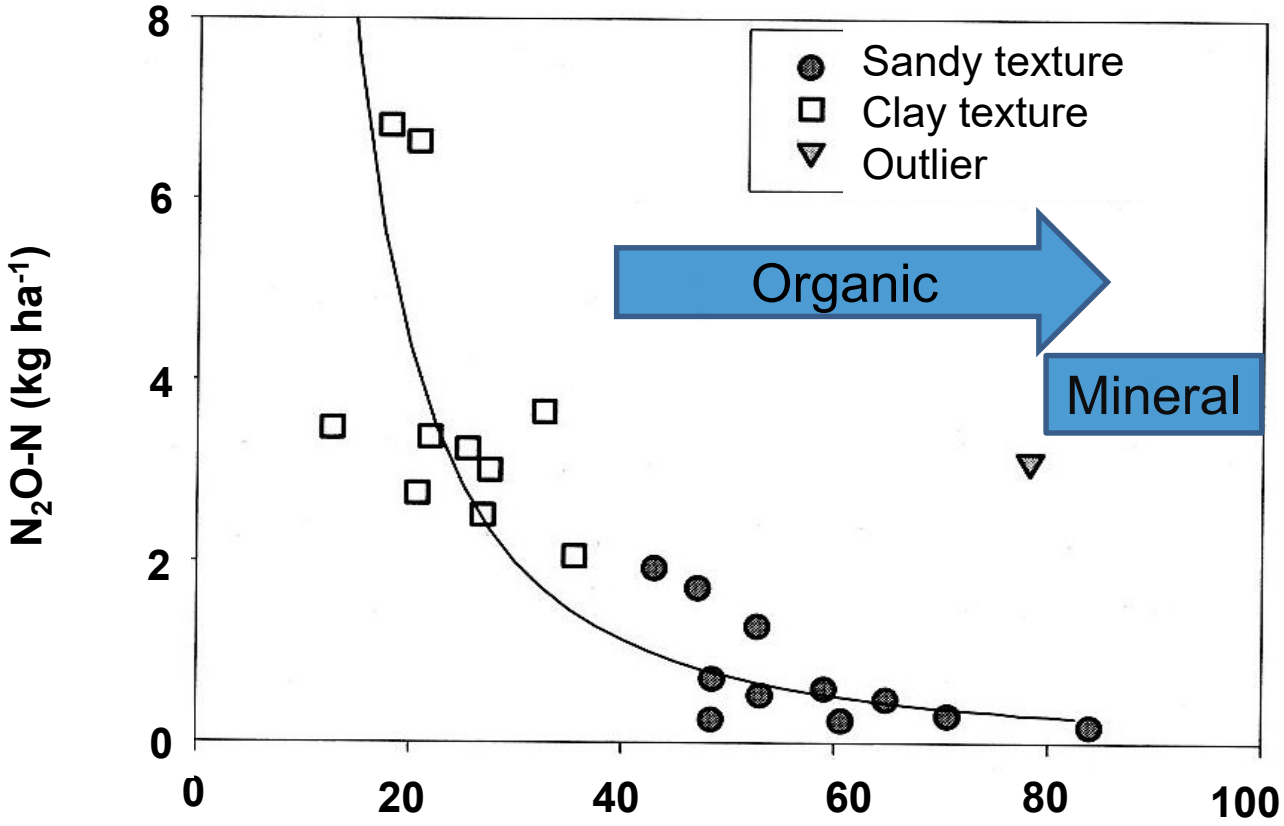
  min. fertilizer + org. fertilizer + crop residues + net SOM mineralisation

- IPCC Tier 1: $E(N_2O)_{indirect}$ = NH_3 + nitrate leaching

N management	N_2O evidence
N amount	Yes
N surplus	**Yes!**
N type (mineral – organic, …)	No
N timing	Ambiguous
N placement (shallow, deep)	
N fast - slow	

