Mineral fertilizer, climate effects and options for improvement

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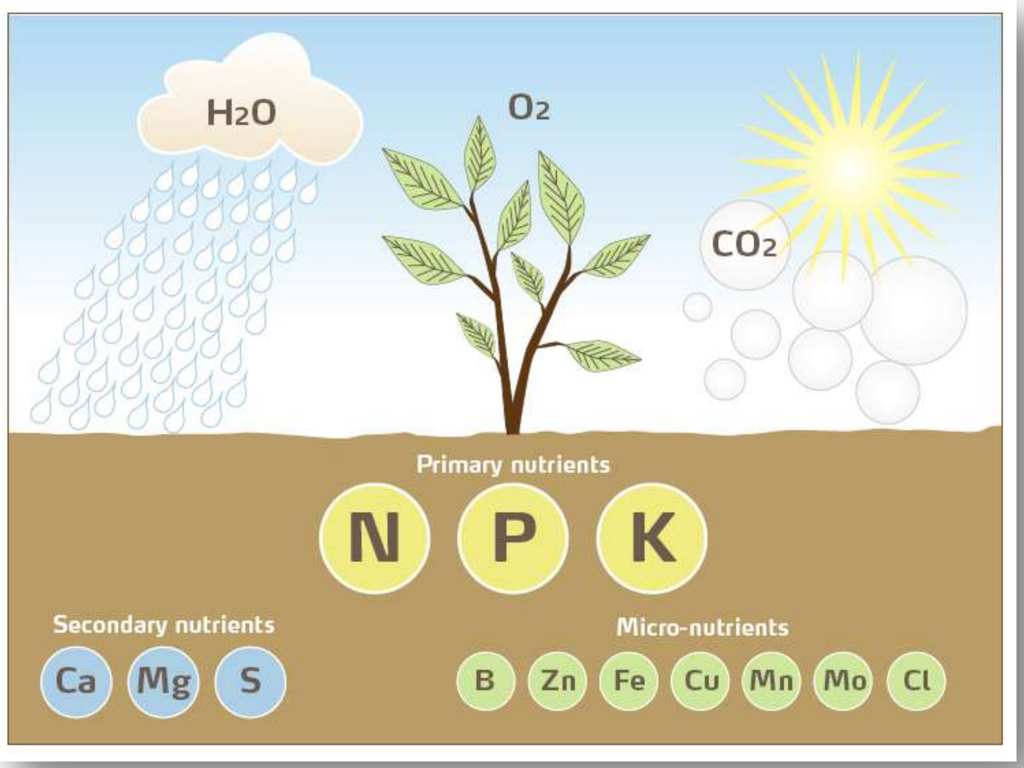
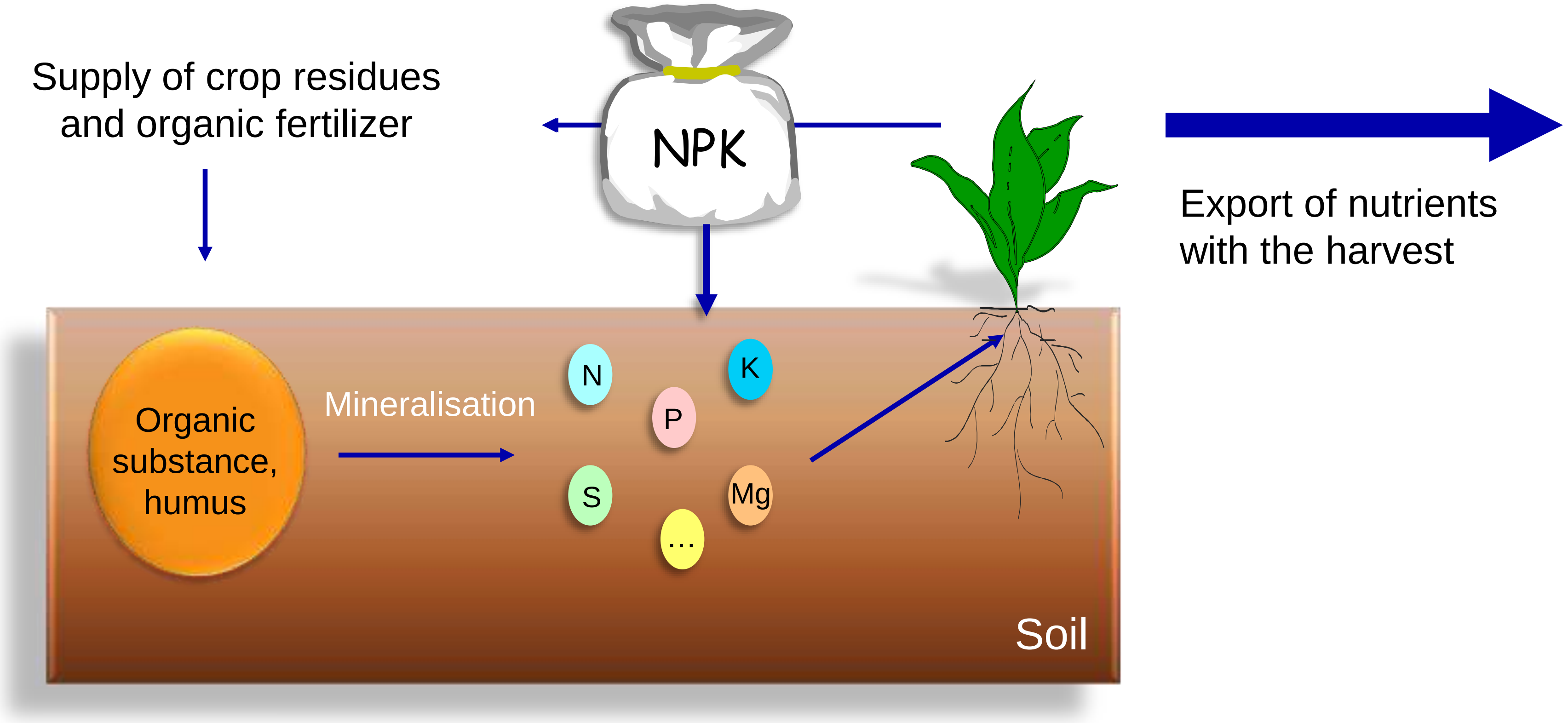
Crops need mineral nutrients to grow

Crops absorb mineral nutrients and water from the soil



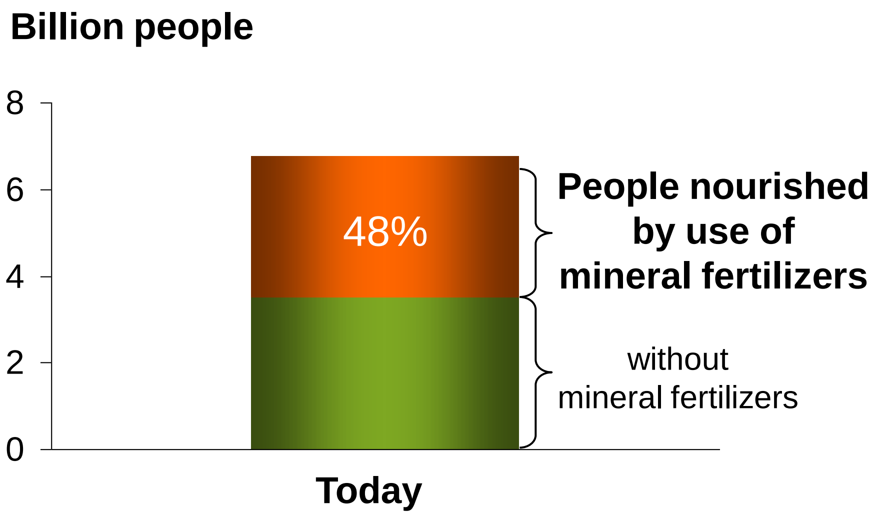
Mineral nutrients are essential building blocks for crops

