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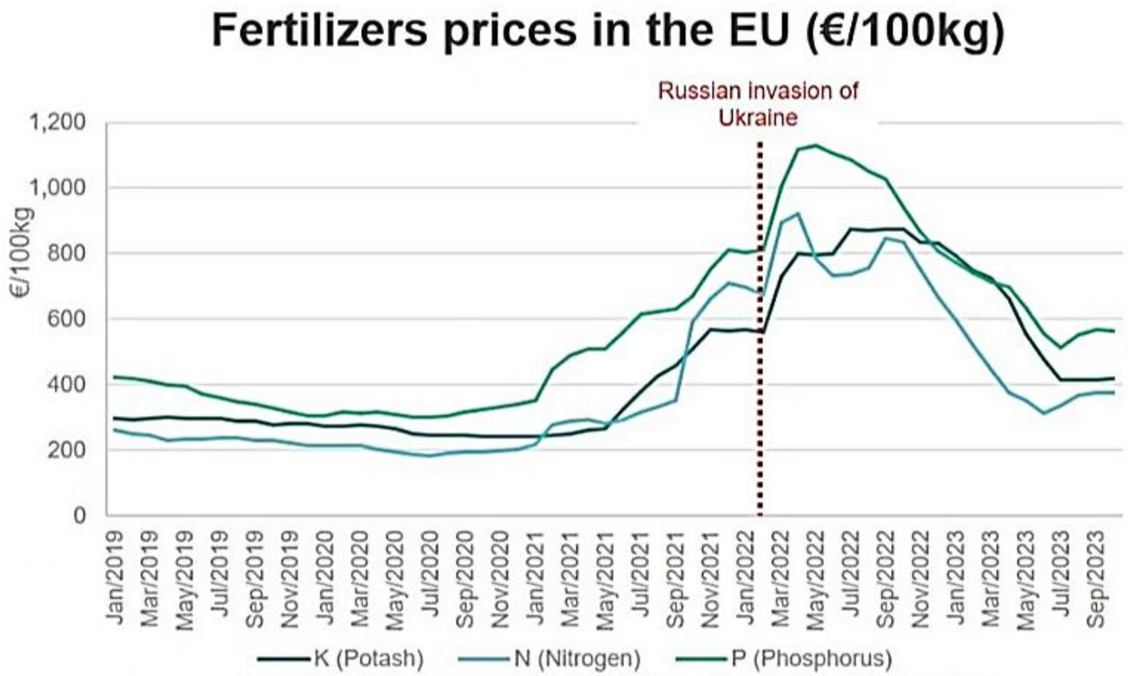
European Commission

Quantifying the impact of an abrupt reduction in mineral nitrogen fertiliser use on EU crop yields

Meeting of the EU Fertilisers Market Observatory

19 March 2024

Context



Sources: Market observatories, European Commission

- High fertiliser prices
- Concerns with fertiliser availability
- Food purchasing power under pressure in EU and globally
- Will farmers apply sufficient fertilisers to their crops?
- Communication from the Commission on *Ensuring availability and affordability of fertilisers*
- … against a back-ground of long-term goal to improve fertiliser use efficiency (e.g. F2F).

