Greenhouse gas emissions from oilseed rape and maize cropping in Germany and mitigation options

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GHG Emissions in
Renewable Feedstock Production
Brussels, 2017-05-23

Background: EU climate and energy targets

2020 climate and energy package:

20 % cut in GHG emissions (compared to 1990)

20 % energy from renewables

20 % improvement in energy efficiency

2030 climate and energy package:

40 % cut in GHG emissions (compared to 1990)

27 % energy from renewables

27 % improvement in energy efficiency

EU target for the transport sector:

10 % renewables

→ Electric motors or **biofuels**.

Fuel suppliers are required to reduce GHG emissions per volume by **6 %** in 2020 compared to 2010.

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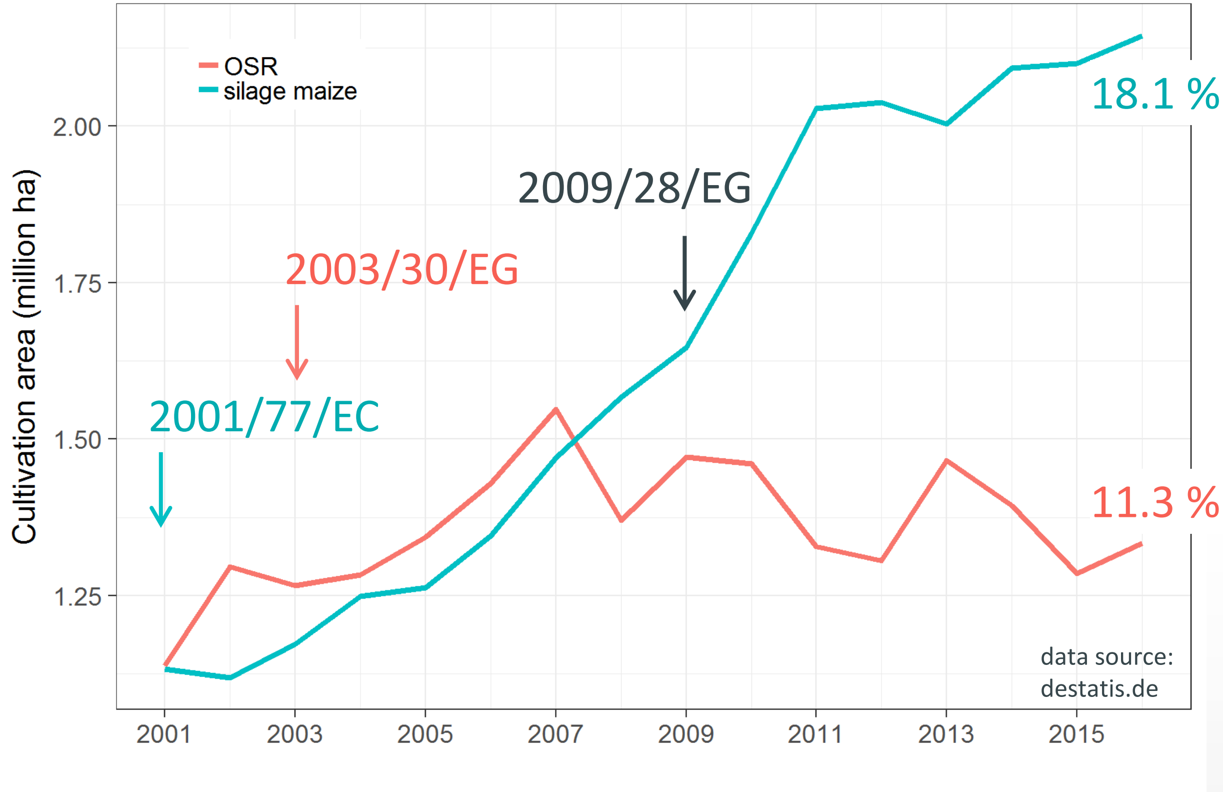
Growth of bioenergy cropping in Germany

A large proportion of the 11.8 million ha German total cropland area is used for bioenergy production.

7 % of electricity produced from biomass.

5 % of fuel are biofuels.



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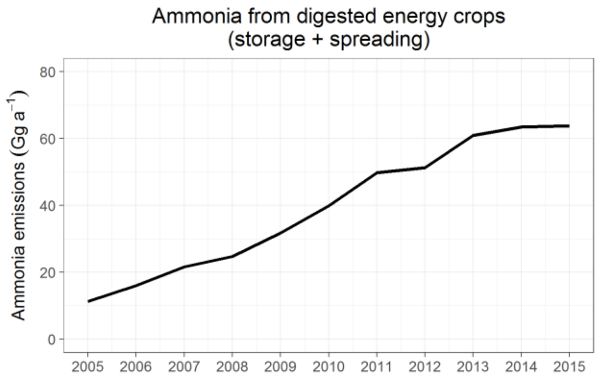
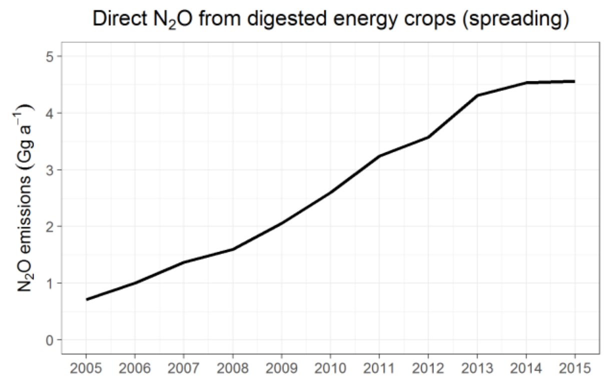
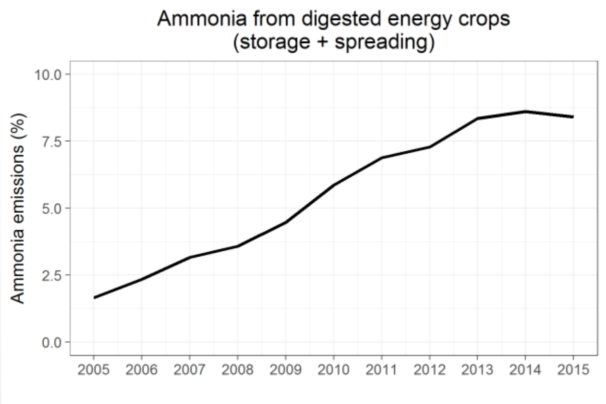
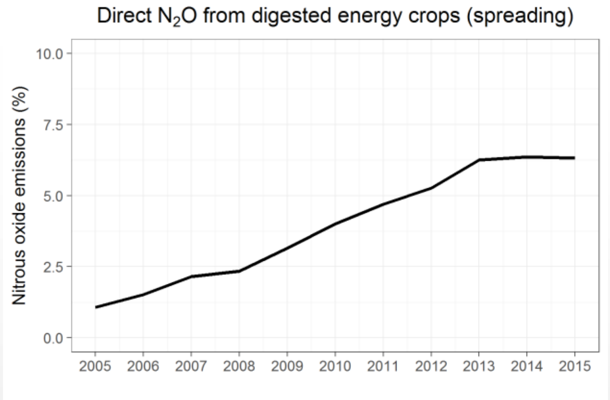
Growth of biogas cropping – environmental impact









