

Mineral Fertilizer in the Future – Sustainable Farming

Dr. Joachim Lammel
Head of Product and Application R&D
Hydro Agri





Definition of Sustainability

"Sustainable development is any development which meets the needs of the present without compromising the ability of future generations to meet their needs" (according to. Brundtland, 1987):

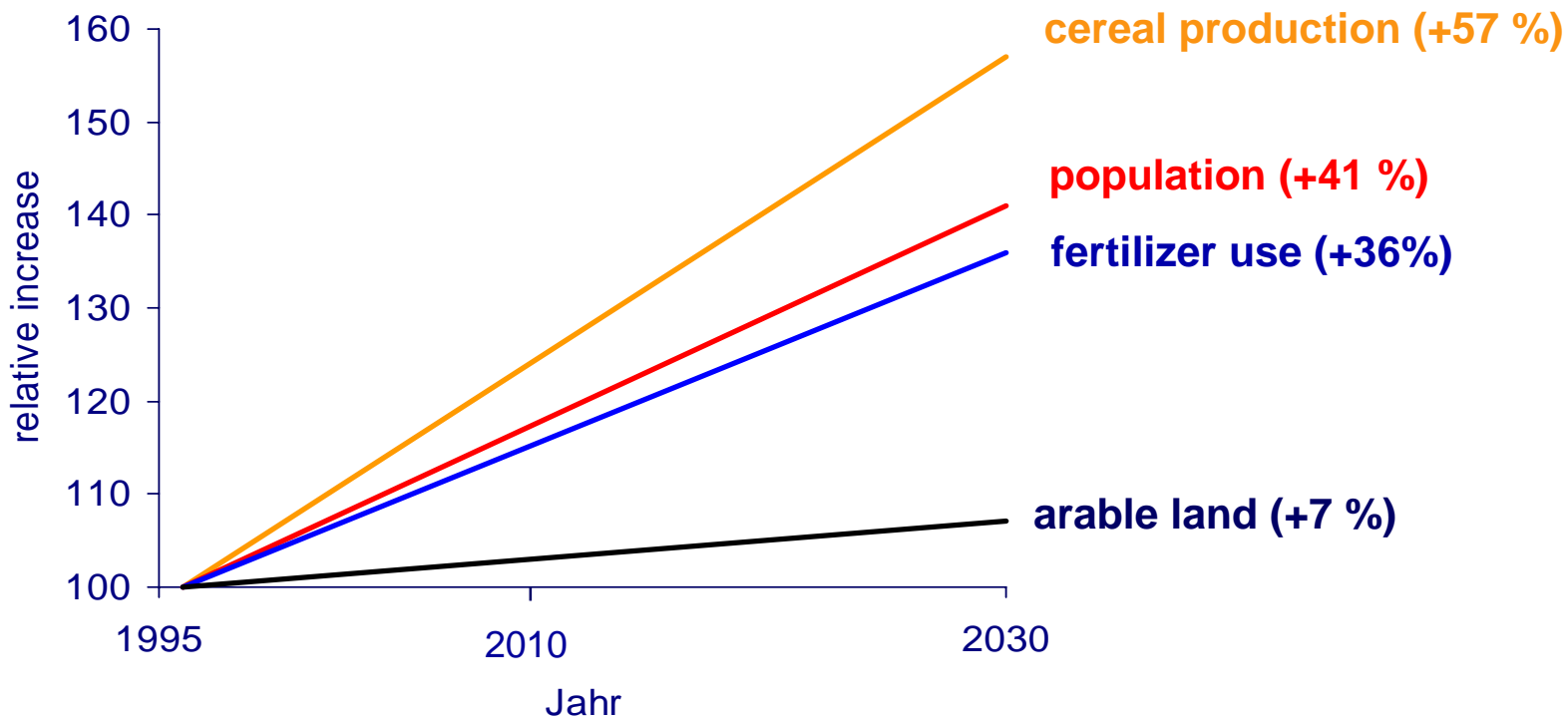
Sustainability comprises three main elements which have to be balanced

- **Social aspects**
- **Economic targets**
- **Environmental impact**

Sustainability in agriculture has to balance

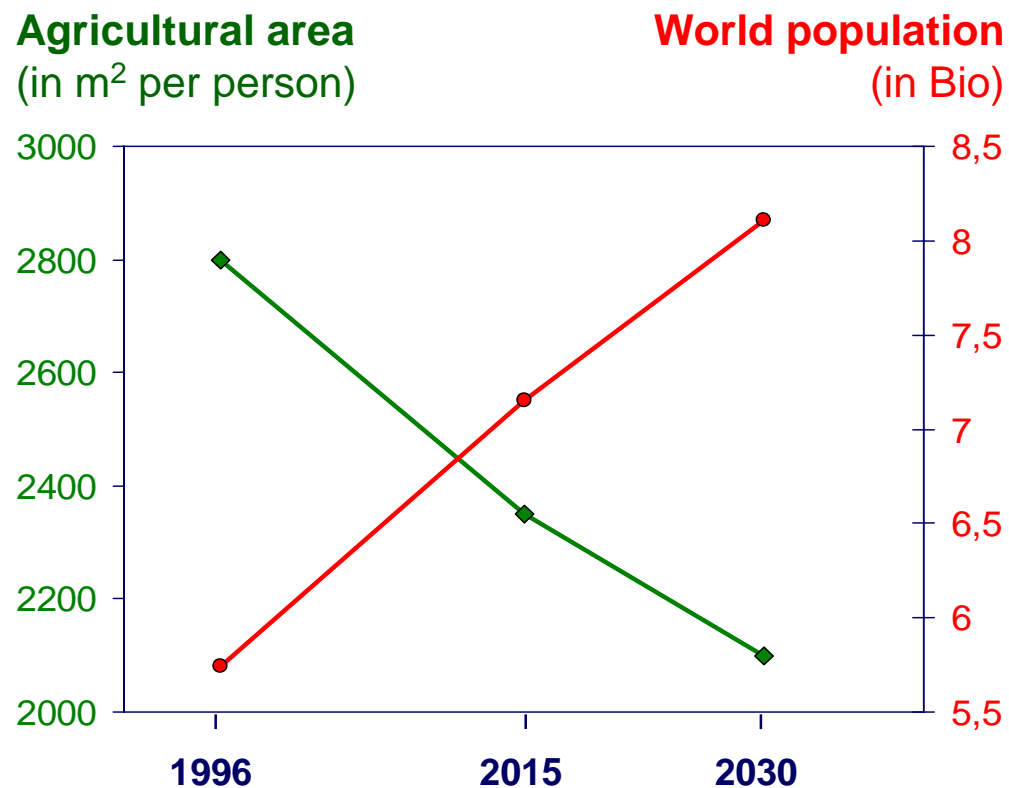
- **the need for food in good quality**
- **at affordable prices for the consumer and acceptable farm income level**
- **produced with minimum adverse effects on the environment**