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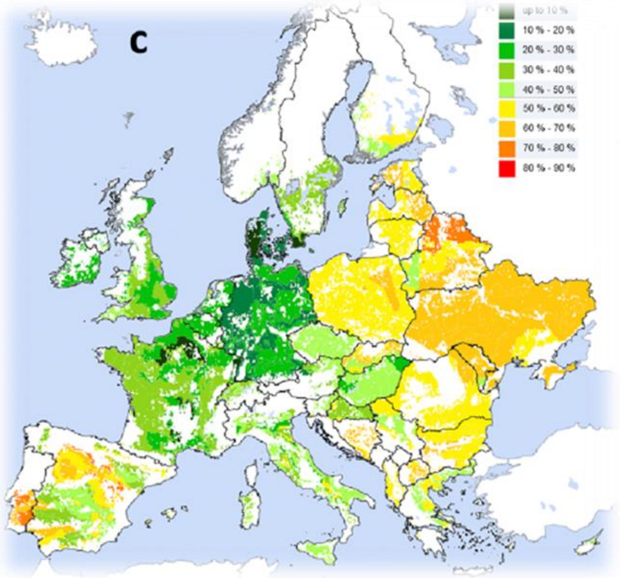
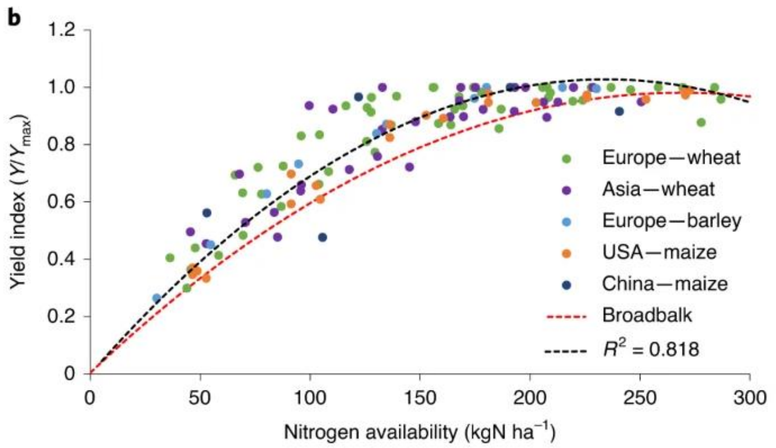
Context

Yield gaps



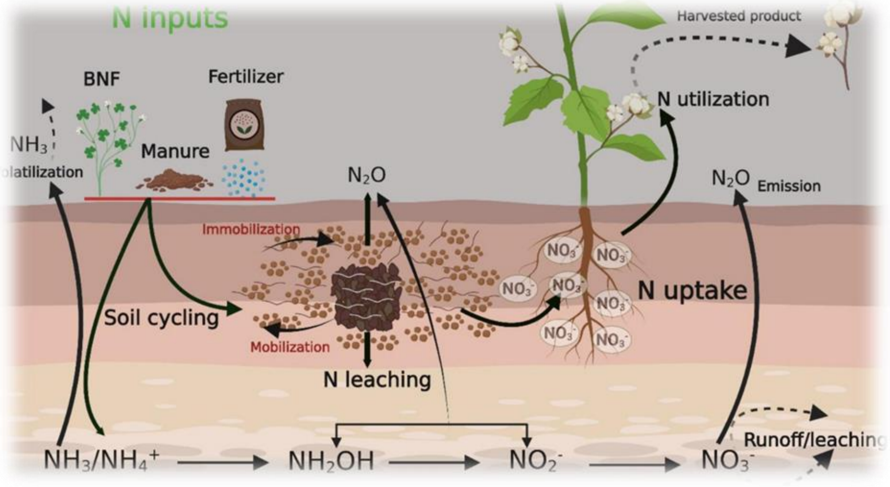
Wheat (% of yield potential)
René Schils et., 2018

Non linearity



Nitrogen response data for wheat, barley and maize trials
Hans J. M. van Grinsven et al., 2022