In the same time period:

Total ammonia emissions from German agriculture increased by 12 %.

Direct N_2O emissions from agricultural soils increased by 9 %.

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Background: Sustainability criteria for biofuels

Currently:	**35 %** GHG savings compared to fossil fuel
2018:	**50 %** GHG savings compared to fossil fuel
2015:	60 % GHG savings compared to fossil fuel for new production plants

Biofuels must not be grown on land converted from forest or wetland.

Biofuels must not be produced from raw materials obtained from land with high biodiversity.

A cap on first generation biofuels:

Biofuels produced from cereal and other starch-rich crops, sugars and oil crops and from other crops grown as main crops primarily for energy purposes on agricultural land shall be no more than 7% of the final consumption. (Directive 2015/1513)

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GHG balance of biodiesel - methodology

Certified accounting methods for GHG balance can be used.

However, farmers usually simply confirm that **default values of the NUTS2 region** are applicable to their product.

The GHG balance takes into account:

- Cultivation
  - **Field N_2O emissions**
  - **Emissions from production of fertilizer** and other agro chemicals
  - Energy for field working
  - Energy for drying
  - GHG emissions during seed production
- Processing
- Transport

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Field N_2O emissions - methodology

Tier 1:

Direct N_2O emissions =

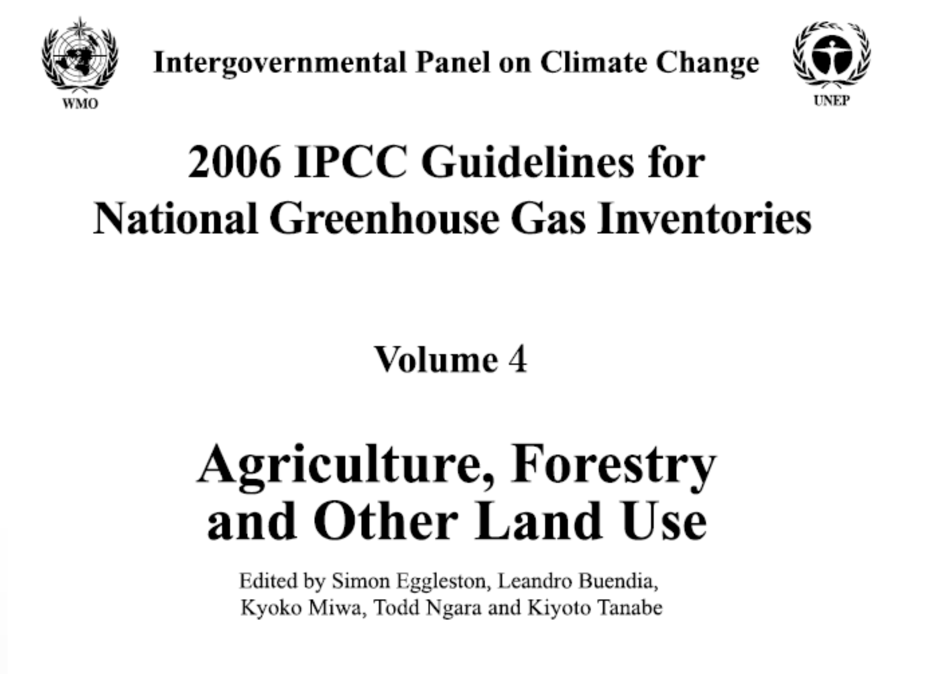
(**annual input of synthetic fertilizer N** +

annual input of organic fertilizer N +

annual amount of N in crop residues +

annual amount of SOM-N mineralized) ×

emission factor


WMO Intergovernmental Panel on Climate Change UNEP

2006 IPCC Guidelines for National Greenhouse Gas Inventories

Volume 4

Agriculture, Forestry and Other Land Use

Edited by Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara and Kiyoto Tanabe

Tier 2: Activity data and emission factors can be **dissaggregated further**, e.g., to be specific for crop types.

Tier 3: Modelling or measurement approaches.

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Field N_2O emissions - methodology

The IPCC (Tier 1) approach was developed for **national** inventories.

The default emission factor of 1 % was derived from a **global** dataset and is **independent of crop type, soil characteristics, and climate**.

→ It was **not** developed for estimation of N_2O emissions from cultivation of a **specific crop** (rapeseed or maize) in a **specific (NUTS2) region**.

→ A Tier 2 approach should be more appropriate.

Do we have sufficient data to derive specific emission factors?