Global trends: Development of cereal production, world population, fertilizer use and arable land



Source: FAO; Towards 2015/30; Technical interim report 4/2000

The intensity of arable production has to increase



- World population increases up to 8.3 Billion people in 2030.
- In the same time the agricultural area can only be extended by about 7%.
- Thus, the agricultural area per person decreases rapidly.

Source: FAO; Towards 2015/30; Technical interim report 4/2000

Continuous cropping without nutrient replacement is mining the soil

Effects of ,soil mining':

- reduced soil fertility
- soil compaction
- reduced humus content
- increased erosion risk
- reduced yields



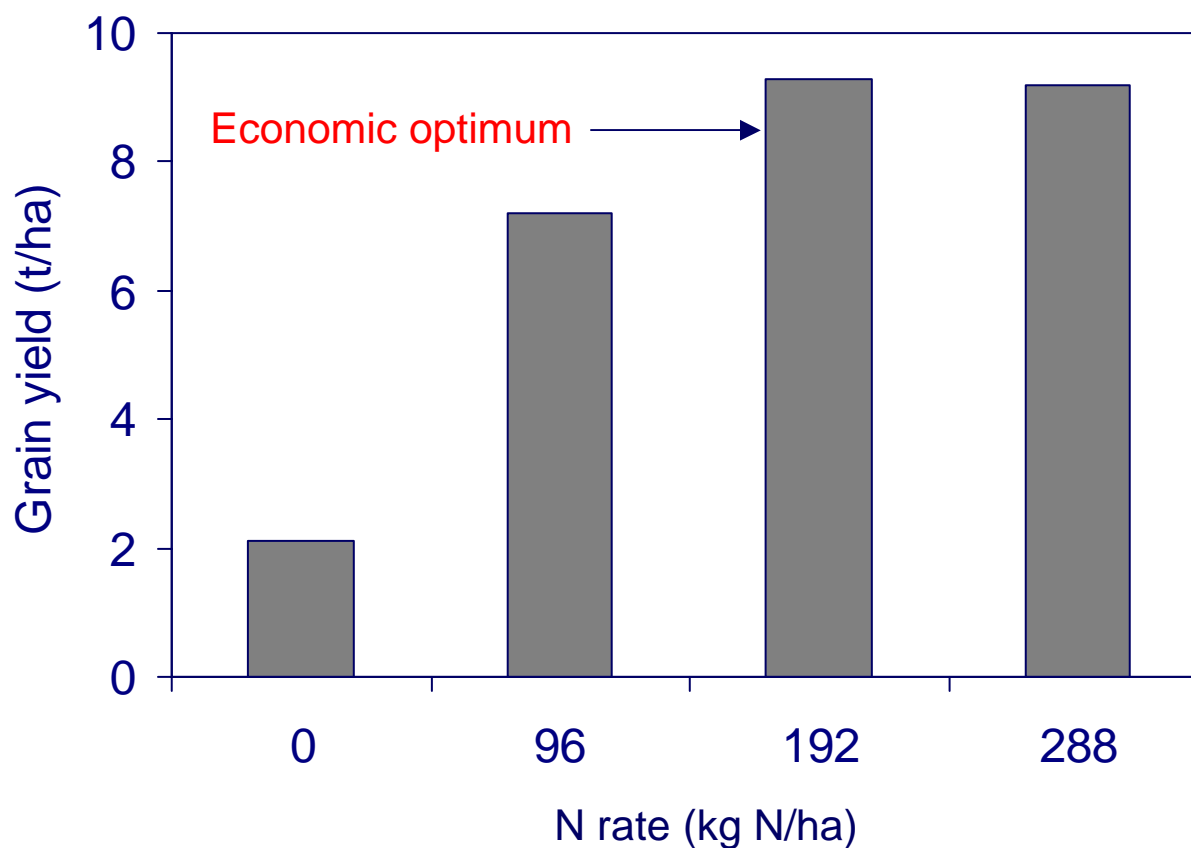
zero fertilizer

Fertilizer + Compost

Photo: Dr. Paul Seward, maize in Kenya

The effect of mineral N fertilizer application can best be studied in long-term trials

Data from a long-term field trial with winter wheat, Rothamsted (UK)
-> without mineral nitrogen the grain yield is only at 2 t/ha;