Mineral fertilizers replace the nutrients that are exported with the harvest



The soil is depleted without mineral fertilizers

Mineral fertilizers are needed

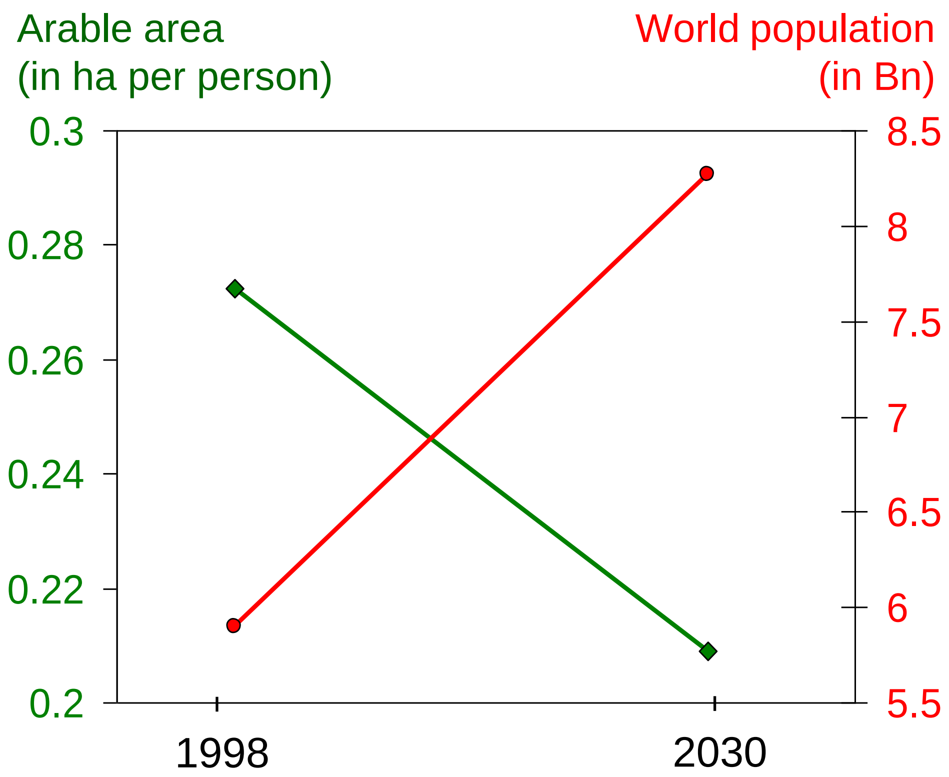


Source: adopted from Erisman et al. (2008), Nature Geoscience

without fertilizer with fertilizer

Today, nearly 50% of the world's population is nourished from the use of mineral fertilizers

More people – Less arable land



We must produce more food per hectar

Environmental effects of N fertilizer use

Benefits

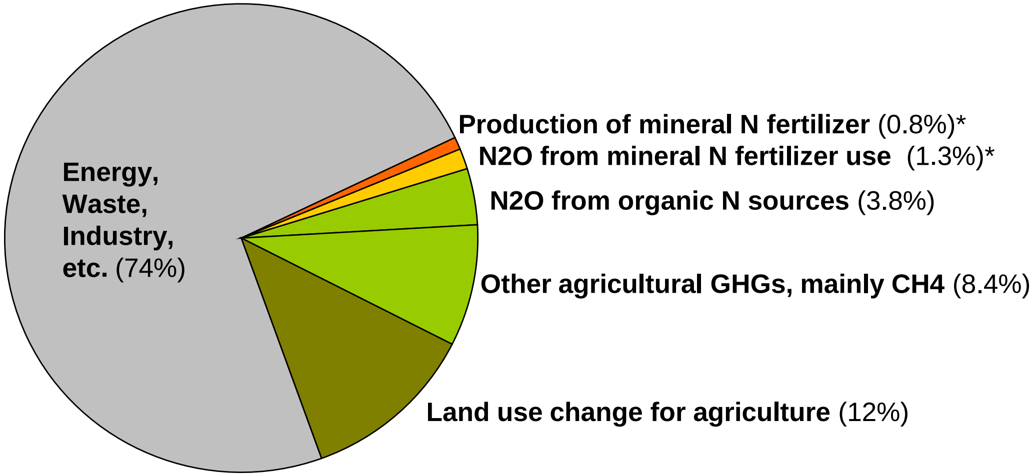
- Increased biomass production
  - Food, Feed, Energy
- Potential for land preservation
  - Efficient land use
- Carbon fixation

Impacts

- Eutrophication
  - Nitrate leaching
  - Ammonia volatilisation
- Off-site acidification
  - Ammonia volatilisaton
- Global warming
  - CO2 emissions
  - N2O emissions

Climate gas emissions

GLOBAL
= 49 bn t CO_2eq
(agriculture contributes 26%)



Based on IPCC (2007), Bellarby et al. (2008), *EFMA calculation

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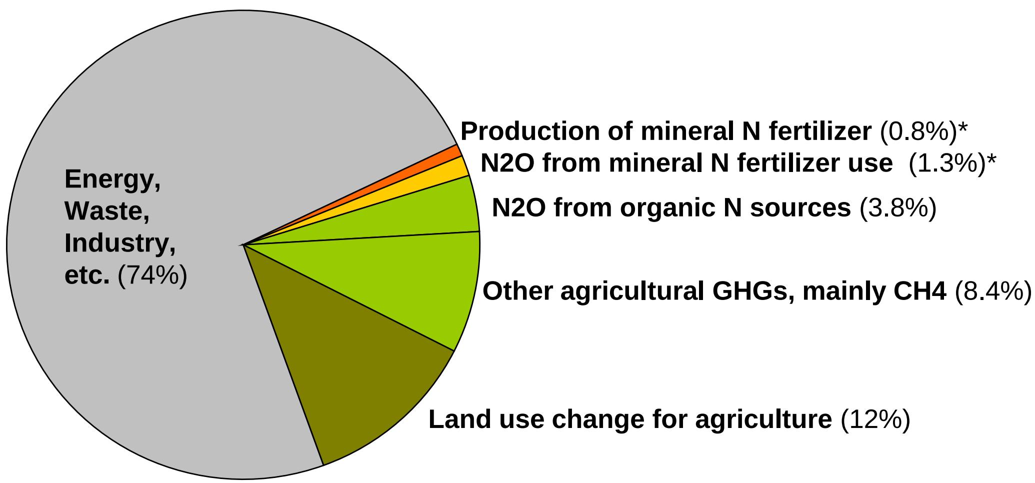
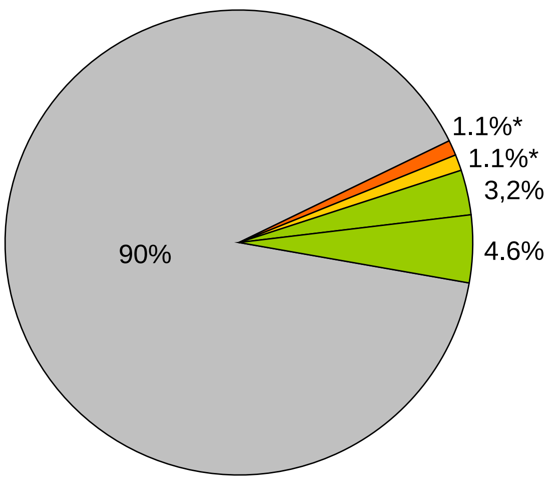


Based on IPCC (2007), Bellarby et al. (2008), *EFMA calculation

EU-27
= 5 bn t CO_2eq
(agriculture contributes 9%)



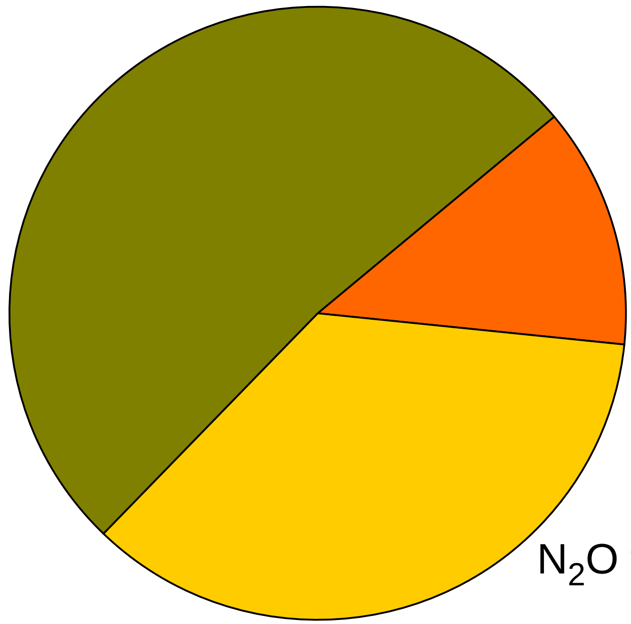
Based on UNFCCC (2008), * EFMA calculation

Emission from land use change is large, but not in Europe

Less intensified agriculture in Europe → more deforestation → more emission

Sources of agricultural GHG emissions (EU-27, 2005)