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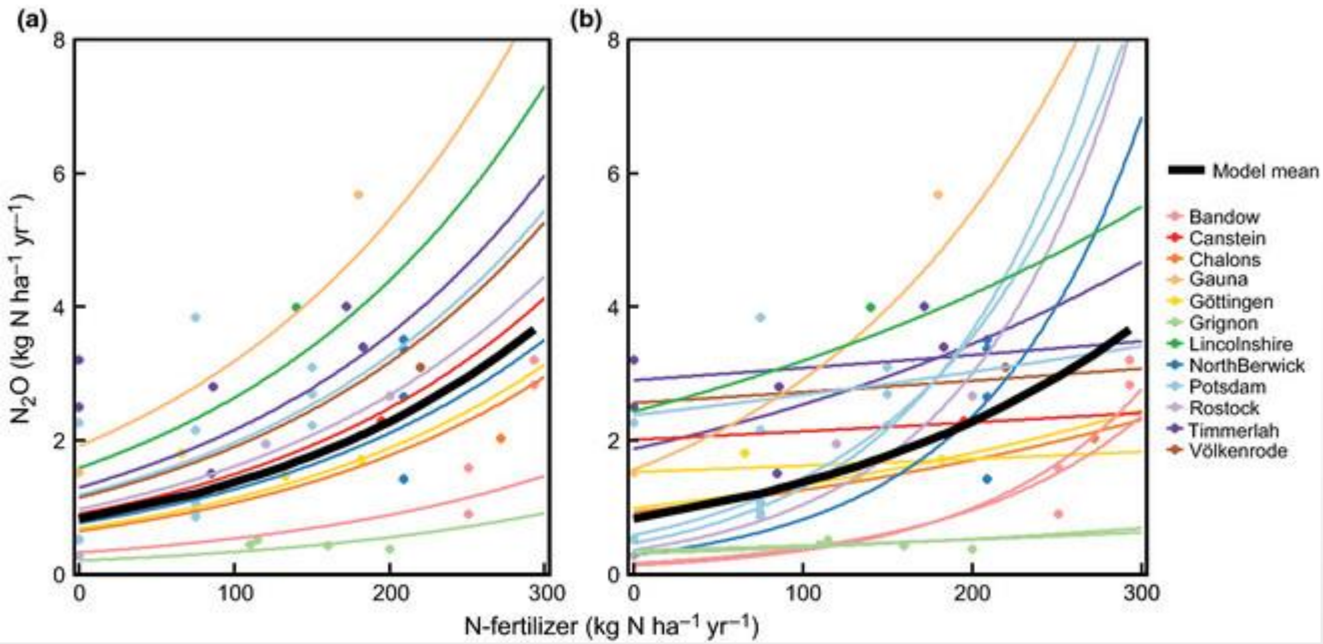
Published data – a meta analysis

Walter et al. (2015): Direct nitrous oxide emissions from **oilseed rape cropping** – a meta-analysis

→ 12 research sites, 43 annual data points



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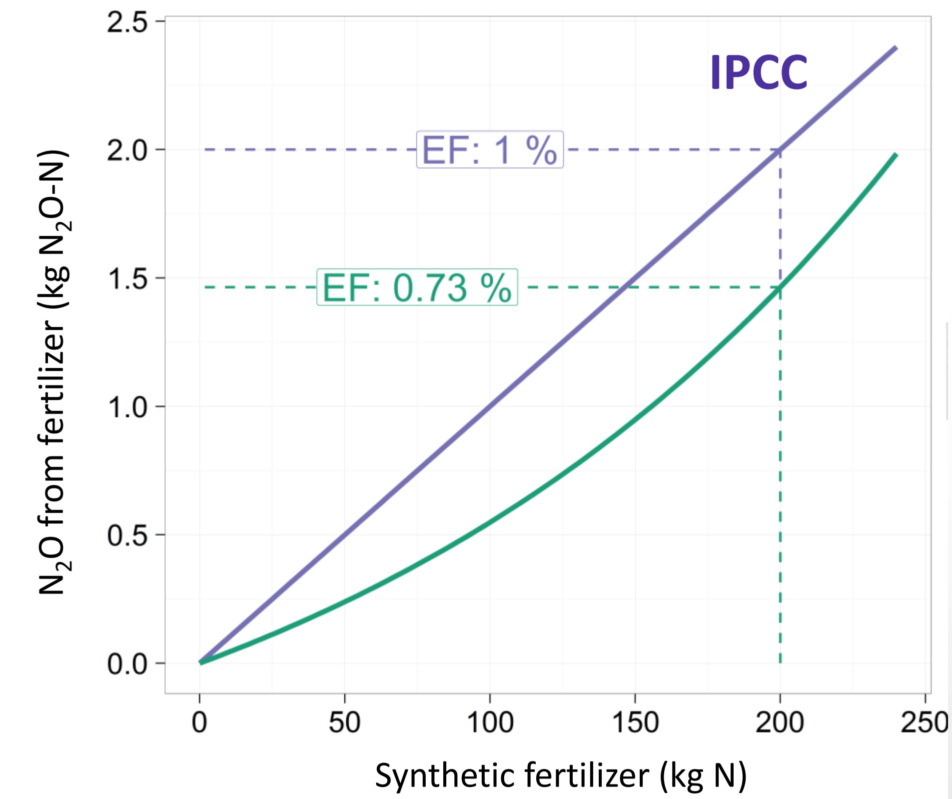
Published data – a meta analysis

Walter et al. (2015): Direct nitrous oxide emissions from oilseed rape cropping – a meta-analysis



→ N_2O emissions are lower than expected from IPCC.

→ Large variation and uncertainty.

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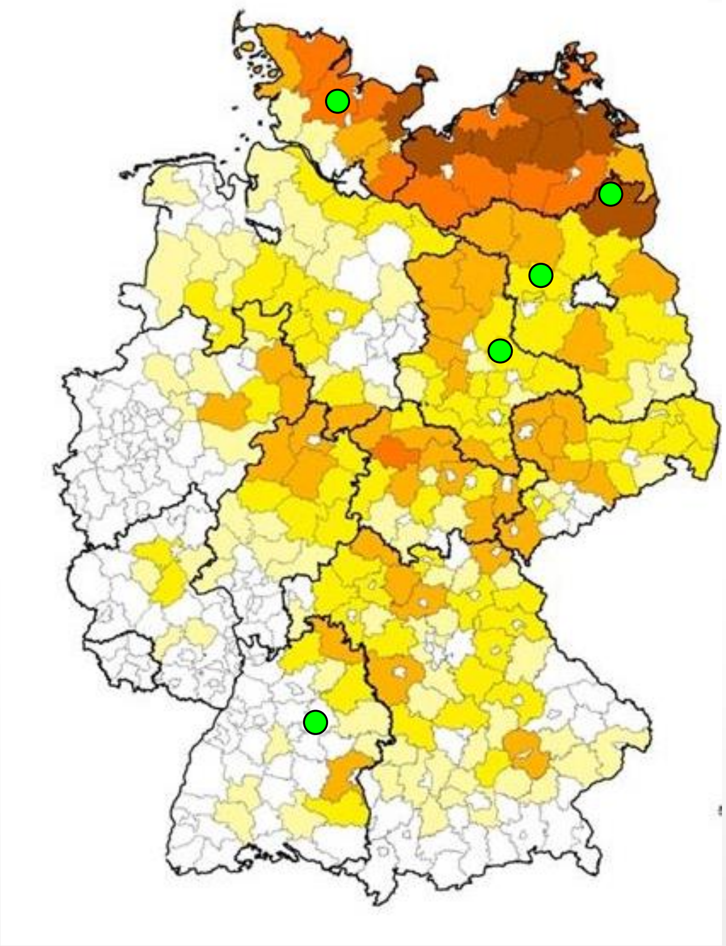
Project:
Mitigation of GHG emissions from OSR cultivation