P = 80kg P₂O₅; K = 108 kg K₂O

Optimum N application produces high yields at low production costs per unit



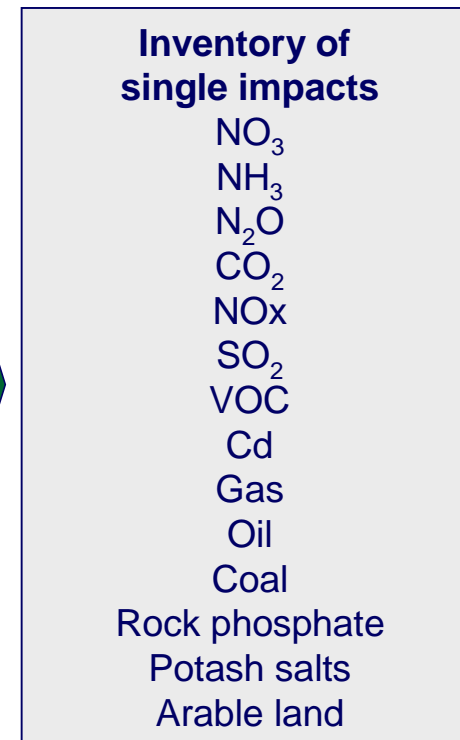
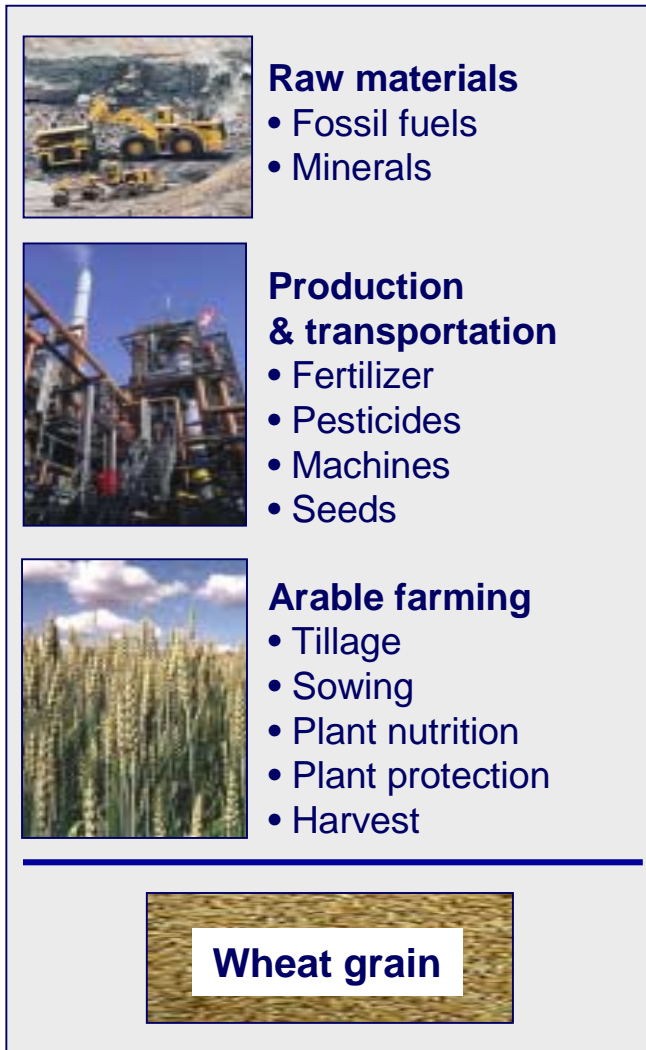
	N rate		
	zero	opt – 50%	optimum
grain yield t/ha	2,1	7,1	9,3
production cost €/ha	558	727	853
production cost €/t grain	269	102	92

Grain market price: 112 EUR/ton

Source: Yield data; long term trial, Broadbalk, Rothamsted (since 1856)

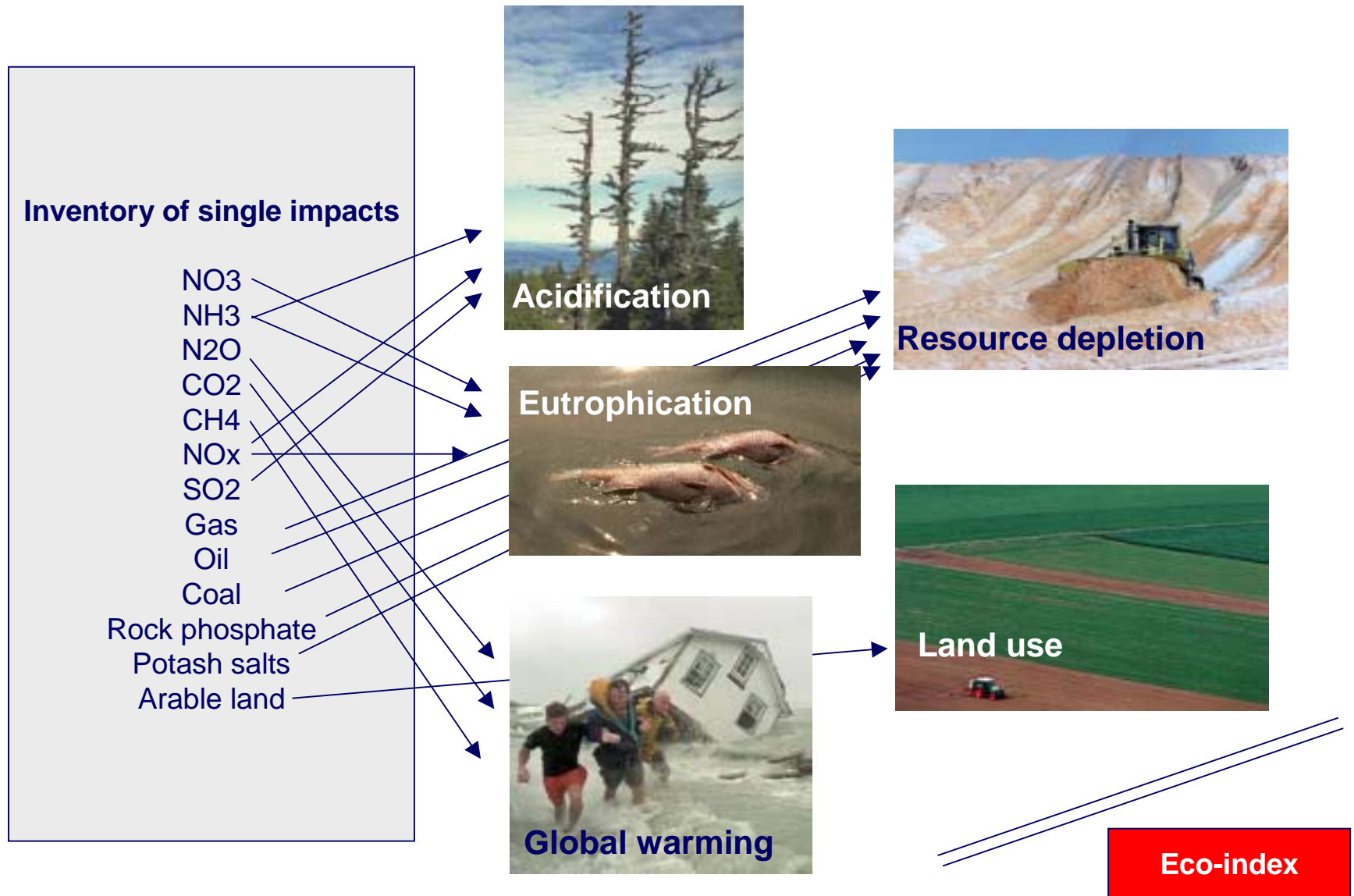
Economic data: KTBL Germany

The environmental impact of wheat production - seen from a Life Cycle Assessment perspective