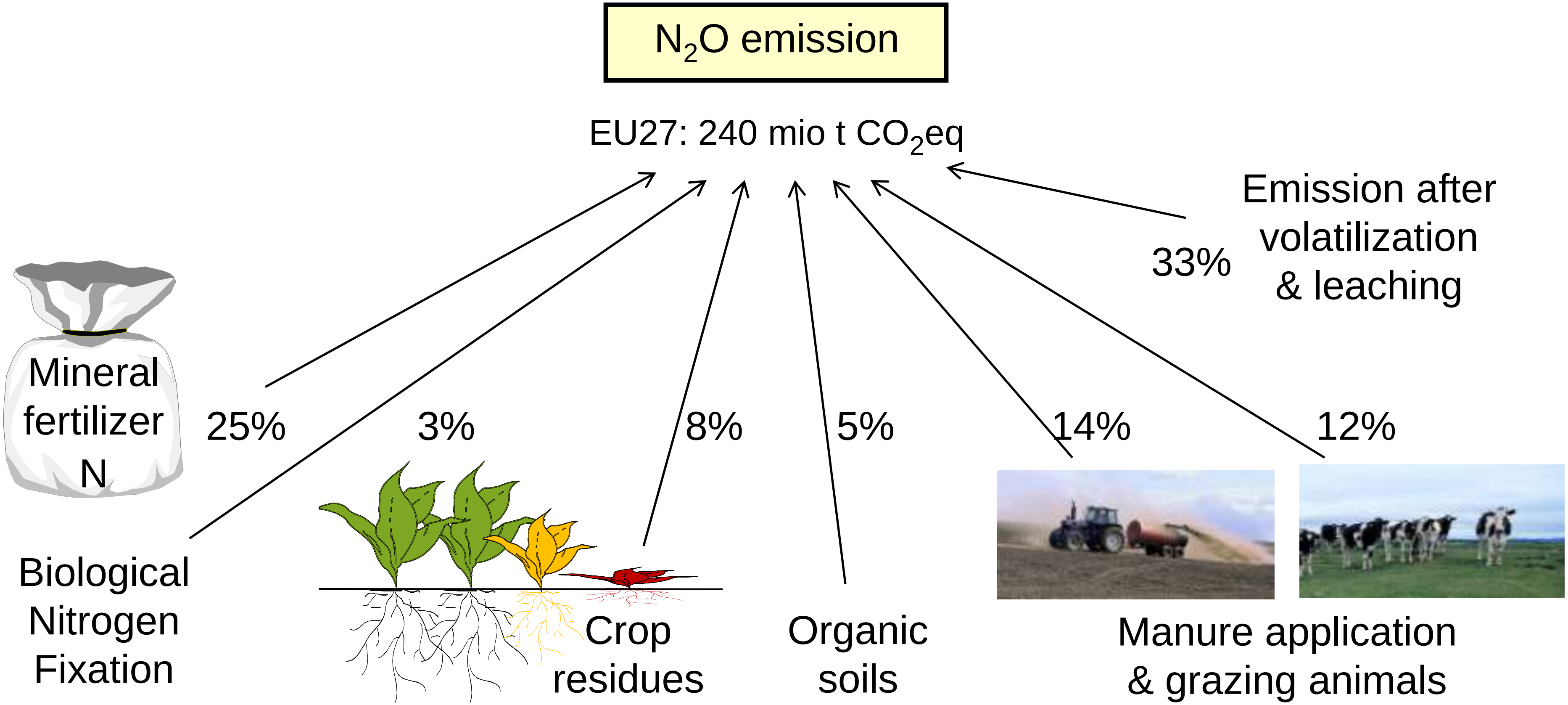
Agriculture contributes 9% to the total GHG emission of 5014 mio. t CO_2eq



Source: United Nations Framework Convention on Climate Change (UNFCCC;2008)

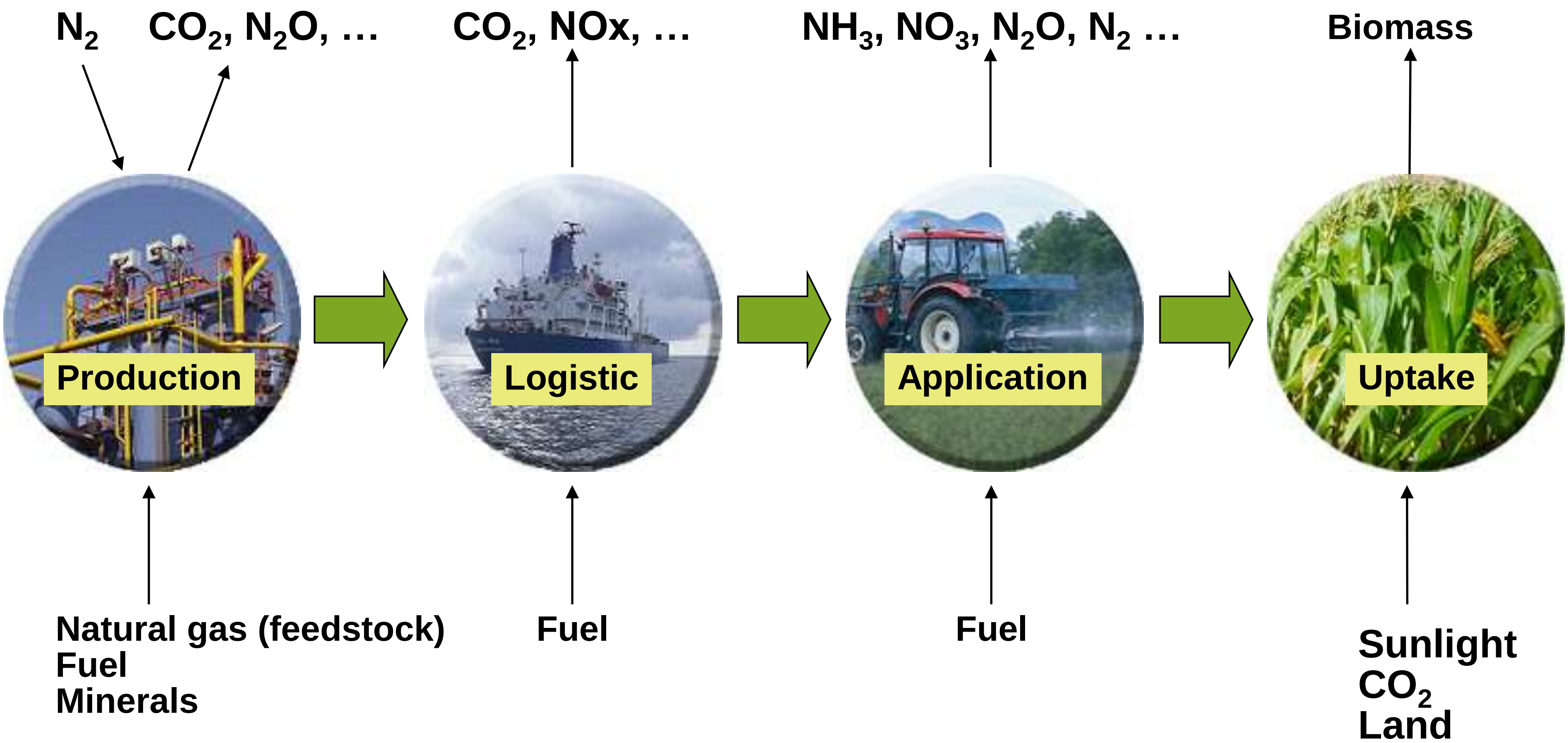
* EFMA calculation

Sources of N_2O from agriculture



Source: United Nations Framework Convention on Climate Change (UNFCCC;2008)

A life-cycle perspective on fertilizer



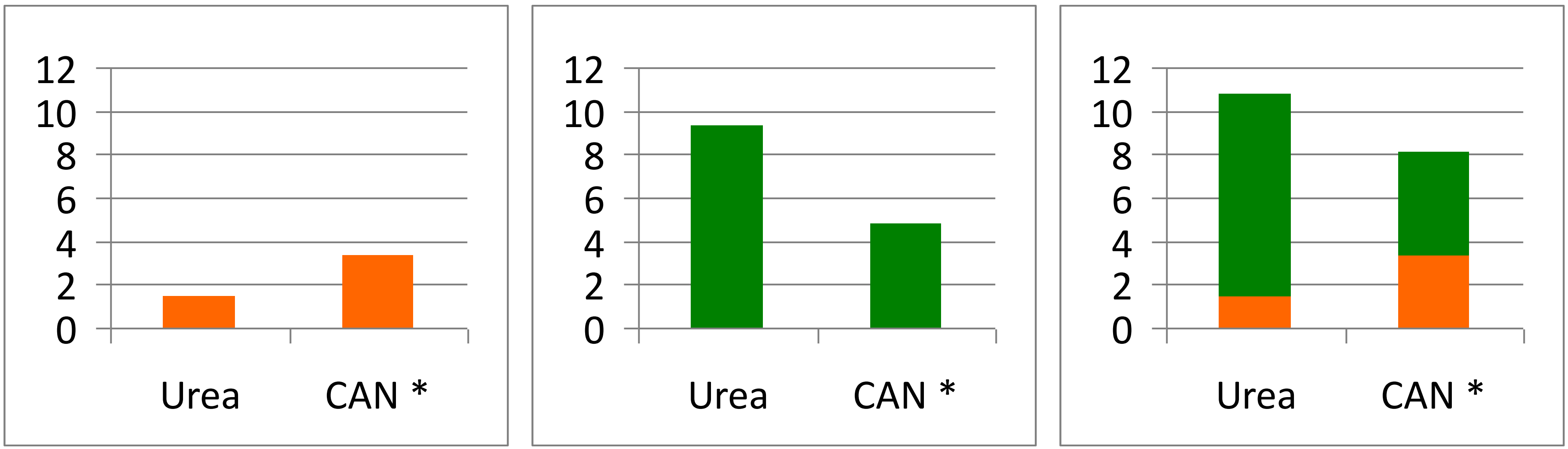
Different fertilizers have different impacts