Soil buffer capacity

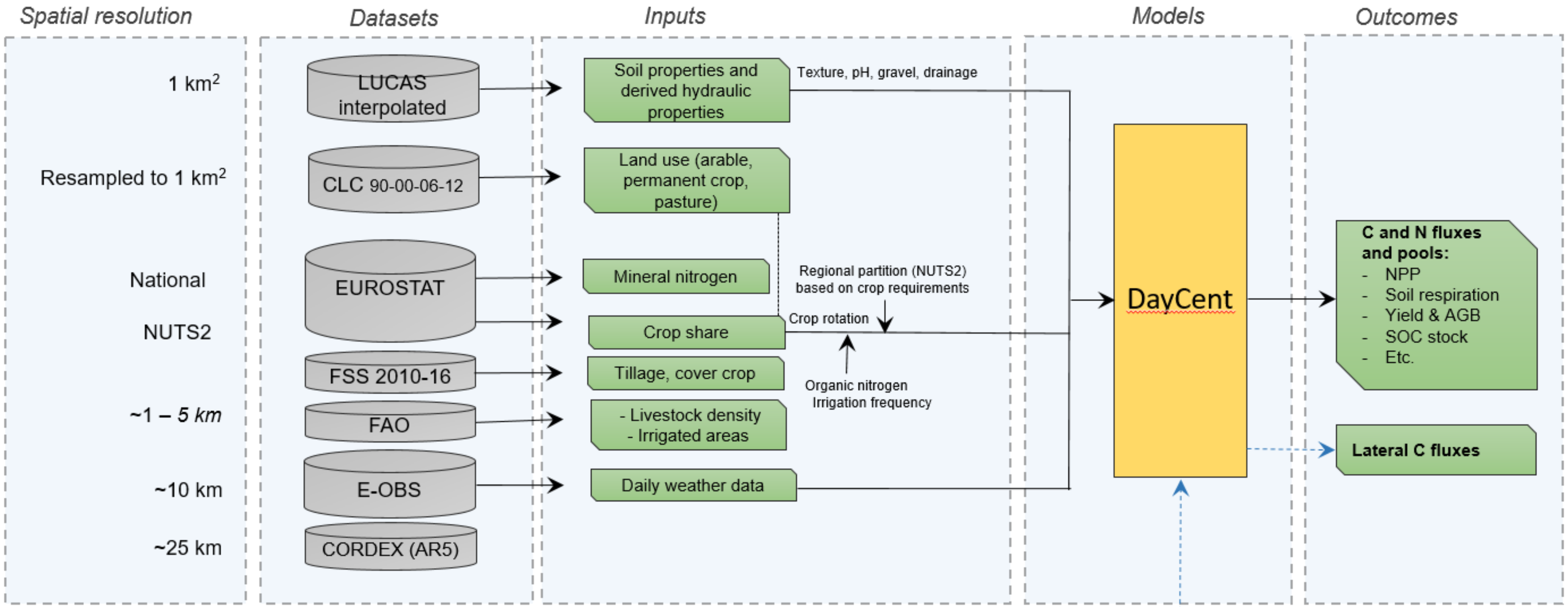


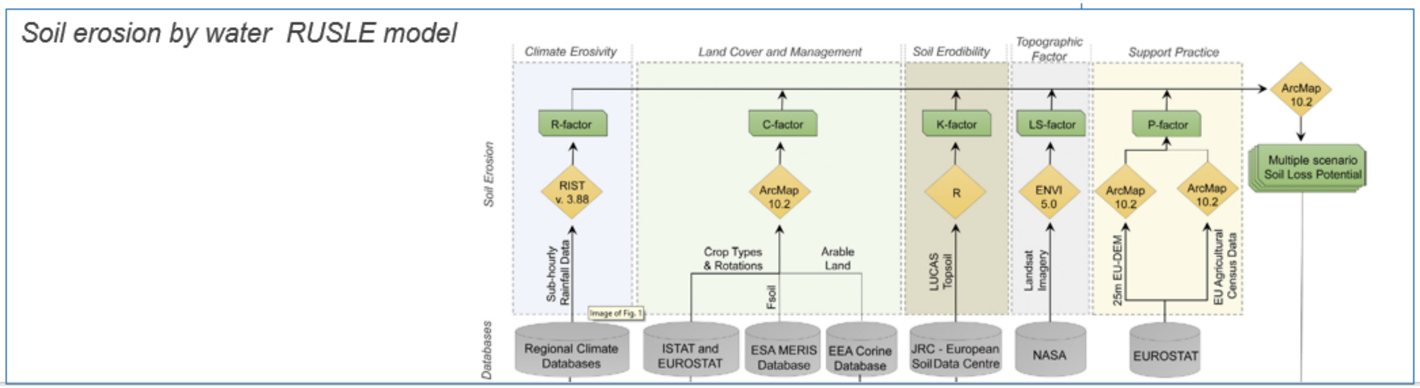
From Chattha et al., 2022
The figure created with Biorender (https://biorender.com/).

Objective of this study: To assess the impacts of reductions in N-fertiliser use on yields of the main staple crops at the EU level.

Methods

DAYCENT MODEL: a state-of-the-art data-rich process-based biogeochemical modelling platform that **simulates C and N flows** within the soil and between soil, atmosphere and vegetation, with **daily time steps**.





Methods

DAYCENT MODEL: a state-of-the-art data-rich process-based biogeochemical modelling platform that **simulates C and N flows** within the soil and between soil, atmosphere and vegetation, with **daily time steps**.