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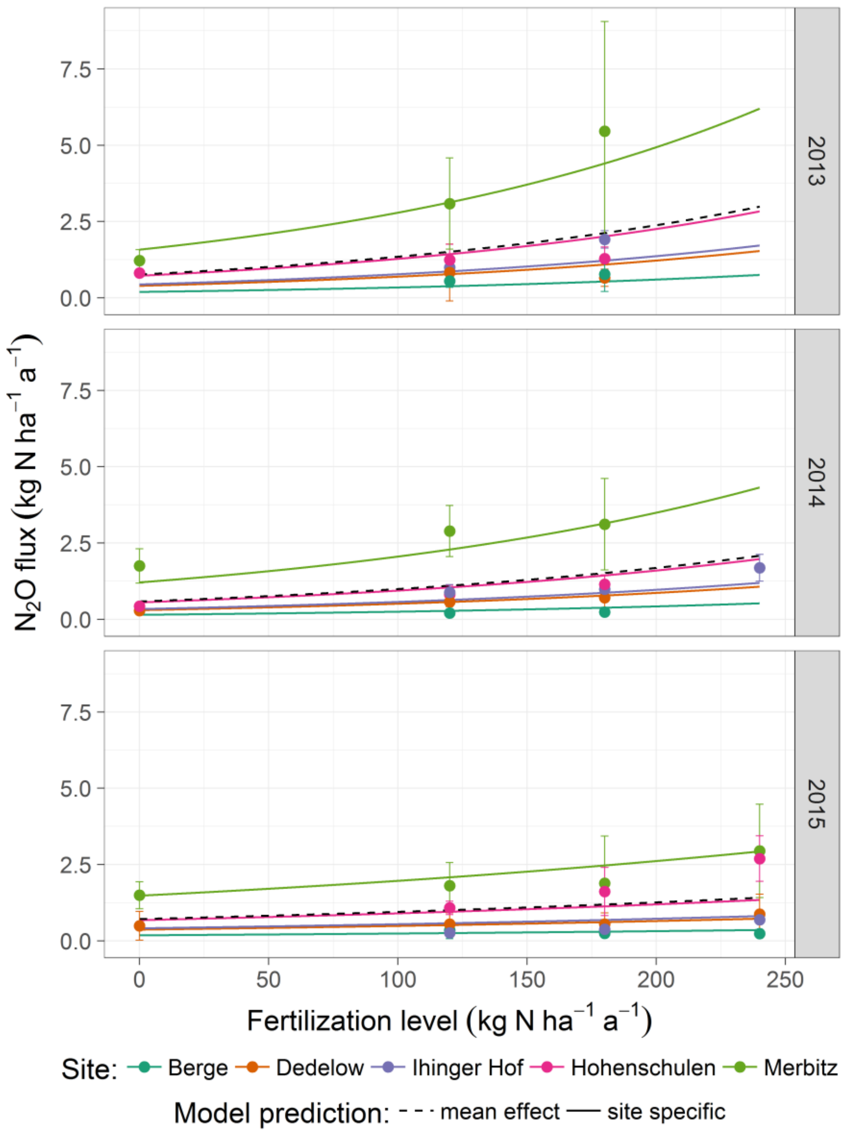
Results of OSR field experiments

- Strong effects of site and year
- Low to moderate emissions

→ Empiric exponential emission model from combined dataset (own + previously published)



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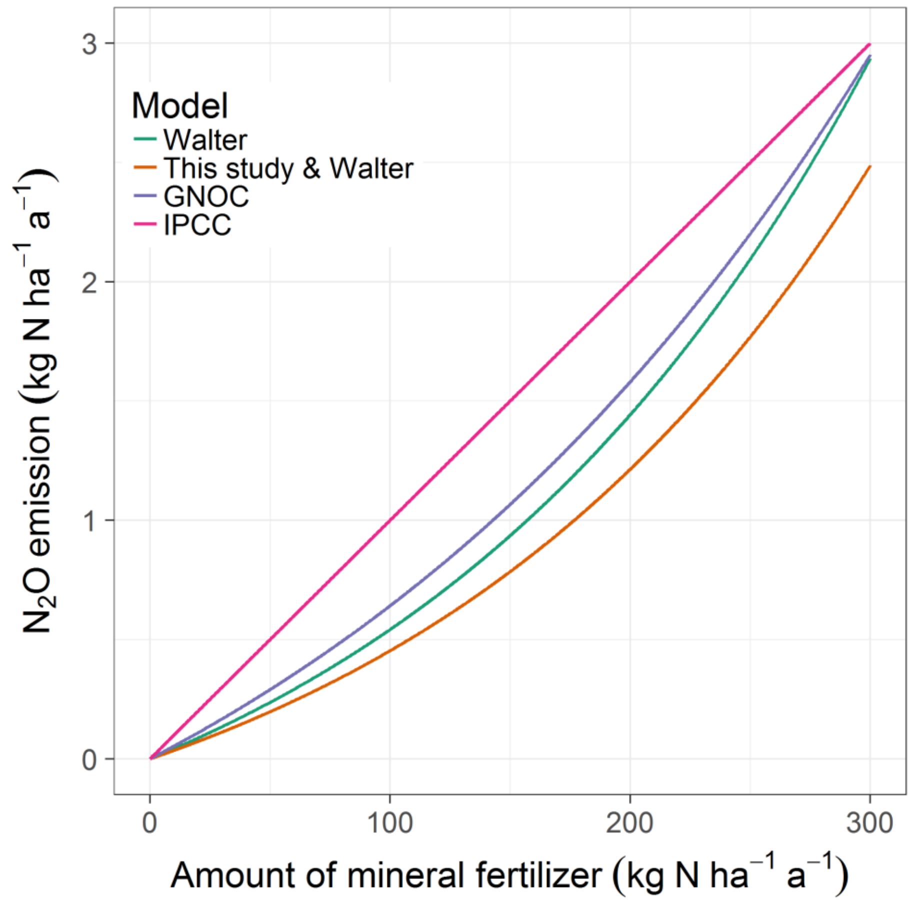
Result of OSR field experiments