Fertilizer production

Application to soil

Life-cycle perspective:
Production & application

kg CO2eq/kg N

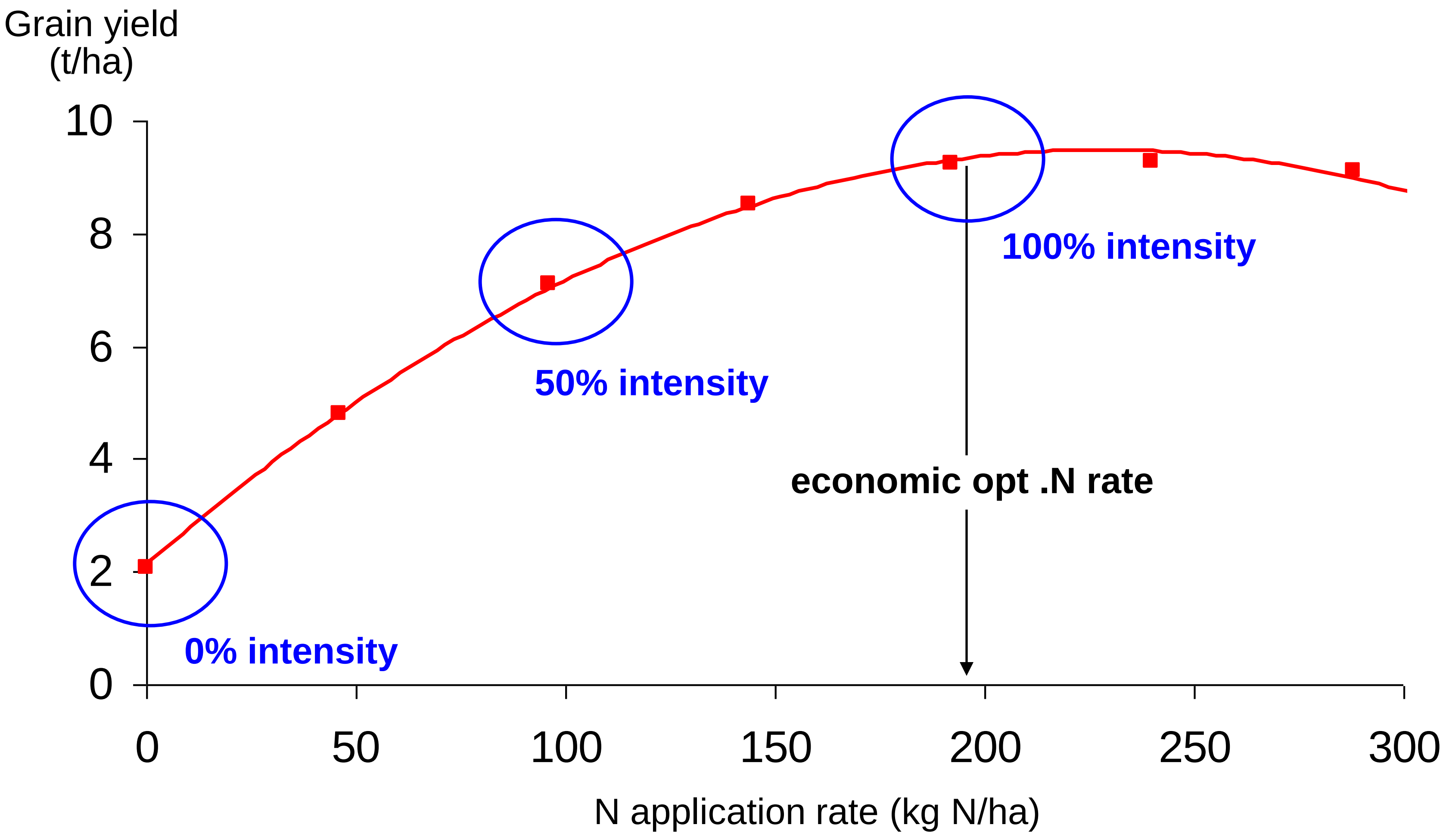


* CAN production includes N2O abatement catalyst

A life-cycle perspective on fertilizers is important
(otherwise regulators may wrongly favour urea)

High intensity in crop production
- Problem or solution ?

Yield response to nitrogen application in a long-term field trial with winter wheat