- **Mineral N fertilizer**: 30% at planting + 70% at standing crops
- Each mineral N fertilization: 75% NH_4 and 25% NO_3
- Organic fertilization: applied generally after harvest or on standing crop in highly demanding crops such as maize. Maximum organic N rate: 170 kg/ha per year
- Mineral N fertiliser use is crop specific, partitioned from national-level EUROSTAT statistics (until 2020) on N use, according to crop requirements
- Spatial allocation of crops is based on EUROSTAT statistics, but only the 4 most representative annual crops at regional level (NUTS2) are simulated in the model framework

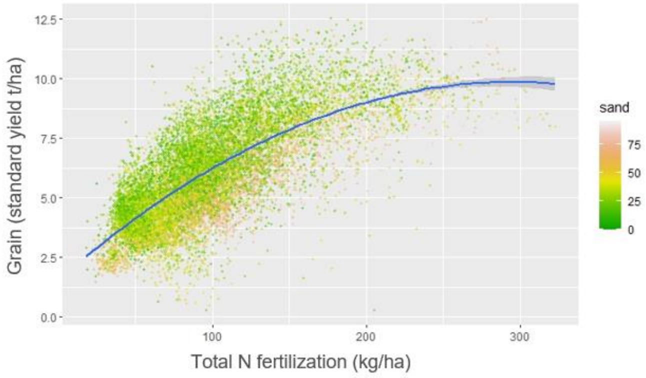
Methods

General appraoch:

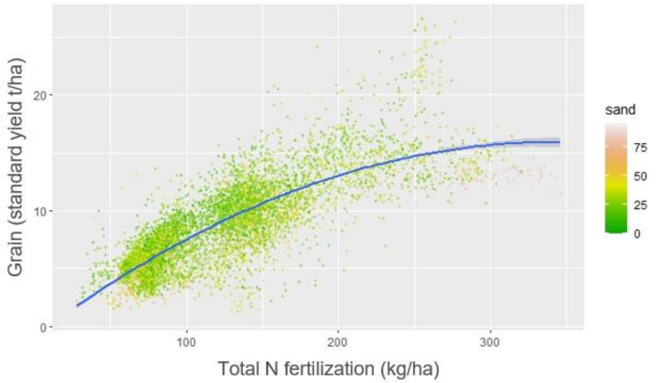
- Three scenarios of abrupt reduction of mineral N fertiliser use (2019-2022) across the EU: -5%, -15% -25% compared with baseline.
- Everything else is assumed to remain equal,
    - same crops,
    - same amounts of organic N-fertiliser use
- Effects simulated with DayCent biogeochemical model, at 1x1 km resolution
- Results aggregated per crop type at NUTS2, national and EU level