Han et al. Nutr Cycl Agroecosys 2017; many others

N surplus – N use efficiency



German fertilizer act,

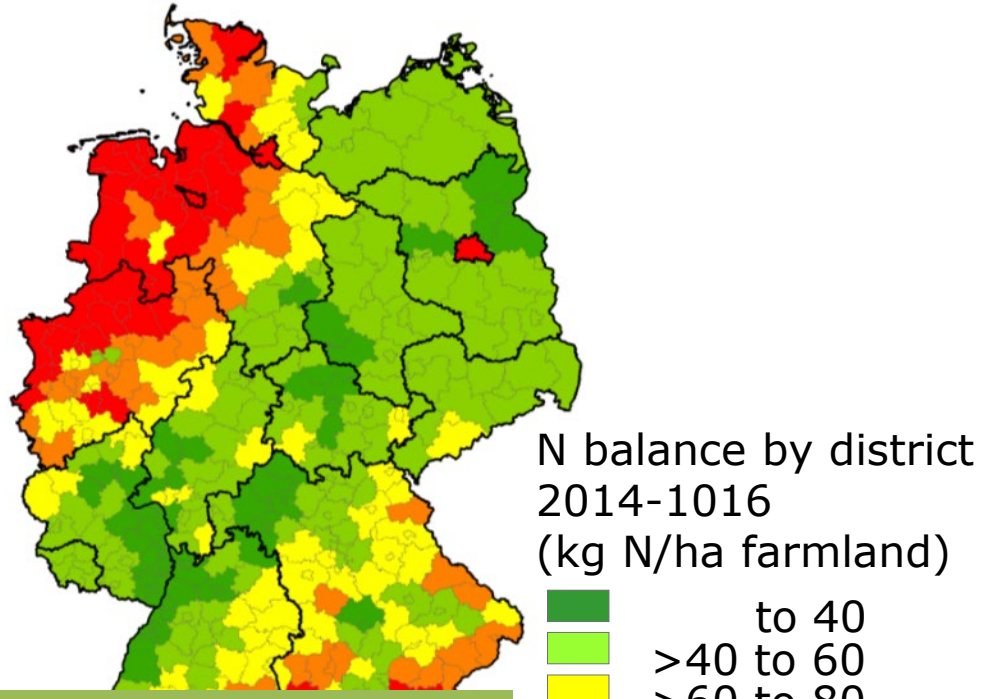
Regional field trials

→ Measure 1: N-efficient application of liquid and solid manure, avoid NH_3!
Avoid N surplus!

van Groenigen, 2004; for N surplus: von Groenigen et al. 2010

High net N surplus on average in Germany

- 2016: average net N surplus of 102 kg N per hectare farmland (BMEL 2018)
- N surplus varies widely between fields, farms and regions
- Why? N imbalances at
  - international/national level (trade)
  - regional level (concentration of animals and agro-biogas plants)
  - farm (with/without animals)
  - field (organic fraction in manure)



→ Measure 2: Inter-farm, inter-regional manure cooperation or balanced animal distribution