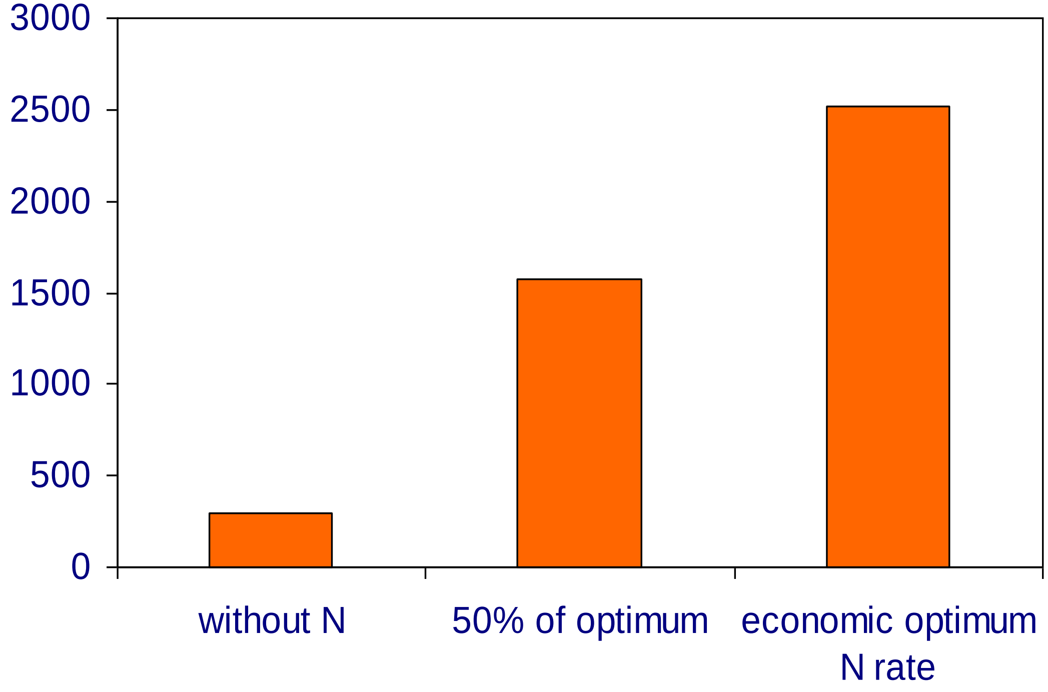


Long term trial: Rothamsted, UK

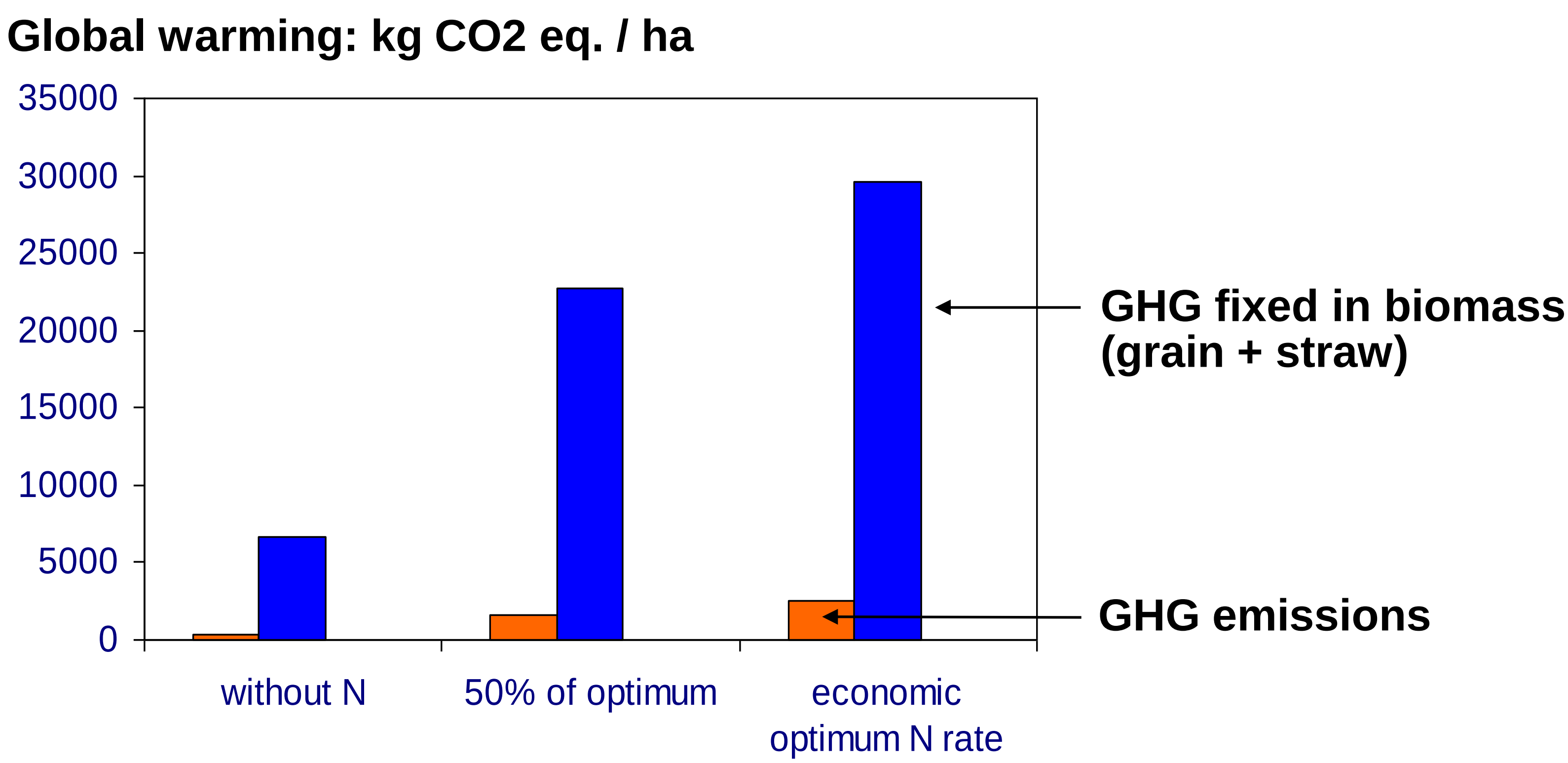

100% intensity
0% intensity

The carbon footprint of wheat production increases with the N application rate

Global warming: kg CO2 eq. / ha

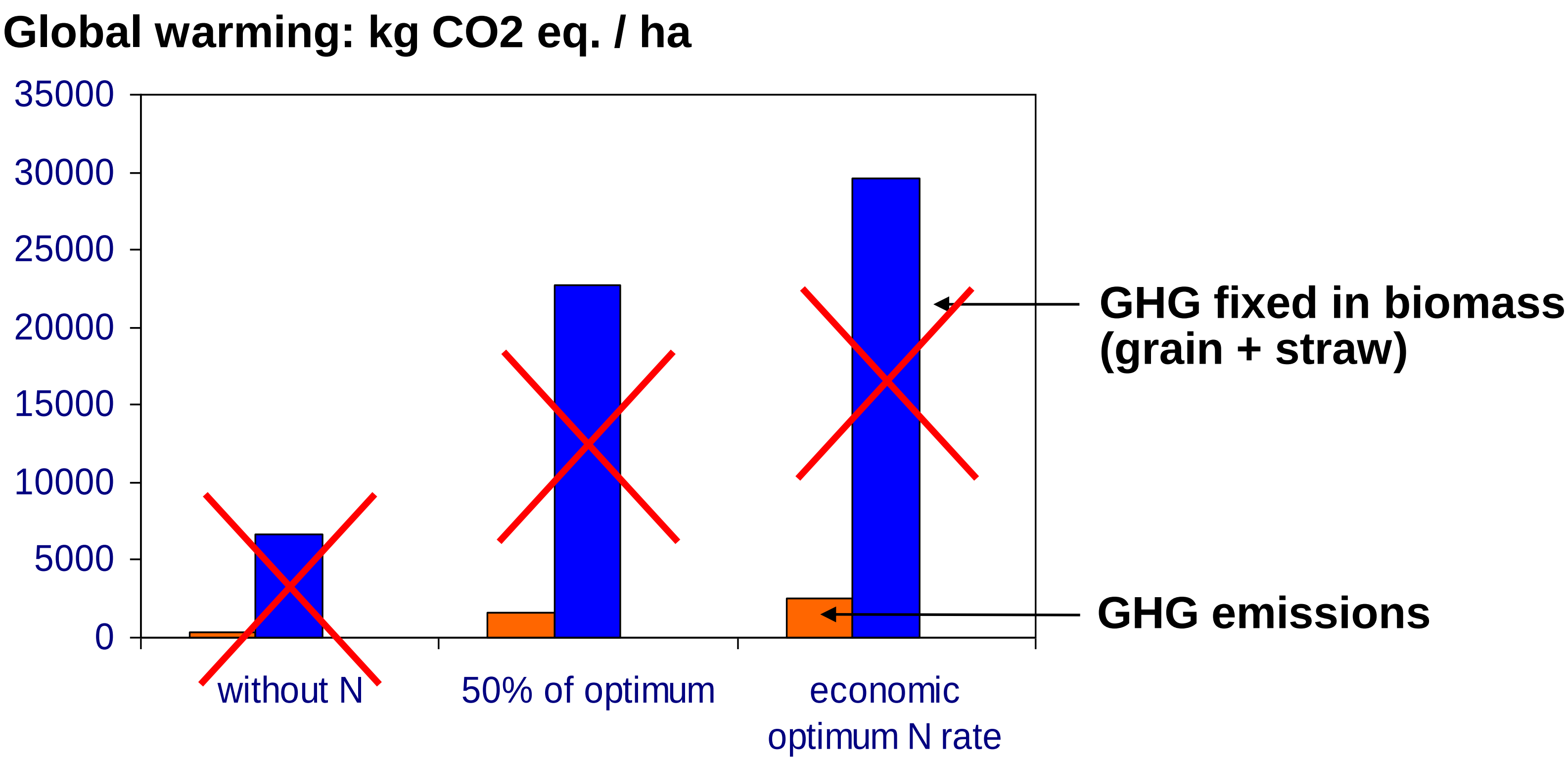


On the other hand the positive GHG balance "ex-field" is enhanced by fertilizer use



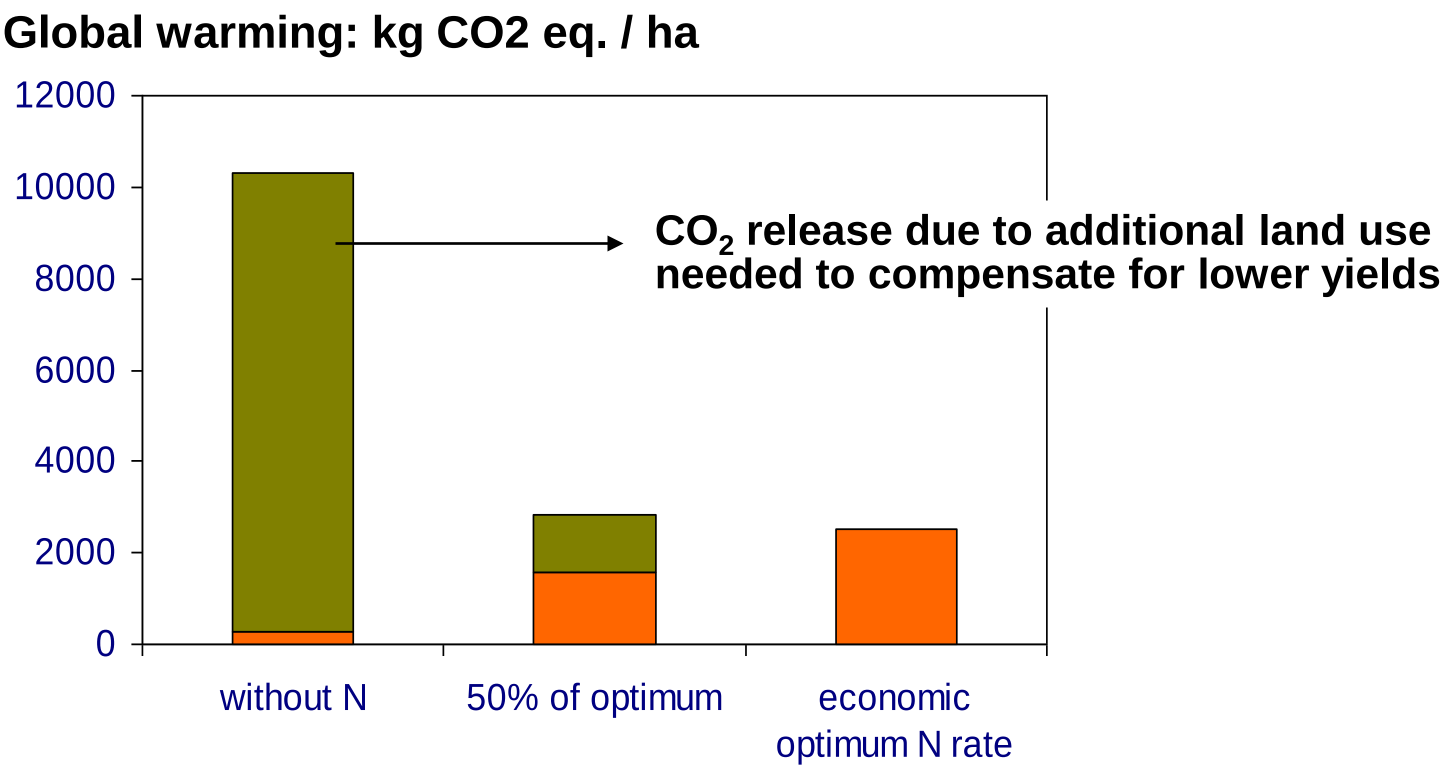
YARA

If the harvested crop is used as food or feed, the CO2 fixation is only short-term



The CO2 fixation can be regarded as a real CO2 saving, only if the harvested biomass is used as bio-fuel and, thus, replaces fossil fuels.