Model validation

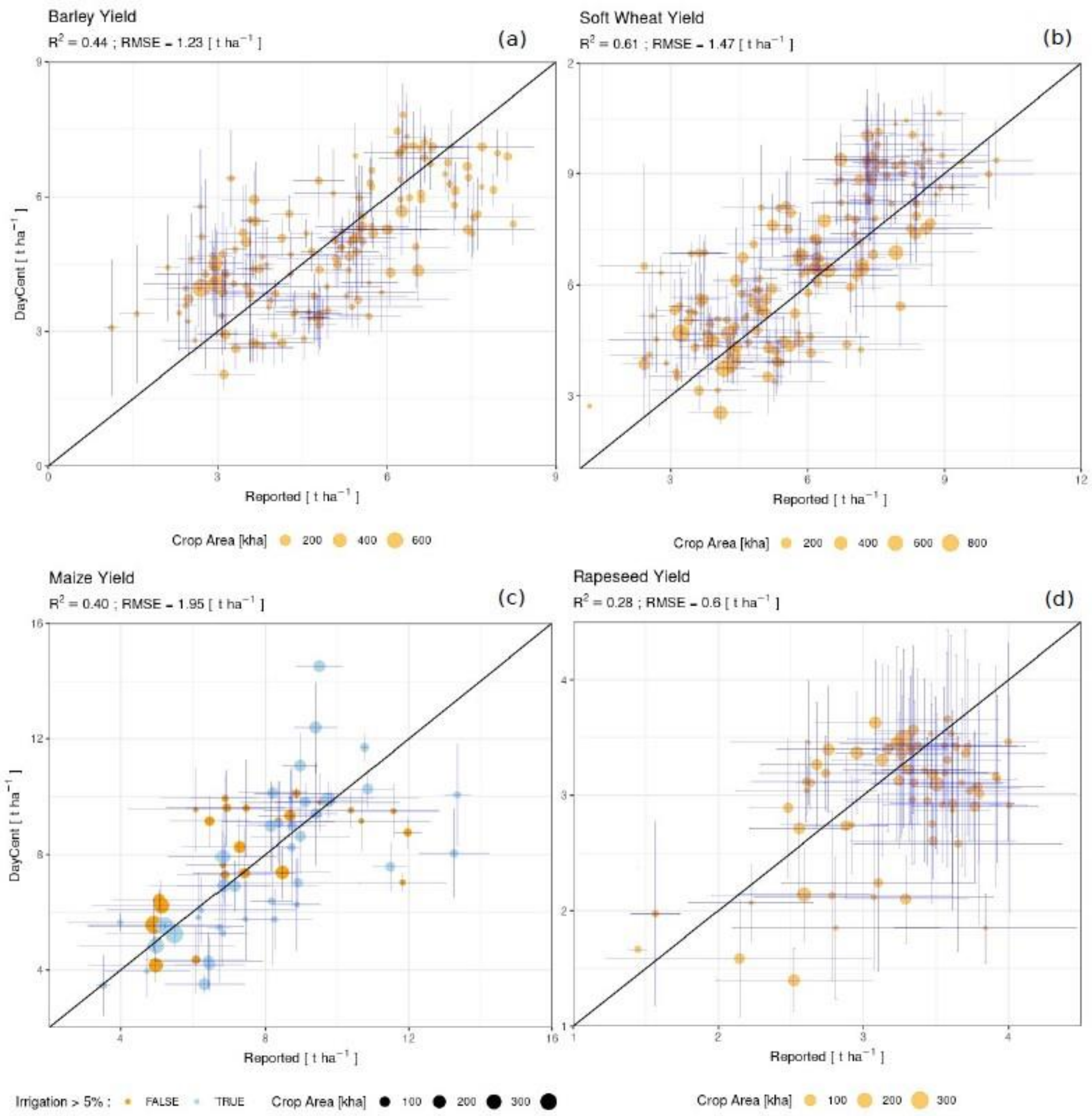
Common wheat



Grain maize



Modelled crop response to N



Simulated yields vs EUROSTAT data

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Results – crop yield reduction at EU27 level

	Reduction of N-fertiliser use					
	5%		15%		25%	
Impacts calculated for	Year 1	Average year 1-4	Year 1	Average year 1-4	Year 1	Average year 1-4
Barley	1.5	1.9	4.4	5.8	7.4	9.8
Soft wheat	1.6	2.1	5.0	6.4	8.5	10.8
Durum wheat	1.4	1.7	4.1	5.2	6.7	8.7
Green maize	1.6	1.6	5.1	5.1	8.8	8.8
Grain maize	1.7	1.7	5.2	5.3	8.6	8.8
Rapeseed	1.4	1.8	4.2	5.4	7.0	8.9
Field beans and peas	0.0	0.0	0.0	0.1	0.1	0.1
Potatoes	1.3	1.4	3.7	4.3	6.1	7.1
Rye	1.1	1.6	3.6	5.1	5.7	8.3
Soybeans	0.0	0.0	0.0	0.0	0.0	0.0
Sugar beet	1.6	1.9	4.9	5.6	8.2	9.4
Sunflowers	0.7	0.9	2.2	2.8	3.7	4.8
Rice	1.9	2.0	6.0	6.4	10.4	11.2
Grassland	0.5	0.6	1.4	1.8	2.3	3.0