→ Empiric exponential emission model for direct N_2O soil emissions from OSR cultivation

→ Emission factor not constant

→ For simplification emission factor at 200 kg N fertilization



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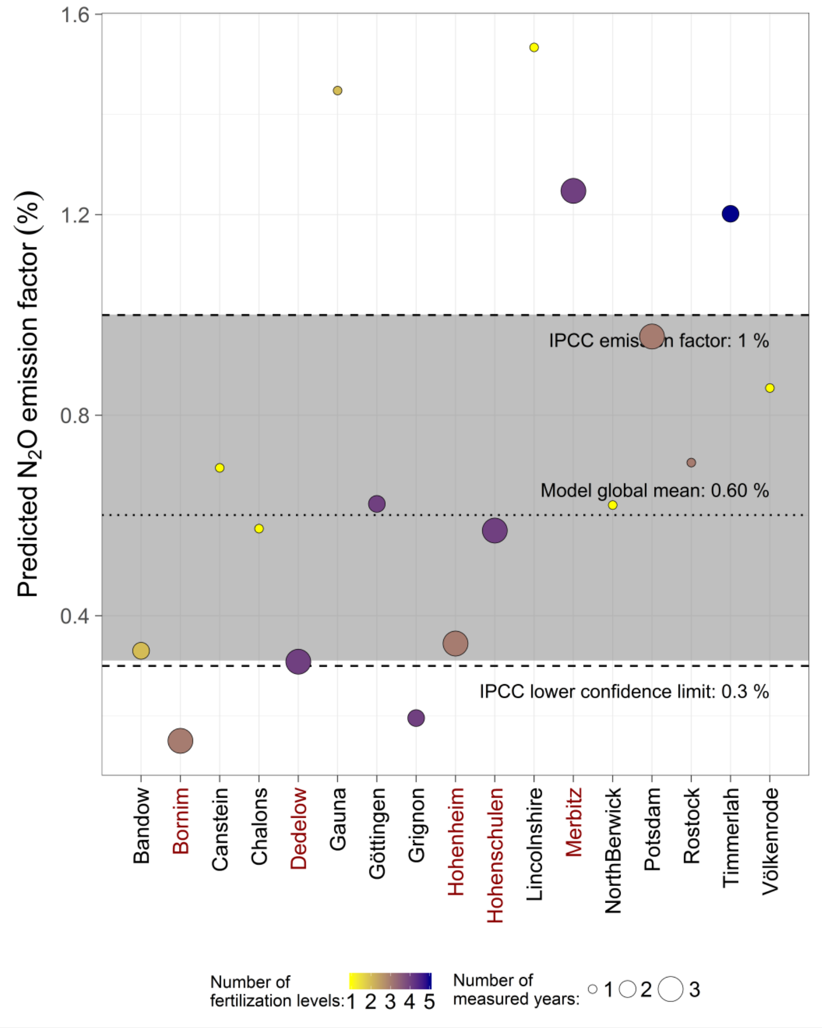
Result of OSR field experiments

Mean OSR emission factor:

$EF_{200} = 0.6$ %

(Confidence interval: 0.3 % – 1.0 %)



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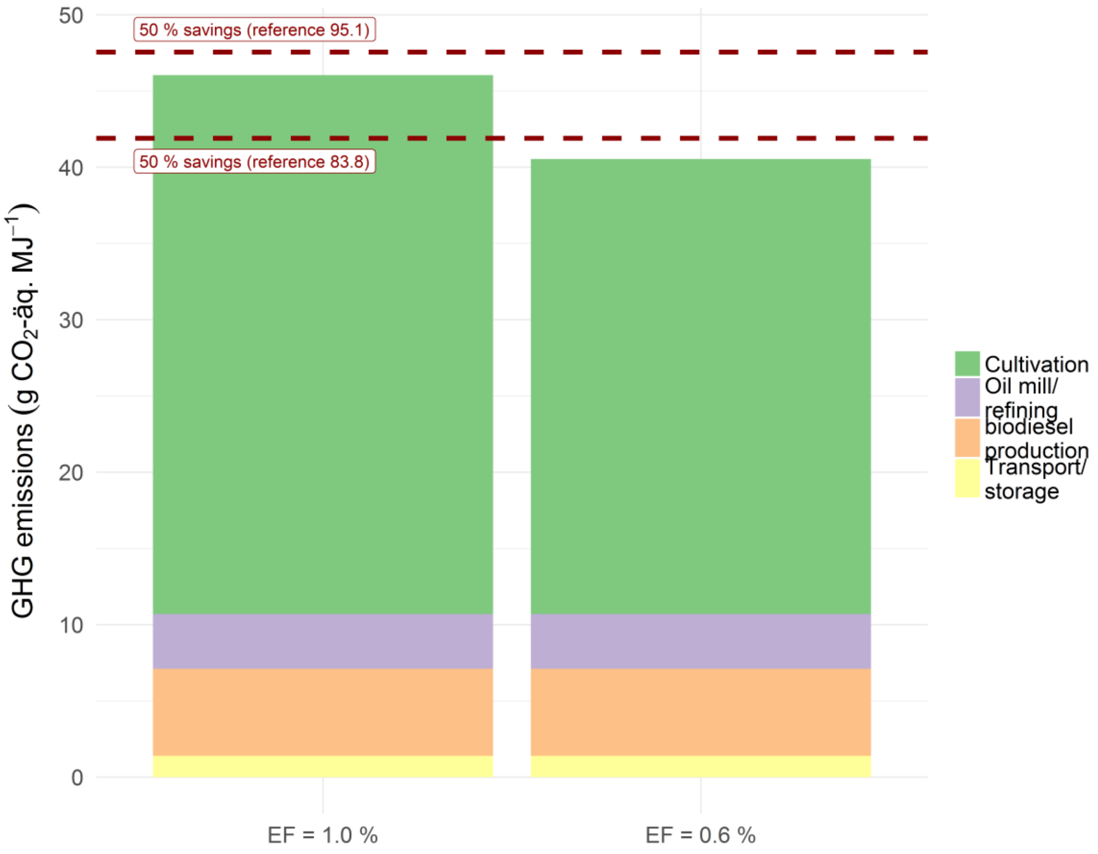
Consequence of lower emission factor



Input values same as NUTS2-defaults reported by Germany,

but assuming 185.5 kg N mineral fertilization.