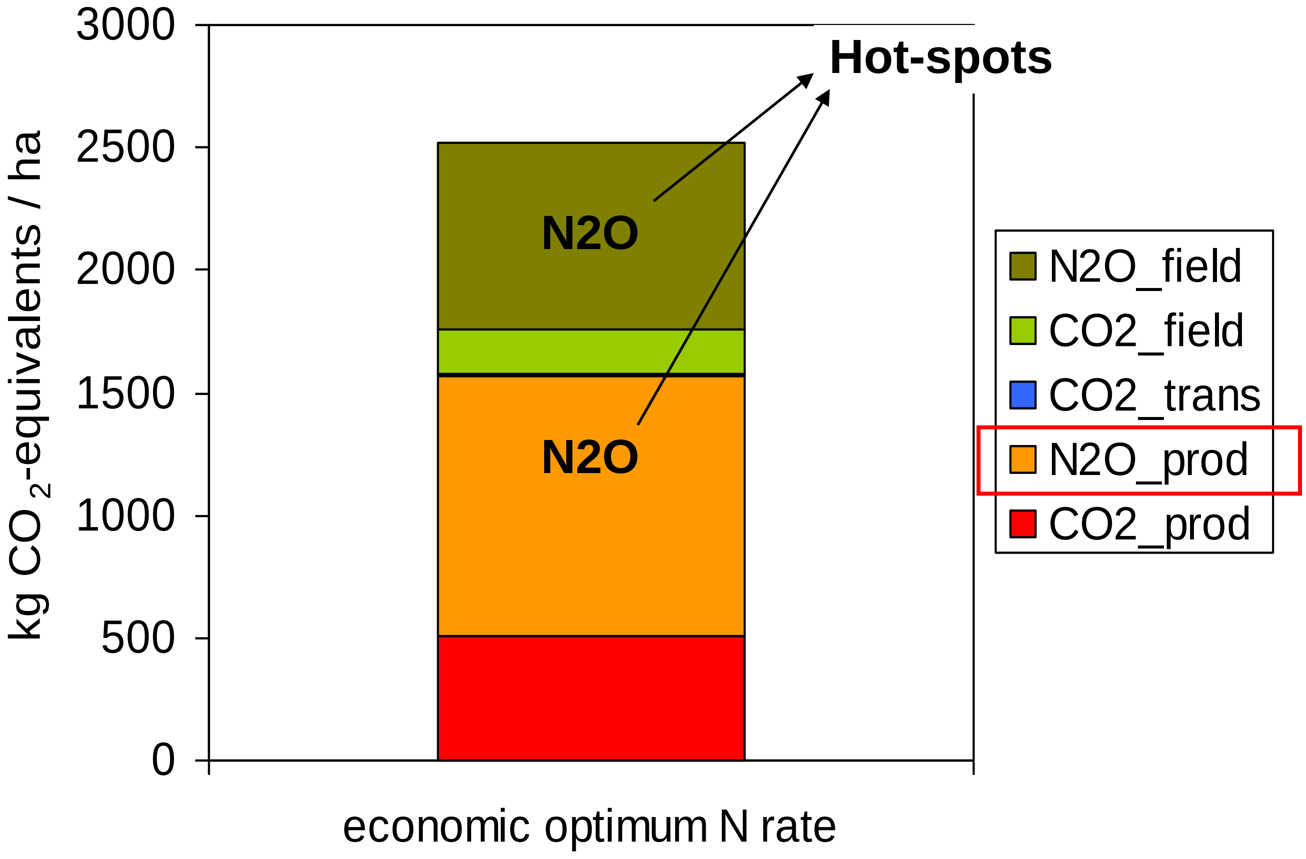
To achieve the same yield, reduced production intensity needs more land and increases GHG emissions



Options to improve the carbon footprint of fertilizers in crop production

Contribution of the single GHG emissions to the total carbon footprint per ha

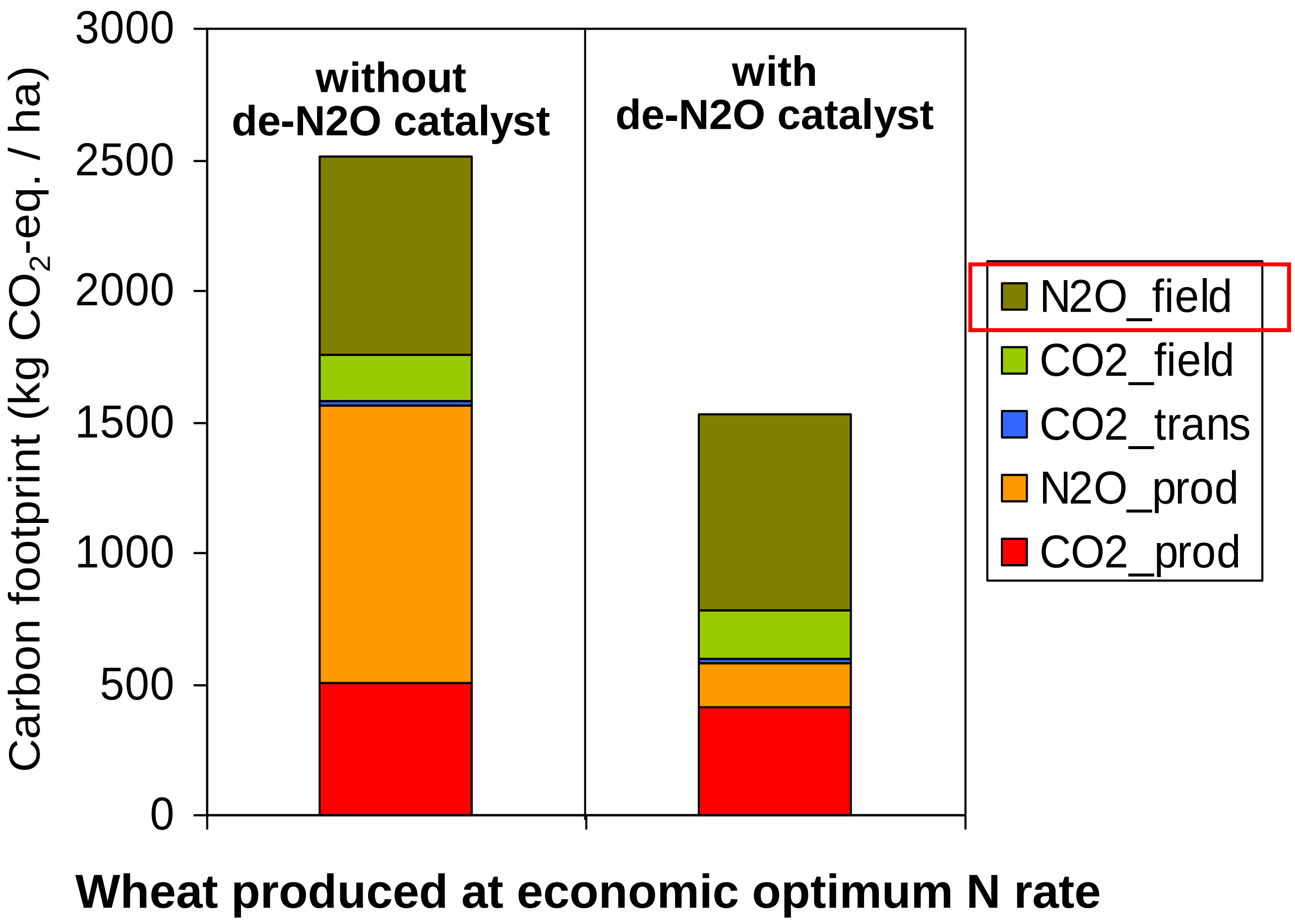
Based on a long-term field trial with winter wheat (UK), N source = Ammoniumnitrate



Improvements in nitric acid production

Impact of the de-N2O catalyst on the carbon footprint of crop production

Based on a long-term field trial with winter wheat (UK), N source = Ammoniumnitrate