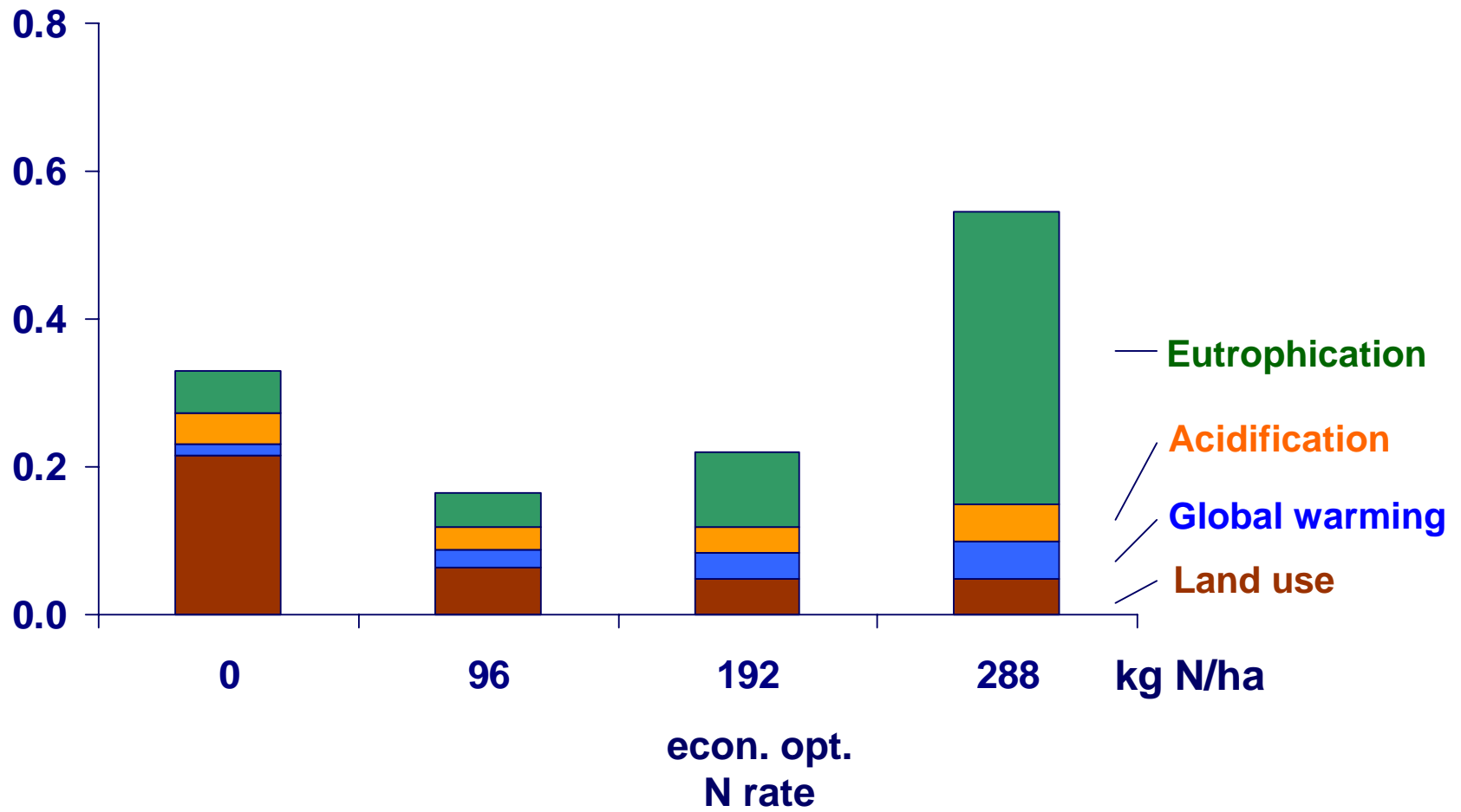
LCA: To summarize the inventory data of single impacts into environmental effects and a Eco-index