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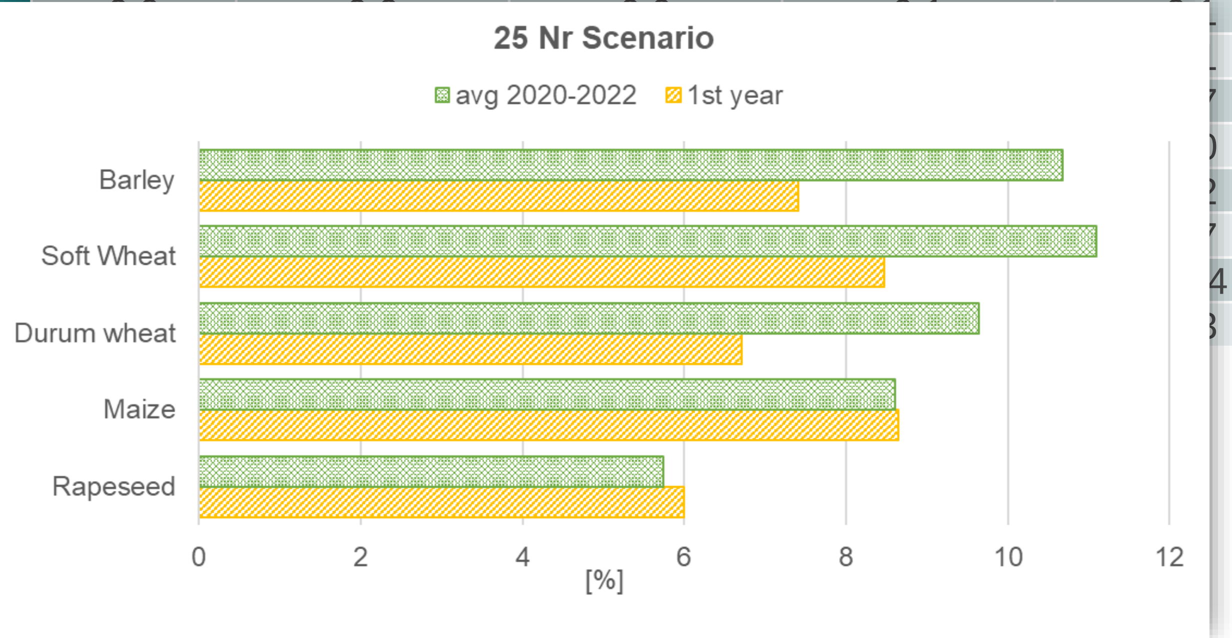
Rapeseed	1.4	1.8	4.2	5.4	7.0	8.9
Field beans and peas	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.1
Potatoes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1
Rye	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.3
Soybeans	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0
Sugar beet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.4
Sunflowers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.8
Rice	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.2
Grassland	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0