Bach and Häußermann, 2018 in KLU 2019

Crop residues, catch crops

- IPCC Tier 1: $E(N_2O)_{direct}$ =

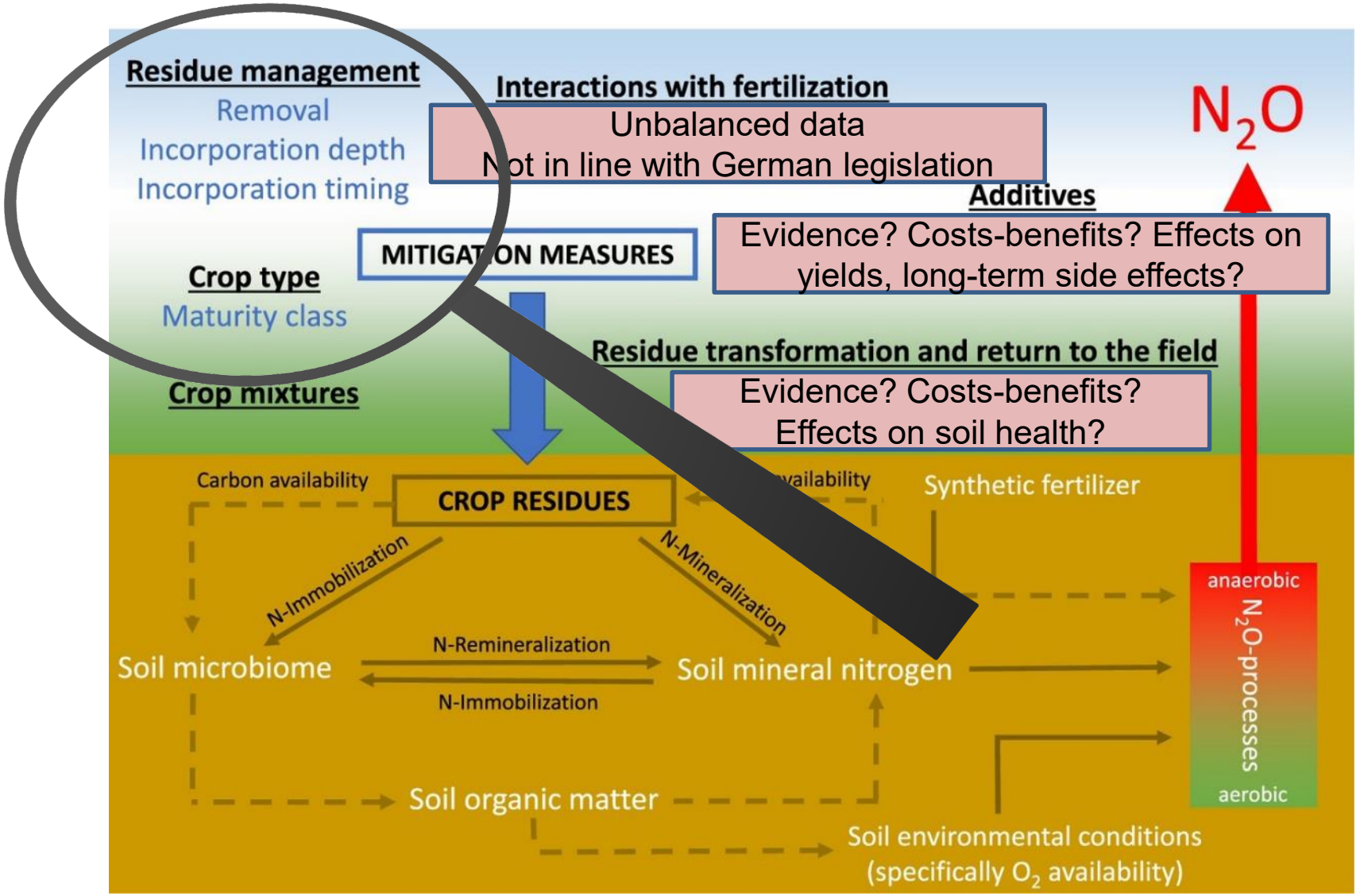
  min. fertilizer + org. fertilizer + crop residues + net SOM mineralisation

- IPCC Tier 1: $E(N_2O)_{indirect}$ = NH_3 + nitrate leaching

N_2O risks:
- post-harvest emissions,
- winter emissions,
- nitrate leaching

Graphic: Loriot

Crop residues



Abalos et al. Sci Tot Env 2022: 154388 (graphical abstract)

Crop residue management

Crop residues …

- increase N_2O by 40-50% against removal, but:

add 30-50 kg N ha^{-1} more than removal

- Mulching or incorporation: not significant
- Incorporation depth: not significant
- Incorporation in autumn: not significant (autumn > spring)

CAP 2023-2027: GAEC 6 „avoid bare soil in most sensitive periods (winter time) → no choice!

LfL

Abalos et al. Sci Tot Env 2022: 154388

Crop residue type

The wider the C/N ratio the lower N_2O.