Aggregated environmental impact of wheat production at different N rates



Environmental impact (EcoX value) / t grain



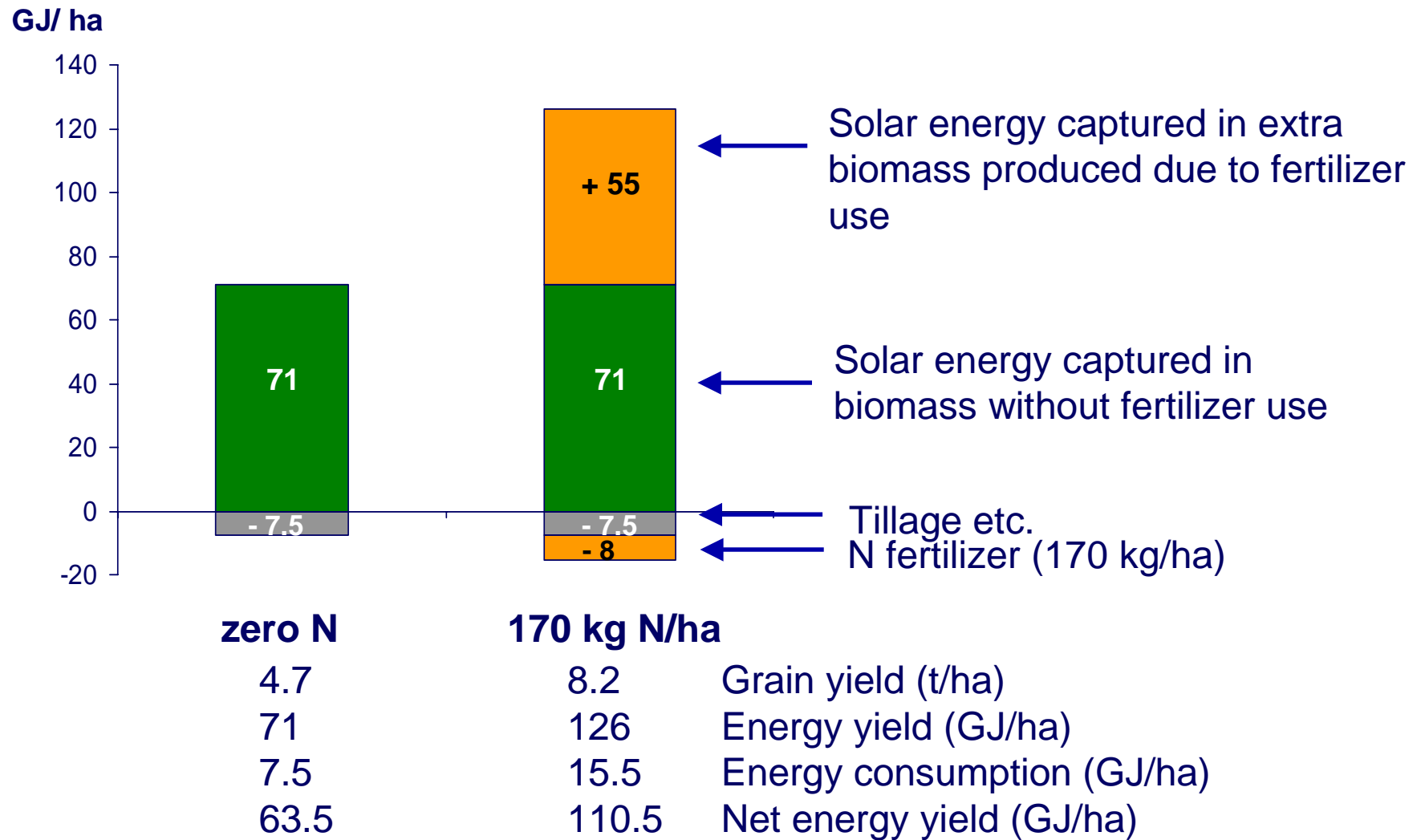
Sustainability of wheat production at optimum and reduced N fertilization



	reduced	optimum
Environmental impact		
		+/-
Economic targets (profit for farmer, food prices)	-	+
Social aspects (food quality, food security)	-	+



Fertilizer use enables the crop to grow more biomass which fixes additional energy



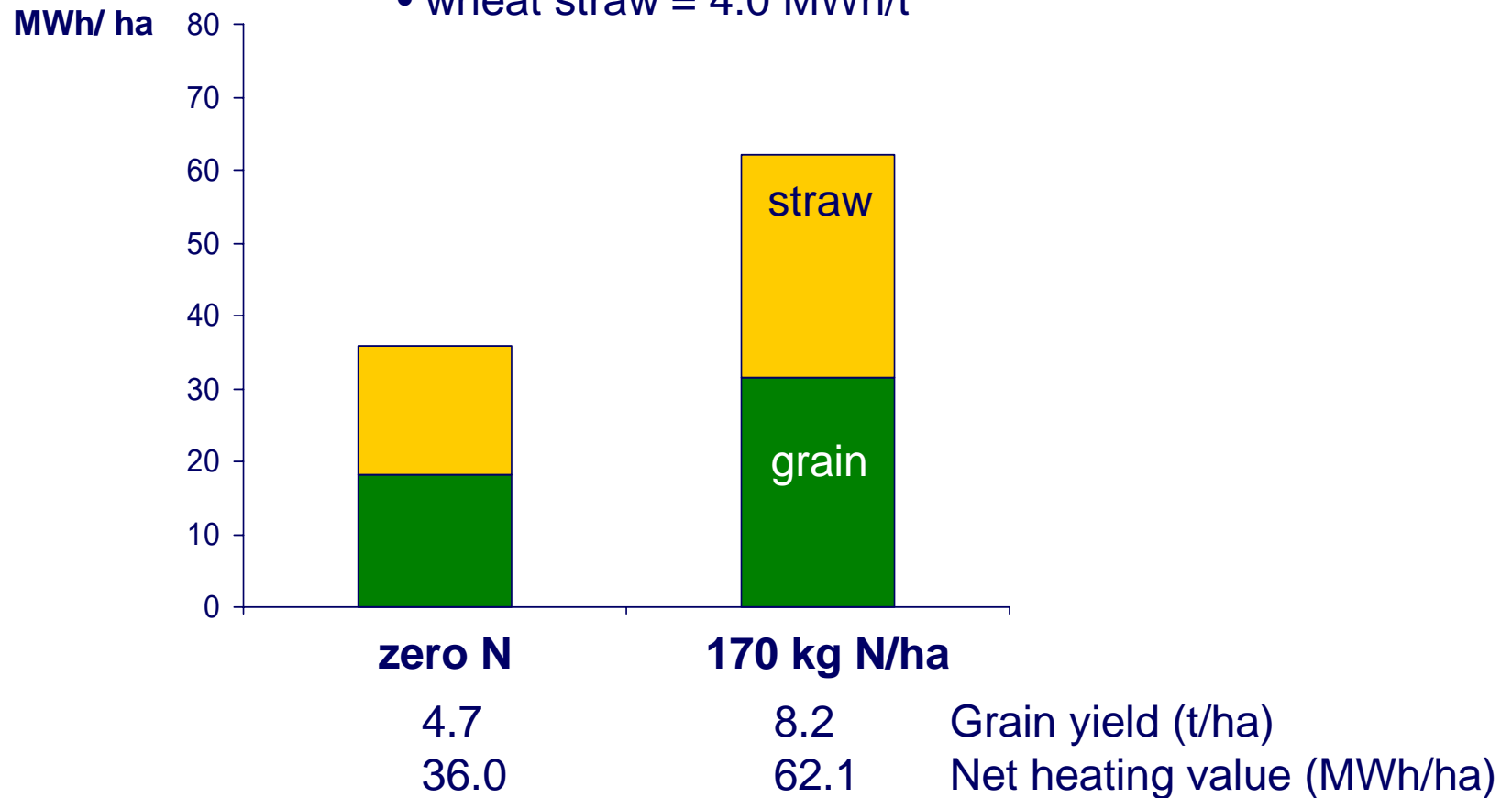
Example: field trials, Germany



Vision for the (near ?) future: Arable farming to produce energy

Heating value (85% DM; Hartmann, 1999):