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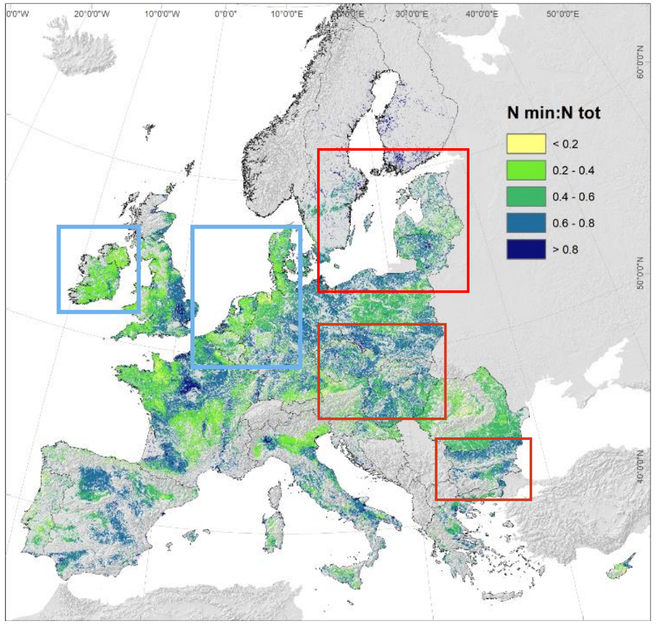
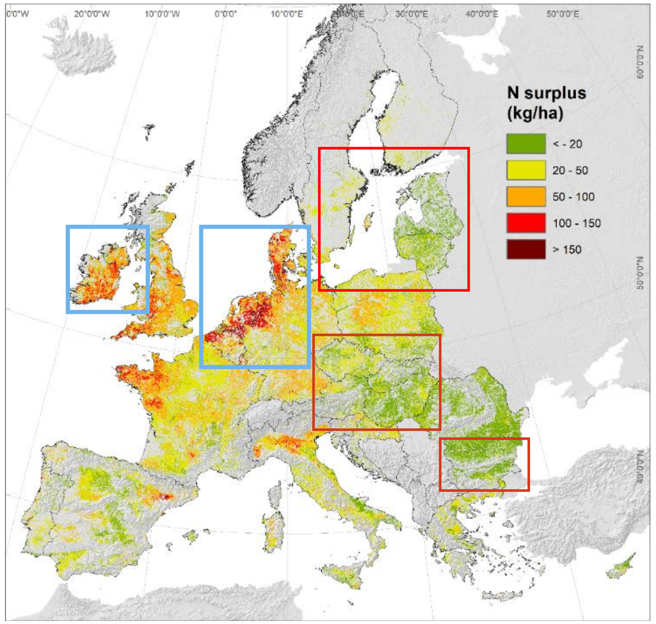
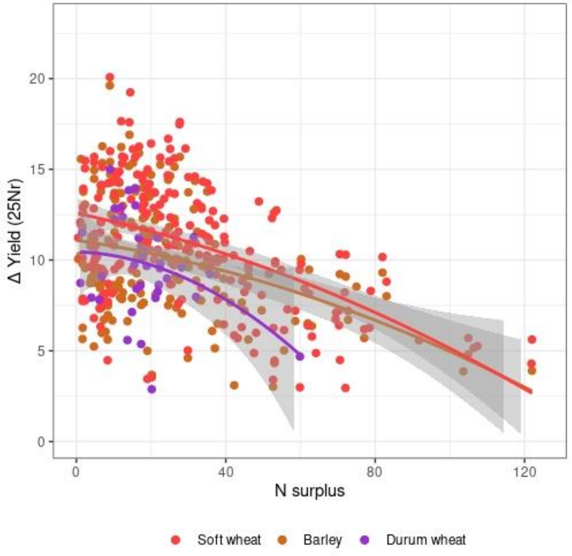
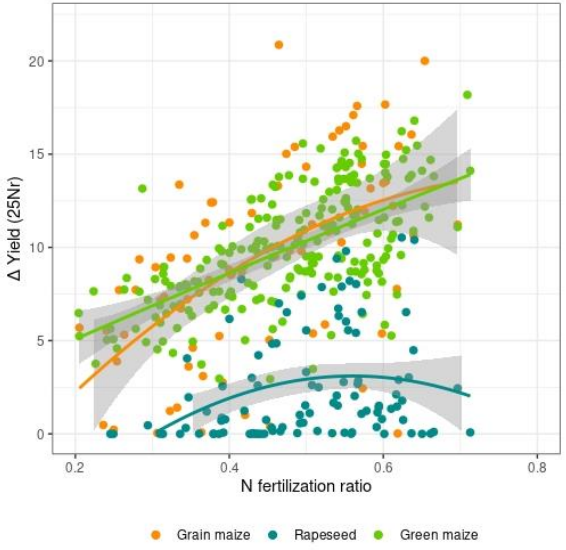
Results

Yield reduction impacts are correlated with N surplus and Nmin/Ntot









Absolute yield reduction compared to baseline

share of N mineral		**surplus**
high		low
low	**variable**	low
high		high
low		high