Critical threshold value: C/N = 30

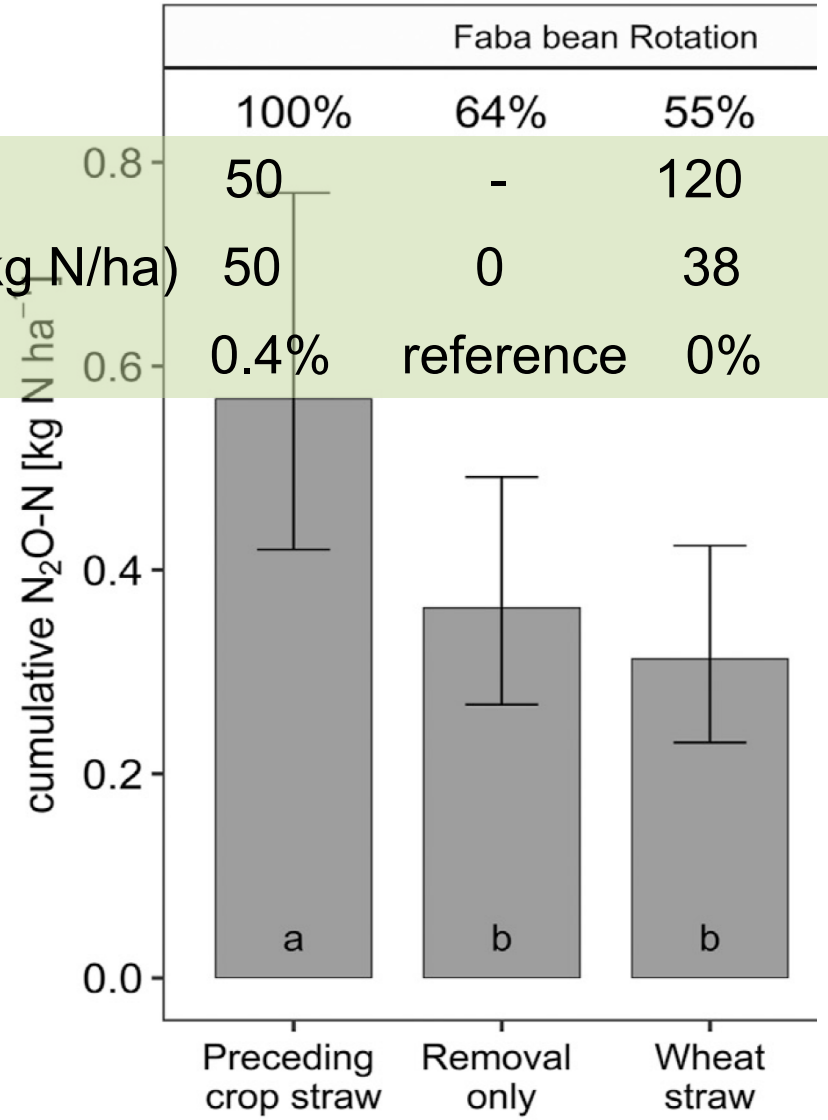
→ Ripe plants are preferable to green crops

→ Exchange residues, manage C/N?

e.g. crop rotation faba bean – winter wheat – winter barley, measurements August - March, fully replicated design, 3 years, Kiel/Germany

→ Measure 3: Crop residues with C/N >30

Faba bean Rotation	100%	64%	55%
C/N	50	-	120
N input (kg N/ha)	50	0	38
EF	0.4%	reference	0%