- wheat grain = 4.1 MWh/t
- wheat straw = 4.0 MWh/t



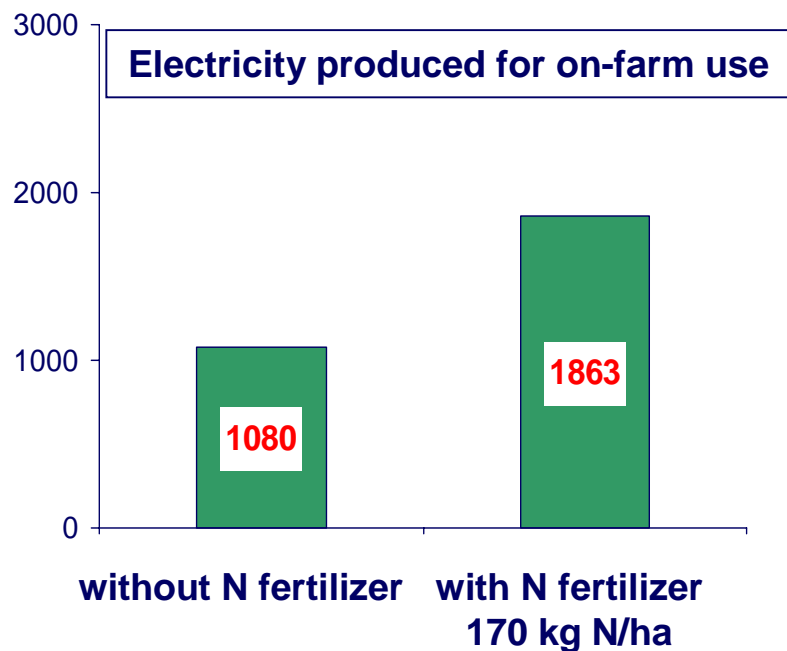


Straw and grain for electricity production - theoretical considerations

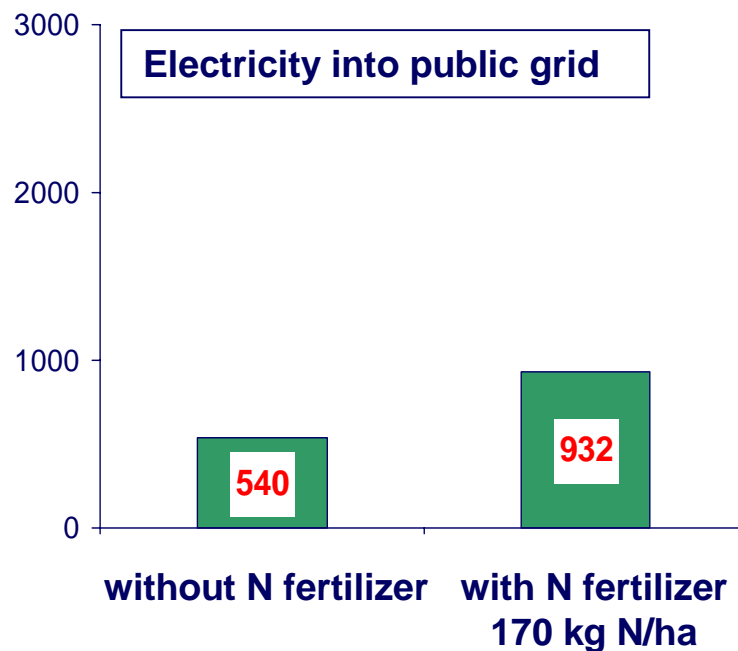
Assumptions:

- 30% efficiency of on-farm power generation
- 10 Cent/kWh by replacement of public electricity; 5 Cent/kWh electricity into the public grid