sensitivity

higher

Expected yield losses

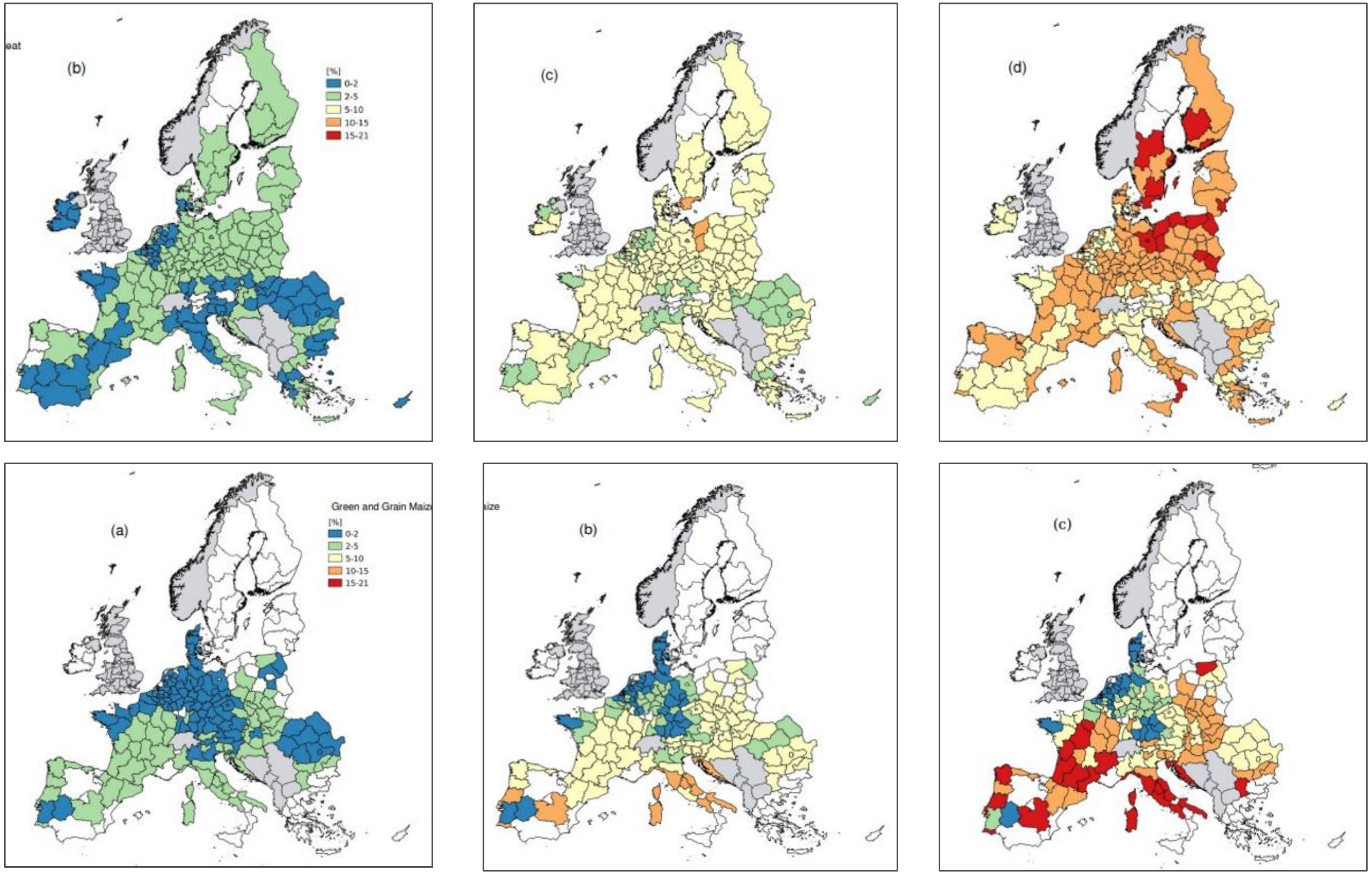
lower

Results:

Yield reductions for reduction of mineral N-fertilizer input by 5, 15 and 25 %.

Soft and durum wheat

Grain and green maize



-5% mineral N **-15% mineral N** **-25% mineral N**

Discussion & conclusions

- Overall, our modelling study indicates similar order of yield response as reported in literature:

  %Yield loss = approximately 1/3 of %N-reduction

  (i.e. crop yield losses in the range of 1-2% with 5% reduction of Nmin fertilizers; ca. 5% yield loss with 15% Nmin reduction).

  however, with substantial variation among regions and crop types.

- Important factors that determine such variation include (1) current surplus use of N fertilisers; (2) share of organic N fertilisers; (3) genetically determined crop N demand; (4) crop calendars; (5) inter-annual weather variations. Most of these factors are represented in the model.

- Yield reductions tend to increase if N use is reduced for multiple years, due to depletion of mineral N and (more gradually) of soil organic matter.

Limitations and potential for follow-up

- This is a study with simple what-if scenarios, not a prediction. Future weather data are unknown.
- Difficult to find data for comprehensive validation.
- Not all feedback mechanisms are included (e.g. if lower availability of feed results in less livestock production there will also be less manure).
- Potential to assess longer-term scenarios with adaptation (e.g. shift to different crops, more efficient N use, use of alternative nutrient sources)
- Publication in scientific journal

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Thank you

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