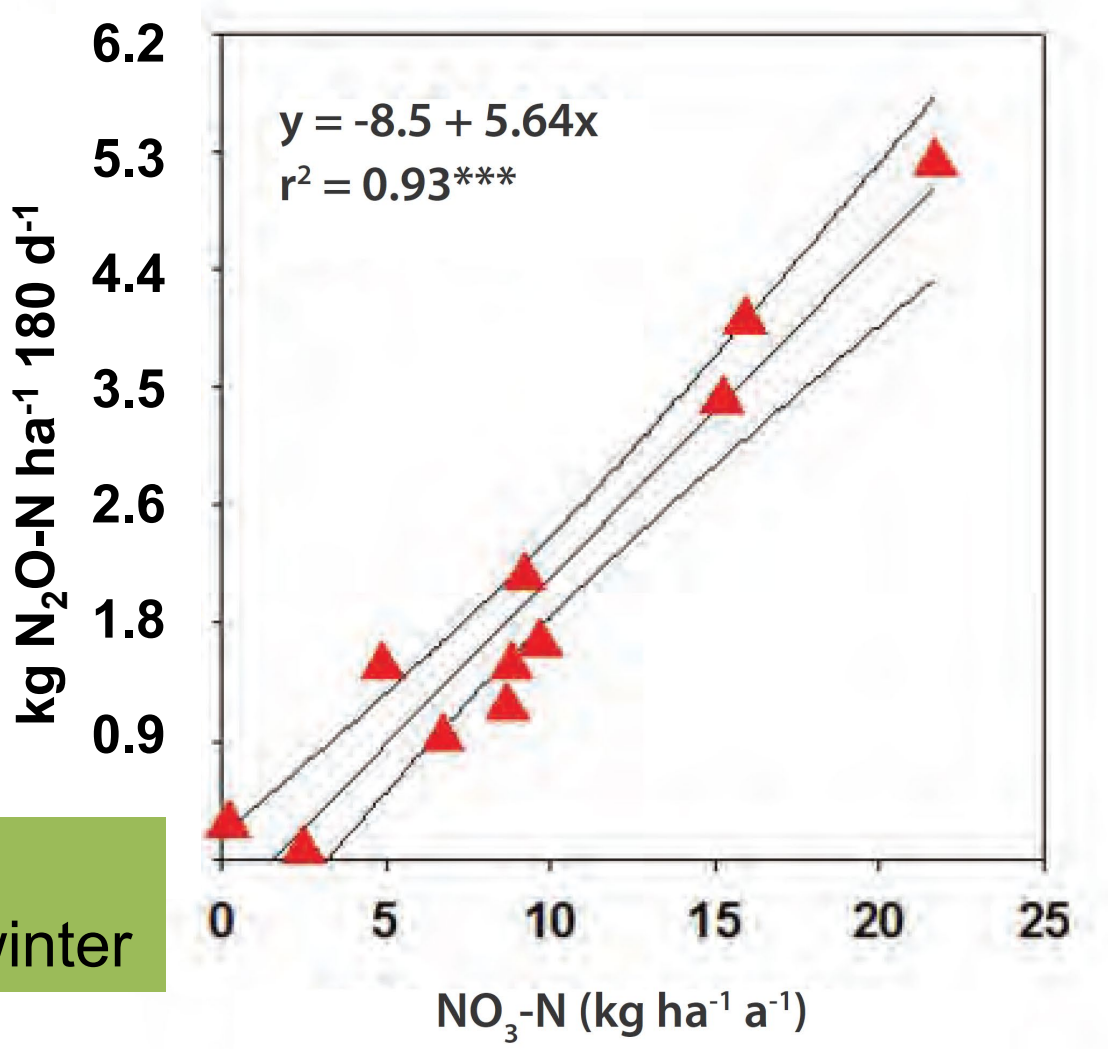
LfL

Abalos et al. Sci Tot Env 2022: 154388, Han et al. Nutr Cycl Agroecosys 2017, Rothardt et al. FONVS 2021: 712013

Catch crops

- Avoid nitrate leaching
- **Reduce freeze-thaw emissions by low mineral nitrogen in soil in winter**

e.g. crop rotation potato - winter wheat – maize – winter wheat, fully replicated design, 3 years, Scheyern/Germany



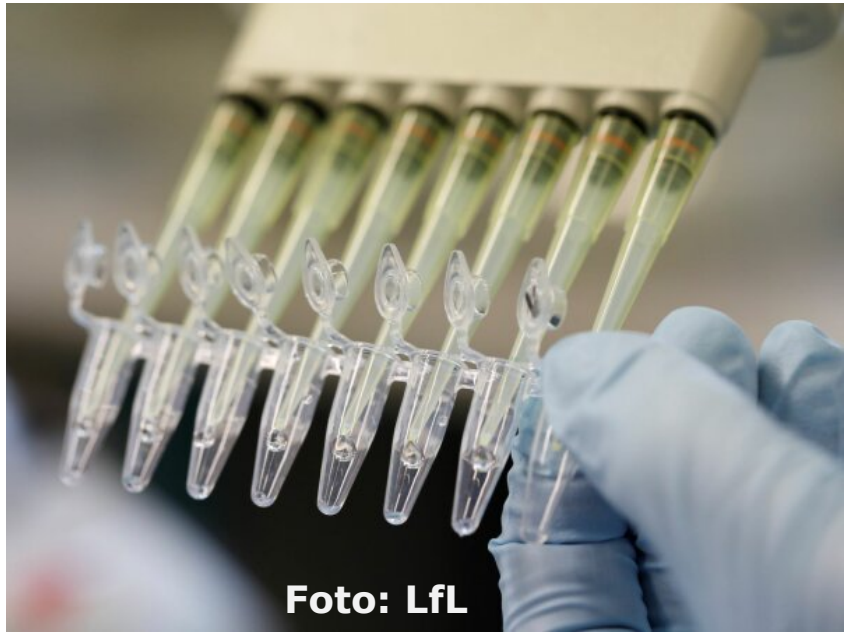
→ Measure 4: Catch crops / winter crops
low nitrate contents in soil in winter