EUR/ha



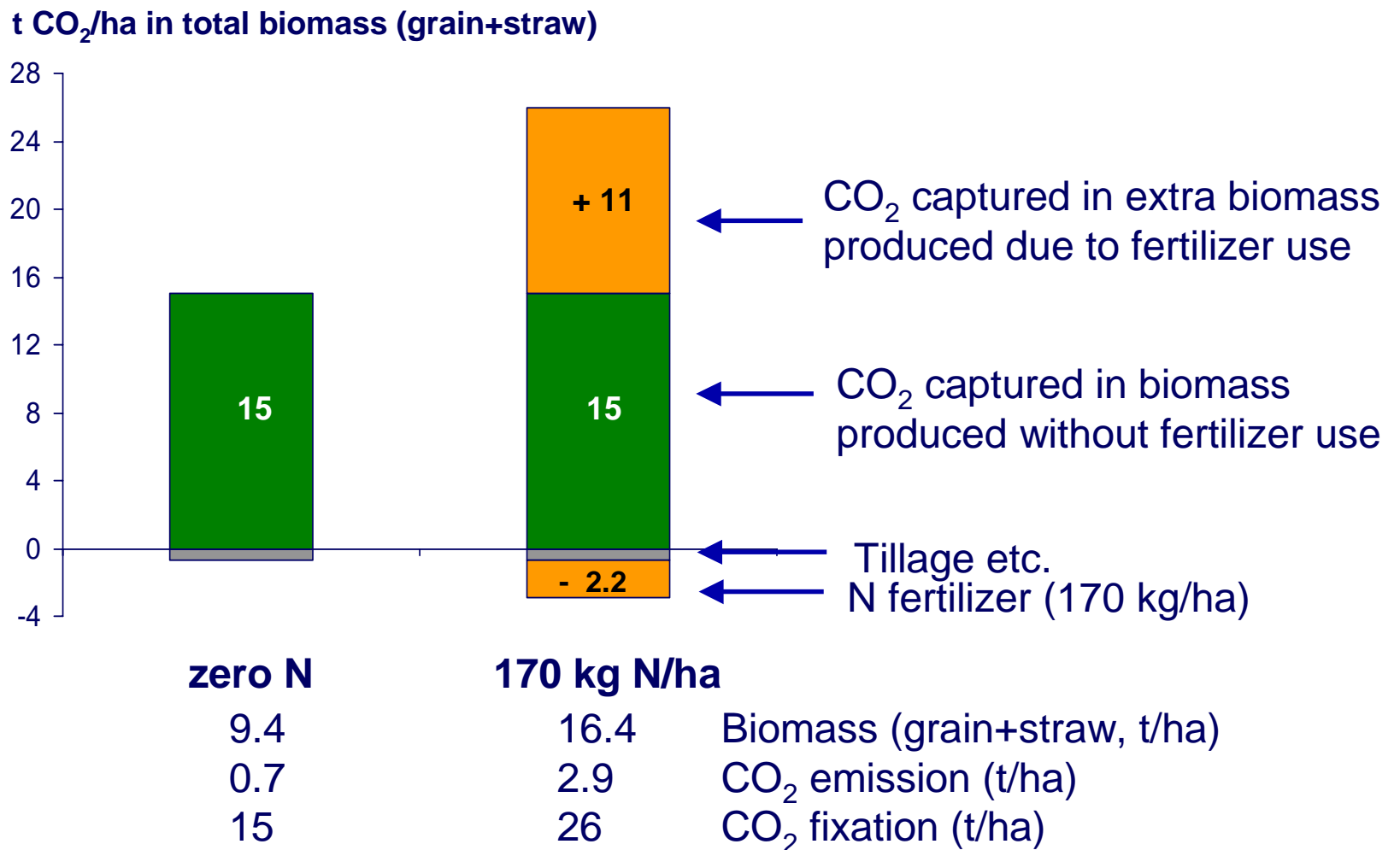
EUR/ha



N fertilizer rate	0	170	kg/ha
Biomass (straw + grain)	9.4	16.4	t/ha
Net heating value	36.0	62.1	MWh/ha



Fertilizer use helps to fix extra CO₂

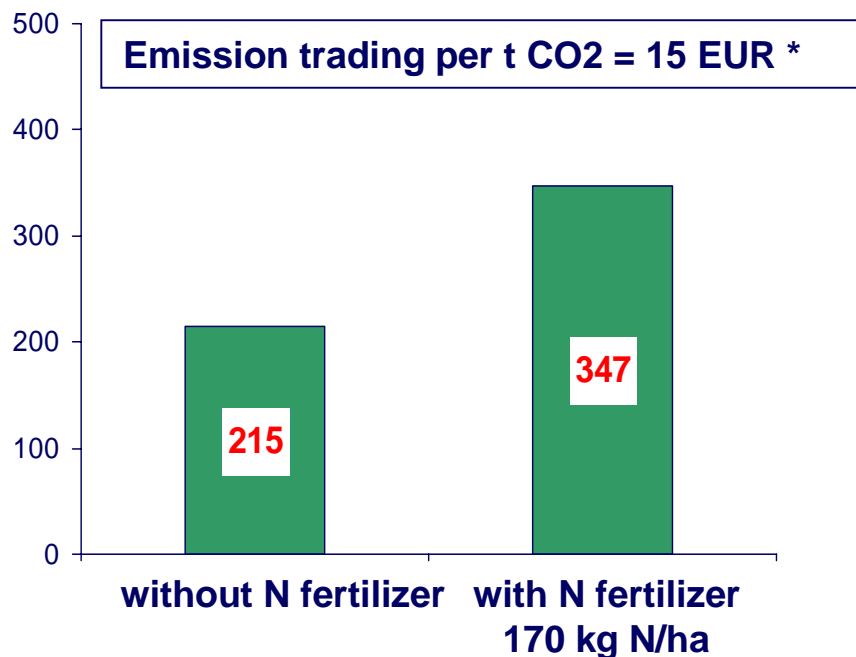


Example: field trials, Germany

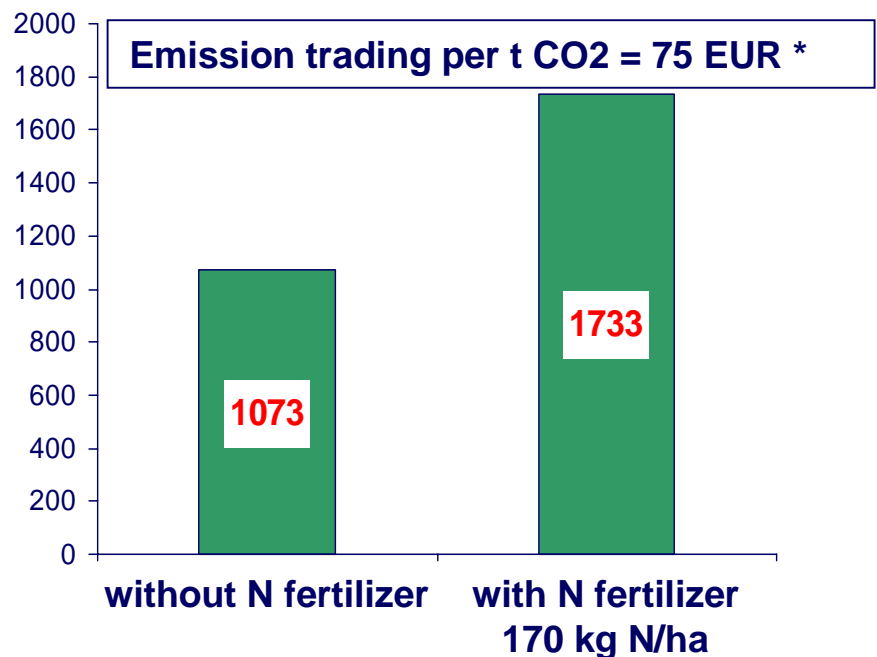
Additional income through CO₂ trading if crops are used to produce energy?