Two natural soil processes release N_2O

Nitrification

N_2O

Urea/Ammonium →  → Nitrate

Soil organisms use ammonium (NH_4) as energy source

Denitrification

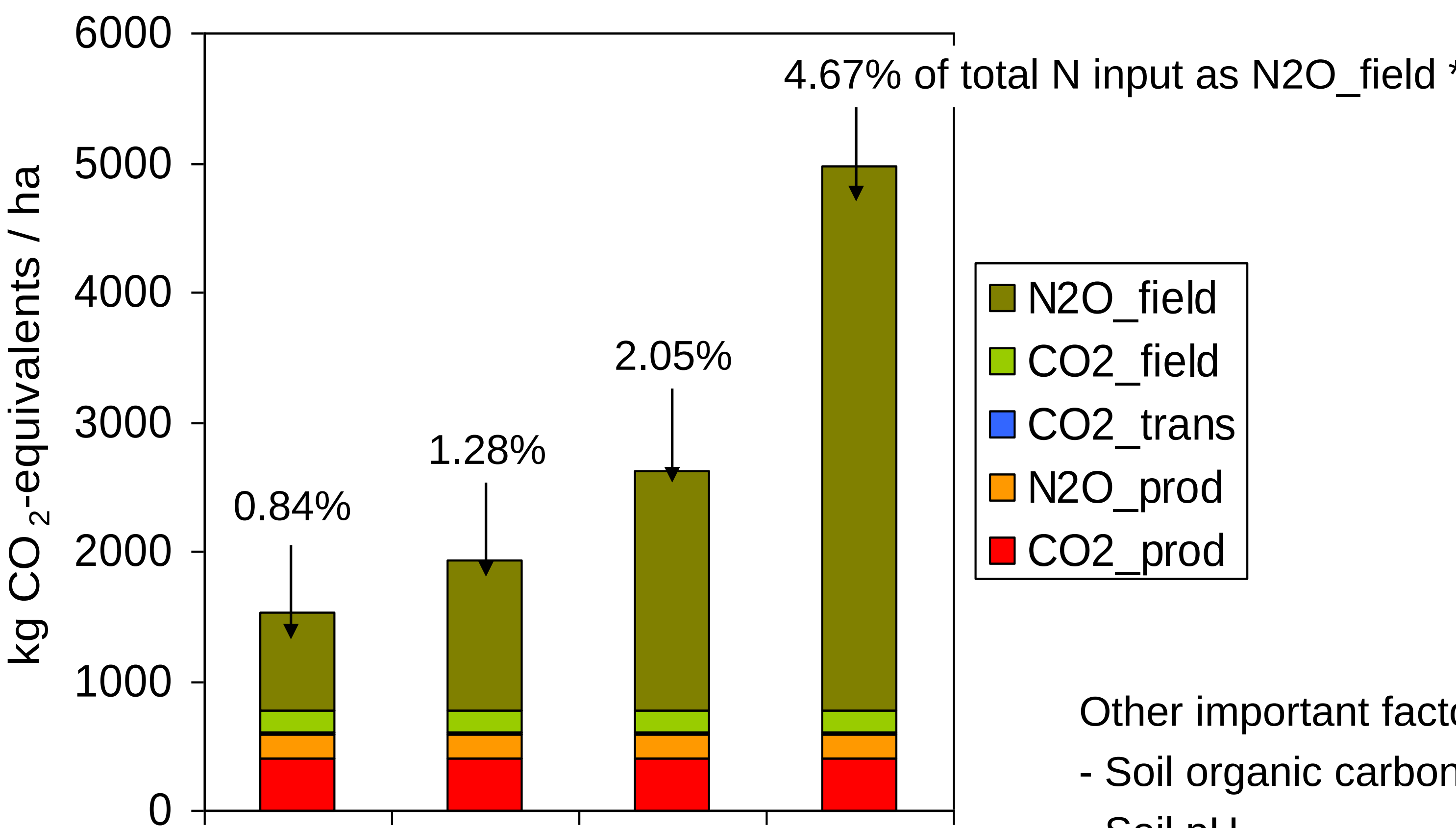
N_2O

Nitrate →  → N_2 gas

Conditional: if oxygen (O_2) is depleted (water logging), soil organisms use oxygen from nitrate (NO_3) for respiration

N_2O from both processes ≈ 1% of N (IPCC, 2006)

Impact of soil and climate on the carbon footprint of crop production



Drainage:	good	poor	poor	poor
Texture:	loam	loam	clay	clay
Climate:	temp	temp	temp	trop

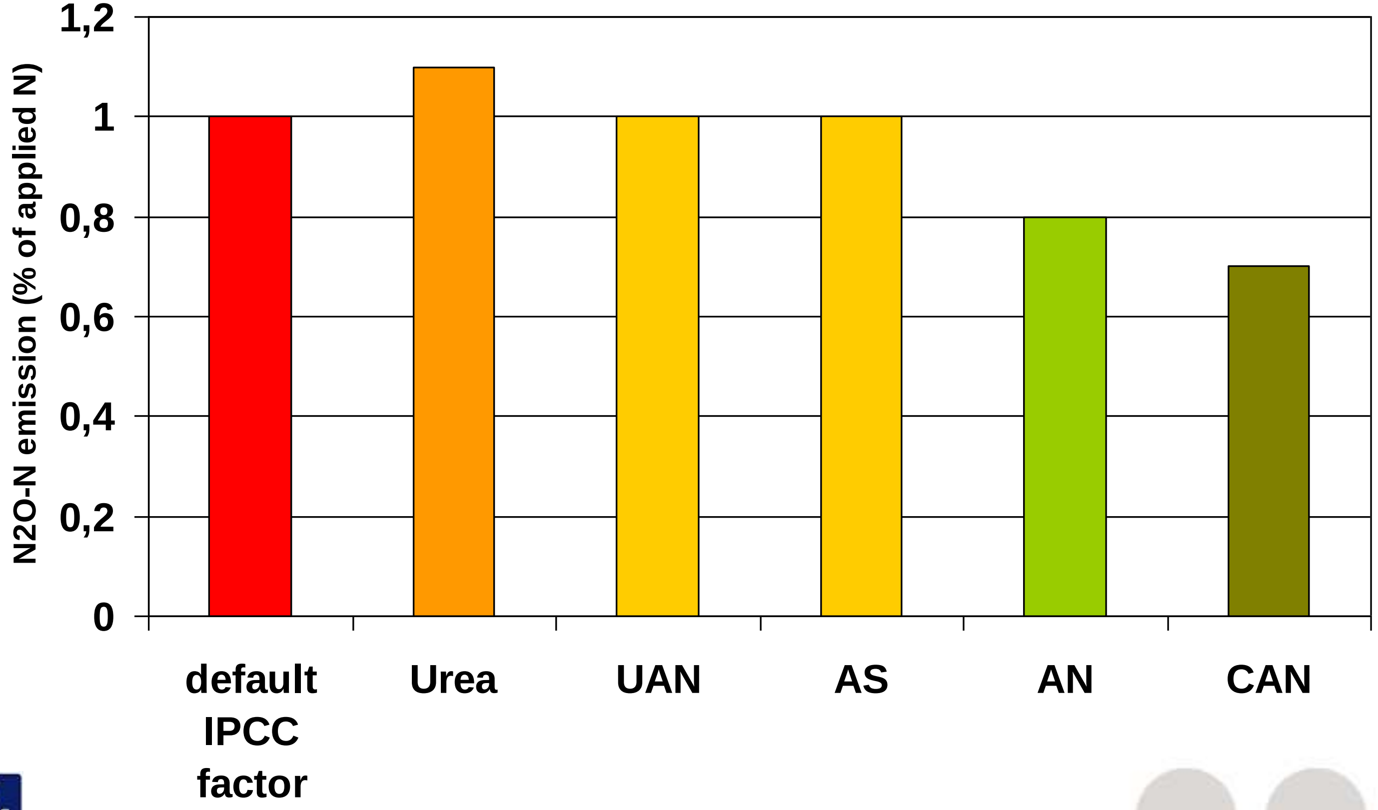
Other important factors:

- Soil organic carbon
- Soil pH
- Fertilizer type

* Calculated according to Bouwman model (Bouwman et al., 2002), uncertainty range –40% to +70%

Average N_2O emissions are lower from Nitrates than from urea and ammonium fertilizers

- Up to now, N_2O emissions from N fertilizers are estimated independently from the N form (default IPCC factor, red bar in the graph below).
- But a new analysis of about 900 in-field measurements from 139 experiments shows differences in N_2O emissions from different N fertilizers.