Ruser et al. 2001 in Senatsarbeitsgruppe 2014

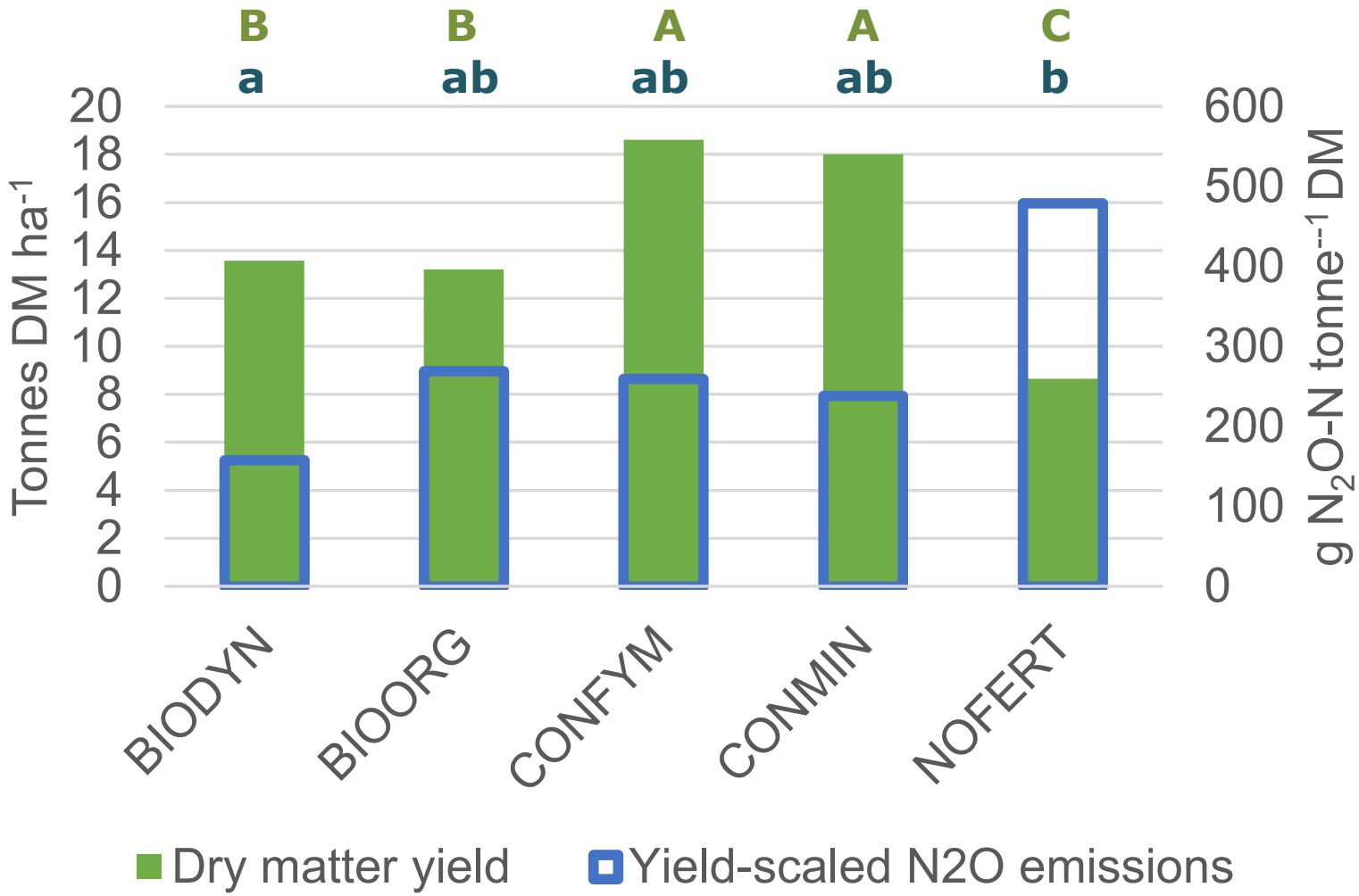
Attempt for a „code of N_2O-smart cropping practices“