Mitigation options for OSR cropping: Improve N use efficiency

- Recommended fertilization:

  c. 190 – 200 kg N

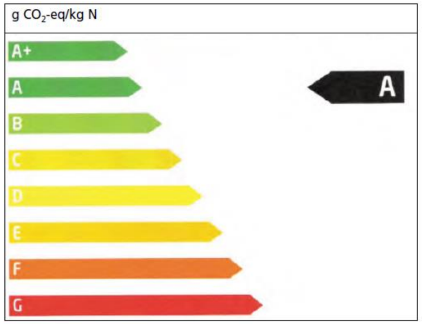
- Fertilization above 120 kg N did not significantly increase **oil** yield

→ Potential for reducing N fertilization

Study site	Year	N fertilization				
		kg N ha^{-1} a^{-1}				
		0	60	120	180	240
Berge	2013	1.17^{b}	1.29^{a,b}	1.38^{a,b}	1.38^{a,b}	1.72^{a}
	2014	1.63^{c}	1.92^{b,c}	2.28^{a,b}	2.42^{a}	2.56^{a}
	2015	0.97^{c}	1.50^{b}	1.74^{a}	1.87^{a}	1.85^{a}
	Mean	1.26	1.57	1.80	1.89	2.04
Dedelow	2013	2.36^{b}	2.62^{a}	2.73^{a}	2.79^{a}	2.78^{a}
	2014	2.43^{a}	2.56^{a}	2.67^{a}	2.74^{a}	2.71^{a}
	2015	1.97^{a}	2.09^{a}	2.10^{a}	2.05^{a}	2.13^{a}
	Mean	2.25	2.42	2.50	2.53	2.54
Ihinger Hof	2013	1.59^{b}	1.78^{a}	2.01^{a}	1.96^{a}	1.92^{a}
	2014	1.22^{c}	1.52^{b}	1.76^{a,b}	1.83^{a}	1.91^{a}
	2015	1.55^{c}	1.64^{b,c}	1.76^{a,b}	1.86^{a}	1.88^{a}
	Mean	1.45	1.65	1.84	1.88	1.90
Hohenschulen	2013	1.64^{b}	2.01^{a}	2.25^{a}	2.32^{a}	2.40^{a}
	2014	2.02^{a}	2.35^{a}	2.50^{a}	2.55^{a}	2.60^{a}
	2015	1.78^{c}	2.04^{a,b}	2.21^{a}	1.99^{b}	2.15^{a,b}
	Mean	1.81	2.13	2.32	2.29	2.38
Merbitz	2013	1.61^{b}	1.75^{a,b}	1.87^{a,b}	1.88^{a,b}	1.96^{a}
	2014	1.18^{d}	1.61^{c}	2.09^{b}	2.23^{b}	2.38^{a}
	2015	1.11^{b}	1.30^{b}	1.67^{a}	1.78^{a}	1.64^{a}
	Mean	1.30	1.55	1.88	1.96	2.00

Mitigation options for OSR cropping : Reduce emissions from fertilizer production

	Ecoinvent*	GABI**	Brentrup& Palliere***	Biograce	JRC-Report****
$(NH_4)_2SO_4$	2,8				
NH_4NO_3 (AN)	8,7	6,9	2,7 - 6,2		
KAS	8,8	7,4	2,8 - 6,3		
Harnstoff (HS)	3,4 (fragwürdig)	4,1	1,1 -1,6		
HS-AN		5,2	2,8 – 4,8		
$Ca(NO_3)_2$	4,0		3,6 – 9,6		
Generischer N-Dünger				5,9	4,0 (4,6 mit Bodenpuffer)



Source: Bauernblatt, 16th May 2015

Use of organic fertilizers avoids production emissions.

→ danger of increased N surplus / nitrate leaching / ammonia emissions

GHG footprint of fertilizer mix has improved. → update default values

A GHG certification system for fertilizers would enable incentives to farmers to use fertilizers with smaller GHG footprint.

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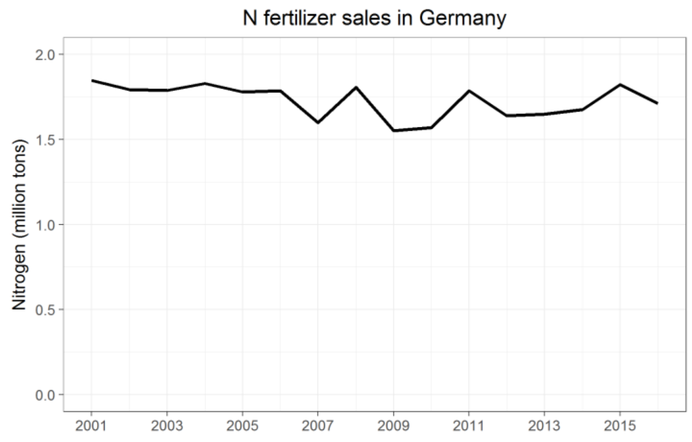
Environmental impact of fertilization with biogas digestate

Although fertilization with digestate has increased dramatically, we do not see reduction in fertilizer use.

→ additional direct N_2O from soils

→ danger of more N surplus and nitrate leaching



Can ammonia emissions be reduced?

Is the 1 % IPCC emission factor appropriate for digestate?