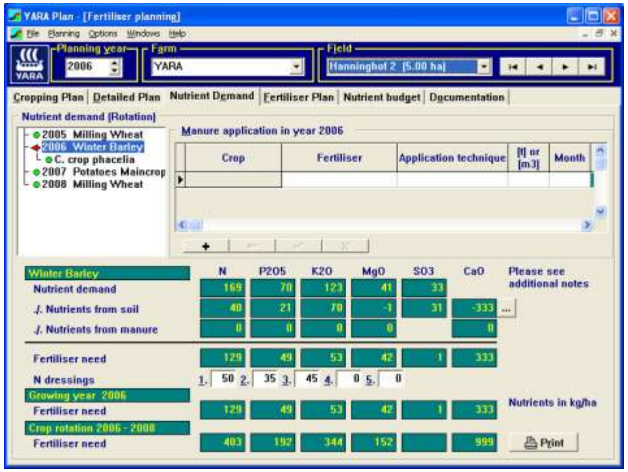
Source: Bouwman et al. (2002)

Options to reduce in-field N_2O emission

- Any means that improve nitrogen use efficiency, in particular
  - Adjust N application rate to actual crop N demand (➔ soil and plant analysis)
  - Synchronize N application with crop N uptake (➔ split application, “just-in-time” fertilization)
- Apply nitrate-based N sources on well aerated and non-waterlogged soils
- Maintain a good soil structure (no compaction, good drainage)

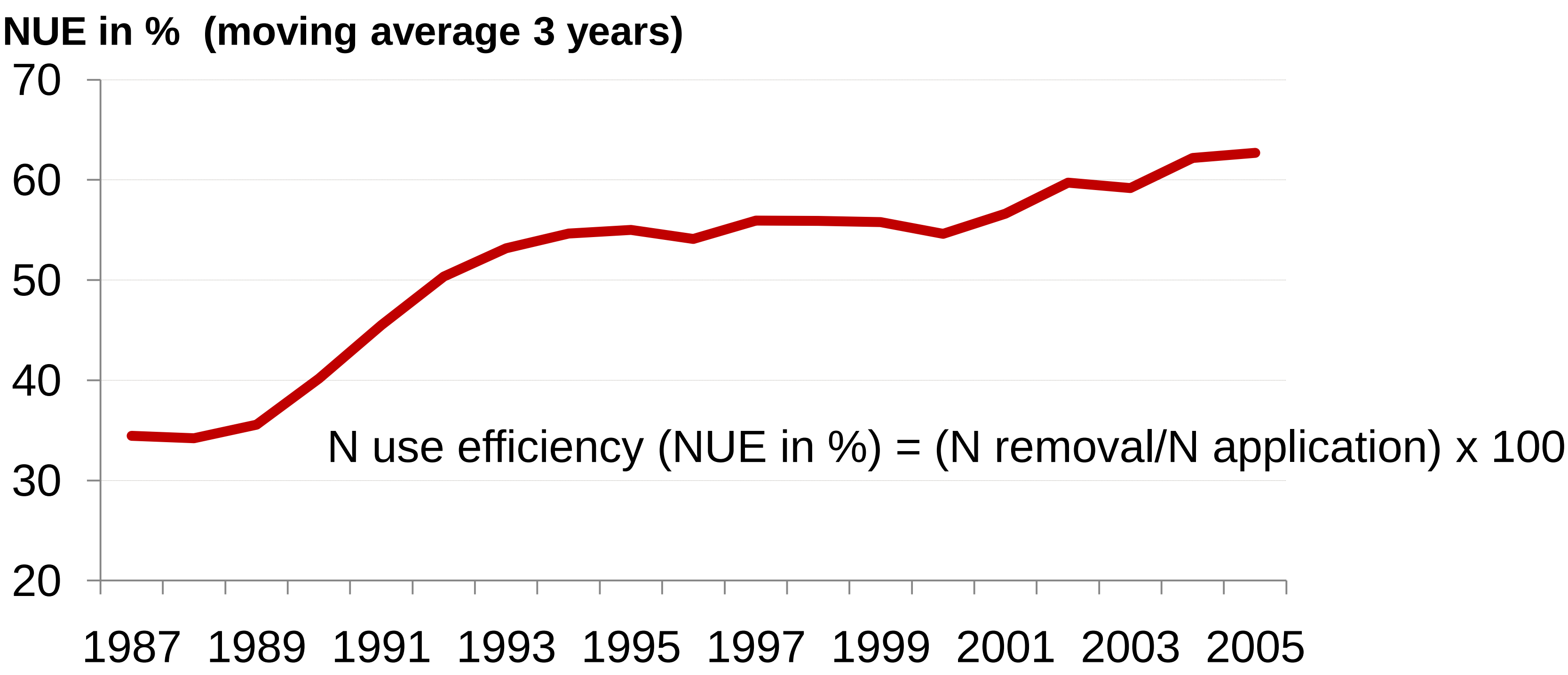
Yara develops tools to support Good Agricultural Practices and to increase N use efficiency

Software and crop monitoring tools help to calculate the right nutrient rate



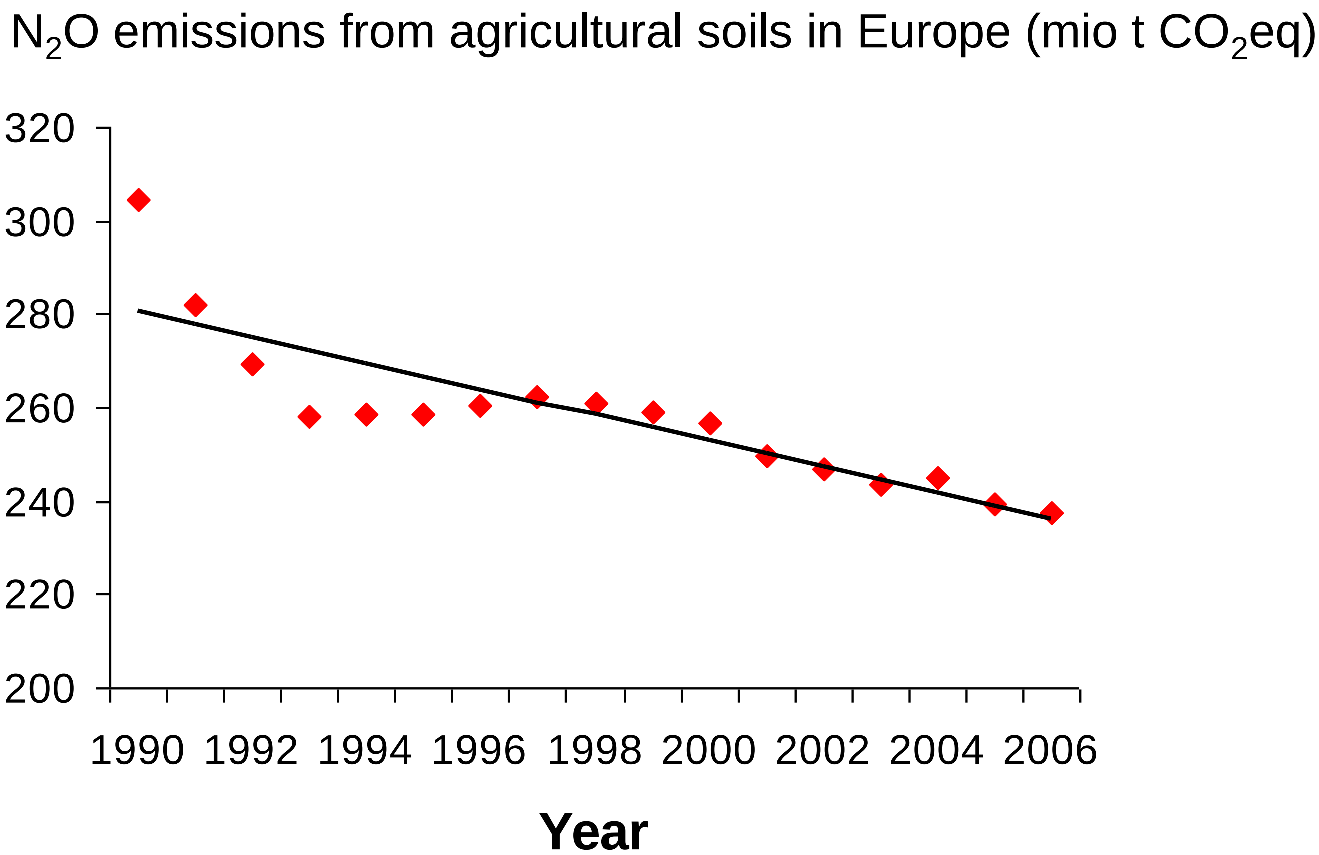
=> these tools helped to improve nutrient use efficiency

The nitrogen use efficiency in Europe is increasing



Source: own calculation based on FAO and Efma data

The N_2O emissions from soil are decreasing



Source: United Nations Framework Convention on Climate Change (UNFCCC, 2008)

The N use efficiency in Europe will further improve

	Average EU27 2006/07	Average of 139 field trials**
Grain yield t per ha - fresh matter*	4.9	9.3
N-content in grain dry matter (%)	2.00	2.09
N removal in grain (kg N/ha)	82	167
N fertilizer application (kg N/ha) N deposition (kg N/ha)	111 20	181 20
N use efficiency (N removal/ N input) * 100	**62 %**	**83 %**

Source: * FAO, ** Yara field trials

The Key Facts

- Fertilizers are needed for feeding the world
- Agricultural land must be used in the most efficient way, to protect wildlife and minimize climate change
- Fertilizers, used correctly, will contribute to solving climate change
- Europe has today the most efficient production plants and the most modern agriculture
- N_2O is released by natural processes regardless of the origin of the nitrogen in the soil
- To reduce N_2O the field the nitrogen use efficiency shall be improved by good agricultural practices