The productivity / technology narrative: maximize yield / N_2O

- Highest N use efficiency, likely best N balance = use mineral fertilizers
- Use nitrification inhibitors with NH_4 / urea based fertilizers
- Remove crop residues
- High, secure yields: irrigate/drain and avoid WFPS prone to denitrification
- Lime for pH > 7 high N_2/N_2O



N_2O emissions from DOK silage maize (longest organic – conventional trial)

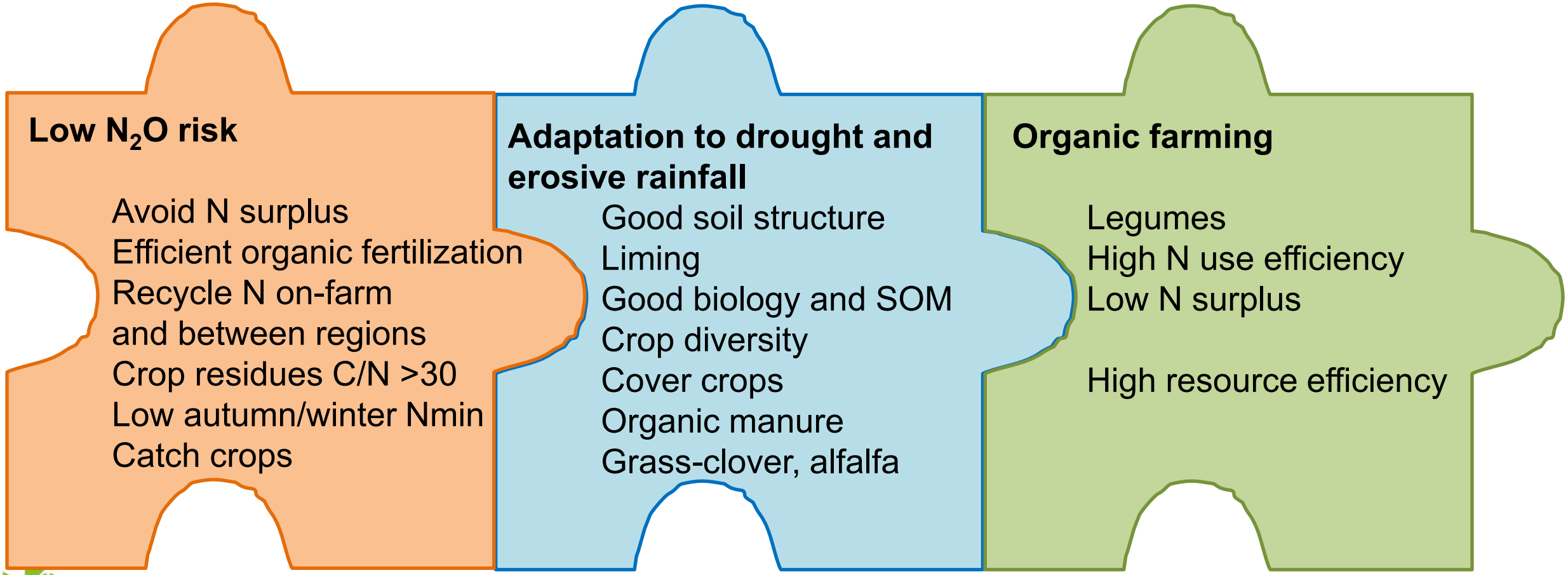


→ Measure 5: Organic farming: no-regret or win-win

Skinner et al. 2018 Sci Reports

Attempt for a „code of climate-smart cropping practices“

The sufficiency / systemic narrative: combine win-win and no-regret measures for GHG mitigation and adaptation to climate change



Does the IPCC methodology account for climate-smart cropping?

- IPCC Tier 1: $E(N_2O)_{direct}$ = ✓ min. fertilizer + org. fertilizer + crop residues (✓) + net SOM mineralisation (✓)
- IPCC Tier 1: $E(N_2O)_{indirect}$ = ✓ NH_3 + nitrate leaching ✓ (✓)

Risk-specific emission factors needed = higher Tier

✓ No N_2O emission from biological nitrogen fixation = no fertilizer footprint!

What matters most for N_2O mitigation?

- Low N_2O per unit of land AND product
- Stable low GHGs per unit of product including the full life cycle balance
- A N-effective human diet