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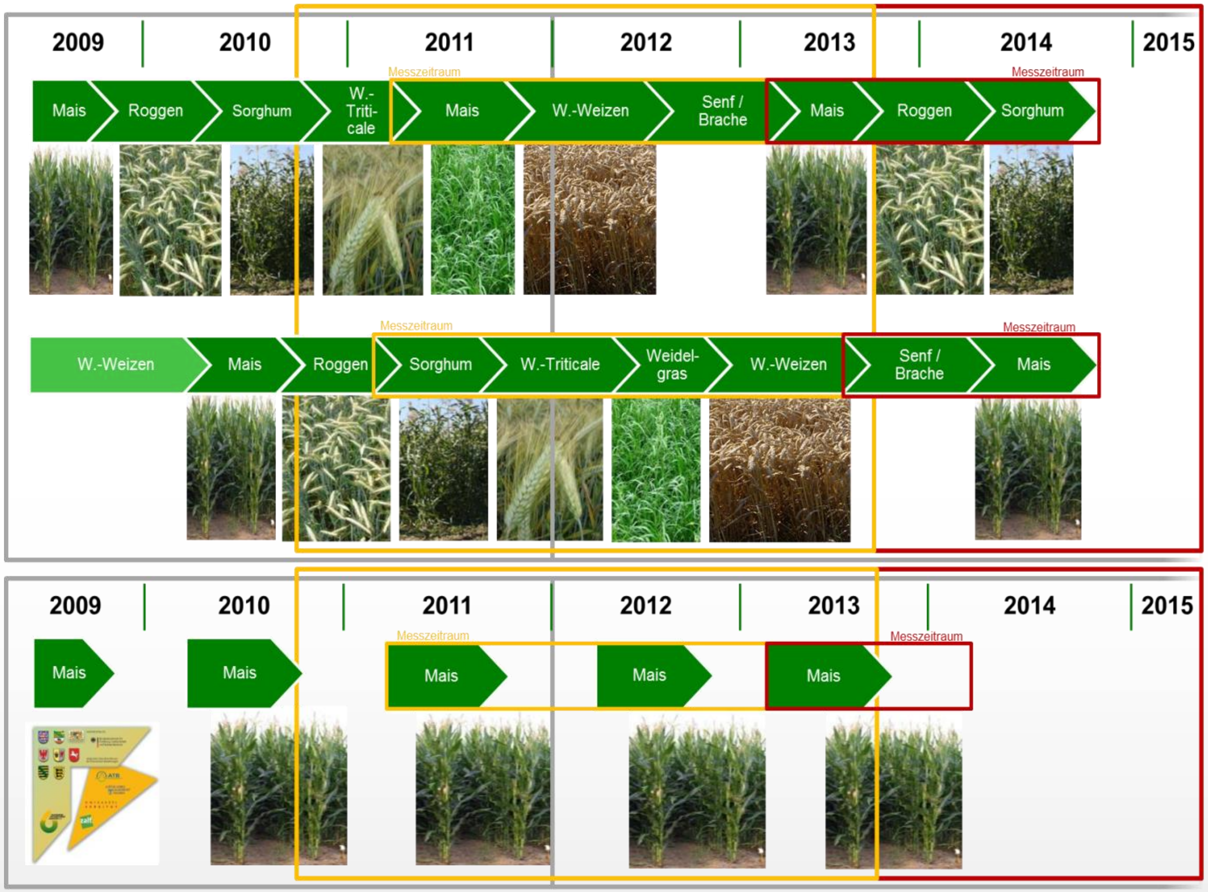
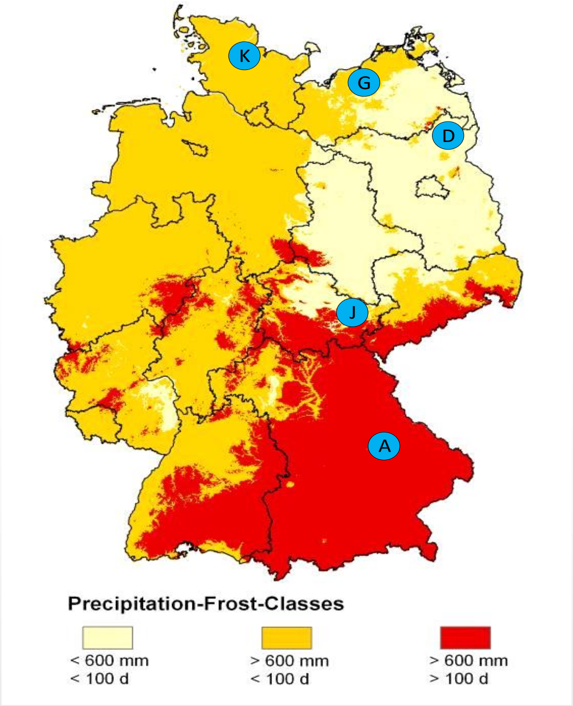
Project: Potentials for mitigation of GHGs during biogas cropping





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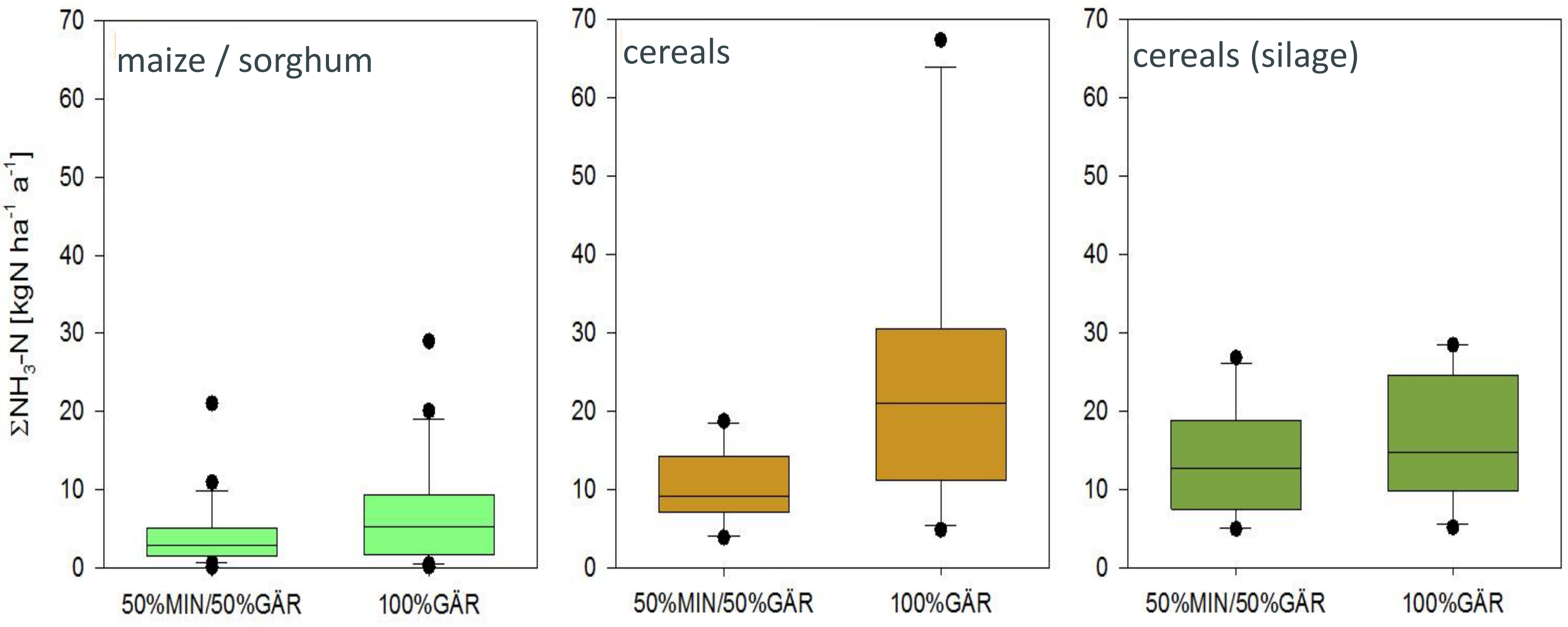
Ammonia emissions from fertilization with digestate

Strong impact of crop type → incorporation / type of application

Best mitigation option is fast incorporation.

New technical solutions for application in growing crops needed!



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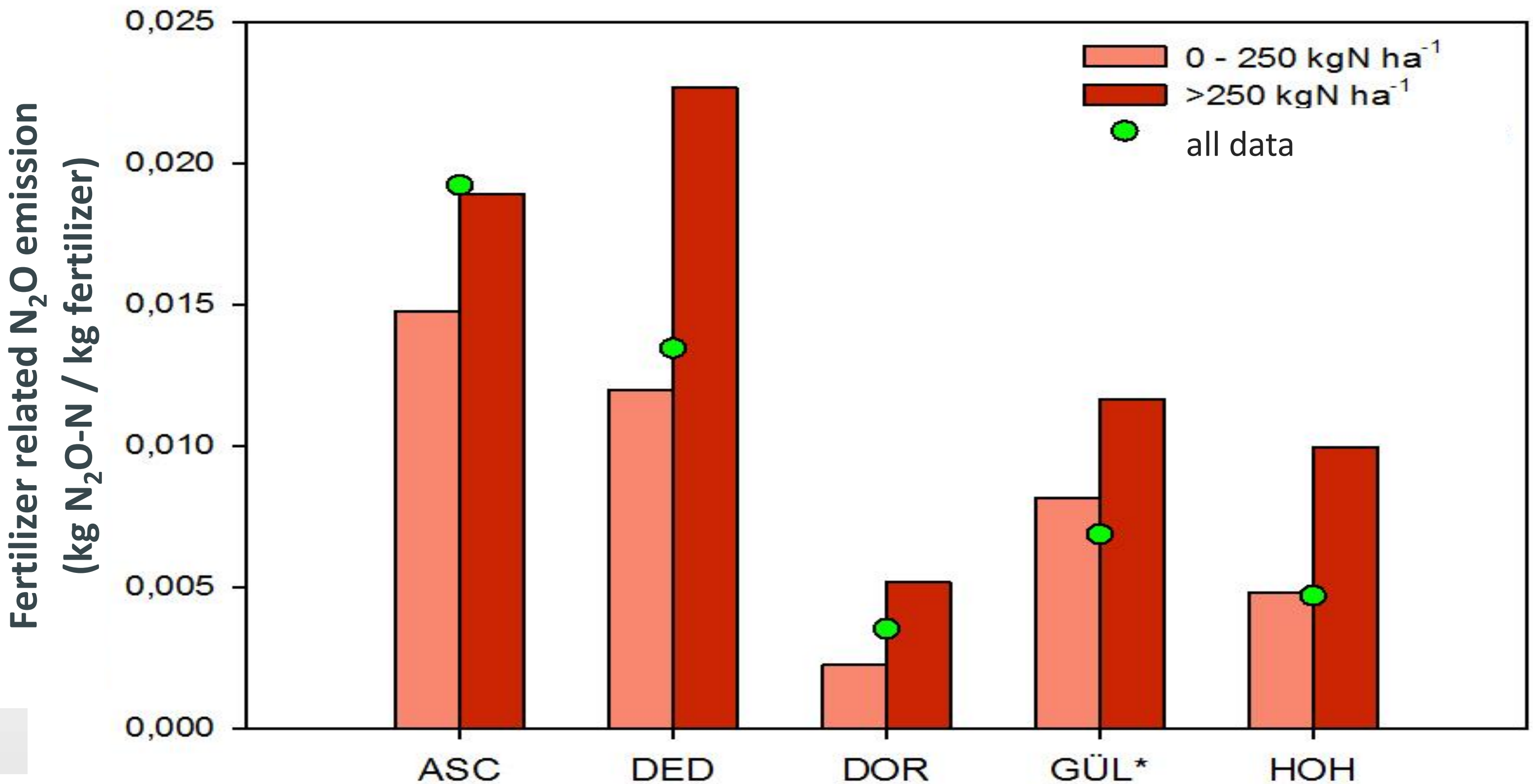
N_2O emissions from digestate application in maize

Strong variation between sites and years. Non-linearity was observed.

Magnitude of direct N_2O emissions as expected from IPCC.



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Mitigation options for biogas cropping: fertilization

Fertilization with digestate needs to be adapted to plant needs. Use of synthetic fertilizers needs to be reduced correspondingly.

→ Otherwise, danger of increased nitrate leaching.

Nitrification inhibitors reduce N_2O emissions (after incorporation) but can increase N surplus.

Technical solutions are needed to reduce ammonia emissions from application of digestate (and other organic fertilizers) into growing crops.

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Thank you for your attention!

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