EUR/ha



EUR/ha



N fertilizer rate	0	170 kg/ha
Biomass (straw + grain)	9.4	16.4 t/ha
net CO ₂ fixation	14.3	23.1 t/ha

* EU Green Paper on greenhouse gas emissions trading within the European Union - COM (2000)87: 15 – 75 EUR per reduced tonne of CO₂

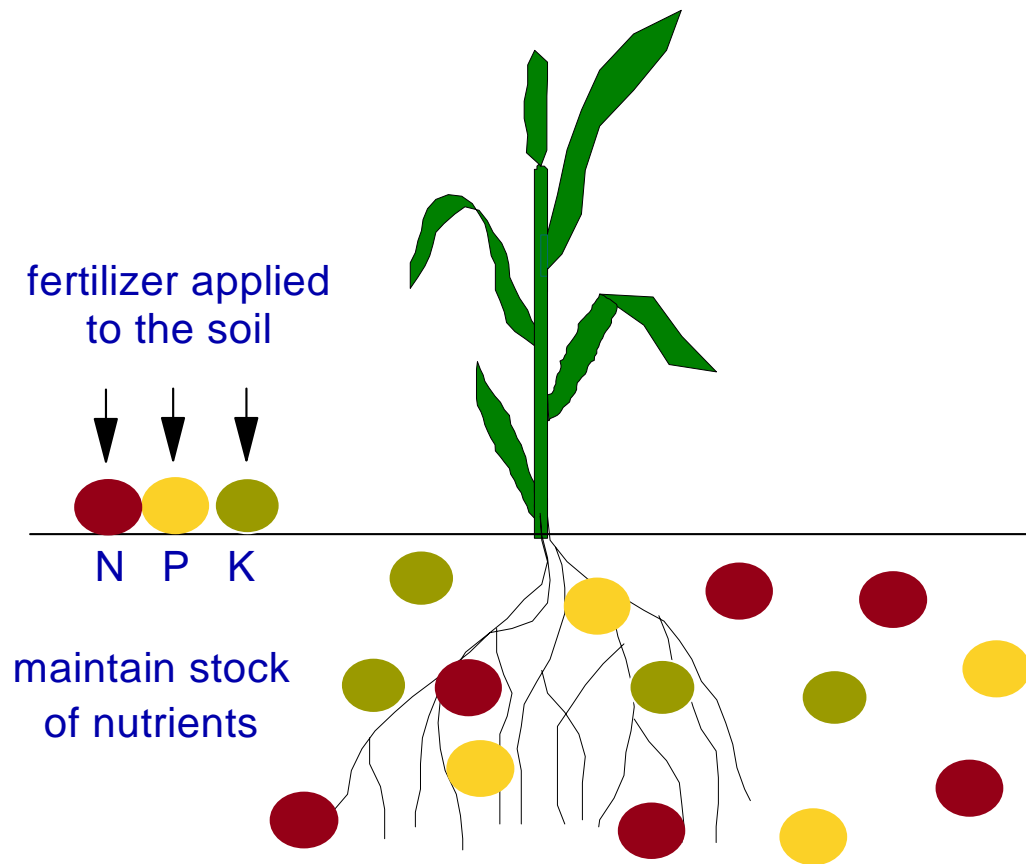
Hydro Agri Plant Nutrition Concept

" Just in time"

To increase the fertilizer use
efficiency



Today's Fertiliser Strategy: "stock-keeping"



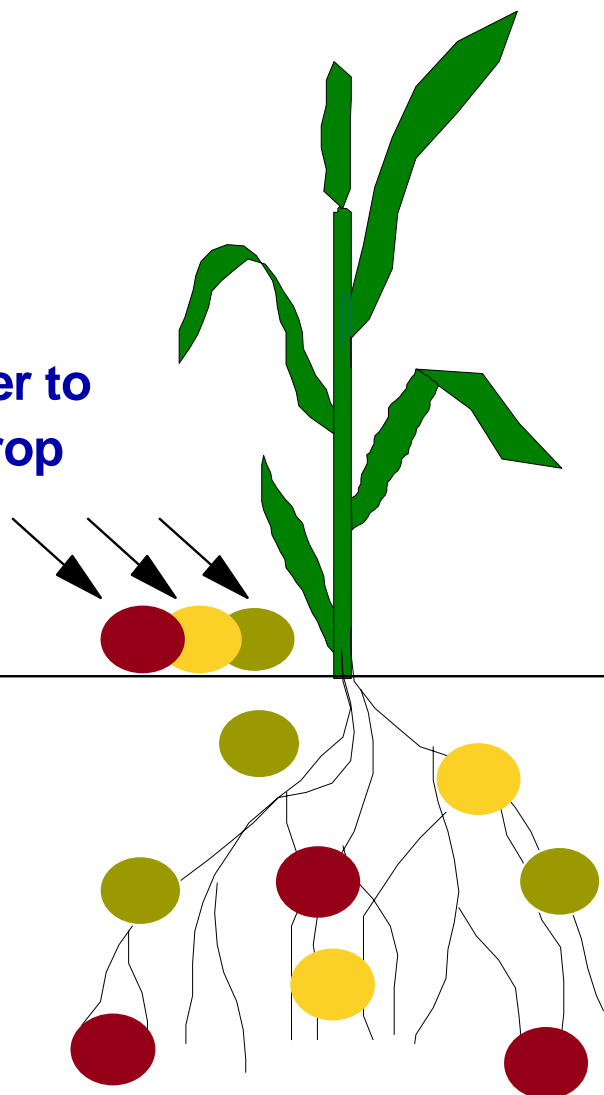
Principle

- ✓ The crop takes up nutrients from the soil. A certain nutrient content of the soil is recommended and shall be maintained through fertilizer application.
- ✓ weak relation between the nutrient content in the soil and crop yield
- ✓ nutrients in the soil are not always plant available

Hydro Agri

"Just-in-time" nutrient management

fertilizer to
the crop



Principle

- ✓ the nutritional status of the crop determines the application rate and timing

Benefits

- ✓ higher nutrient use efficiency because nutrients applied when needed

Prerequisites ~ Research

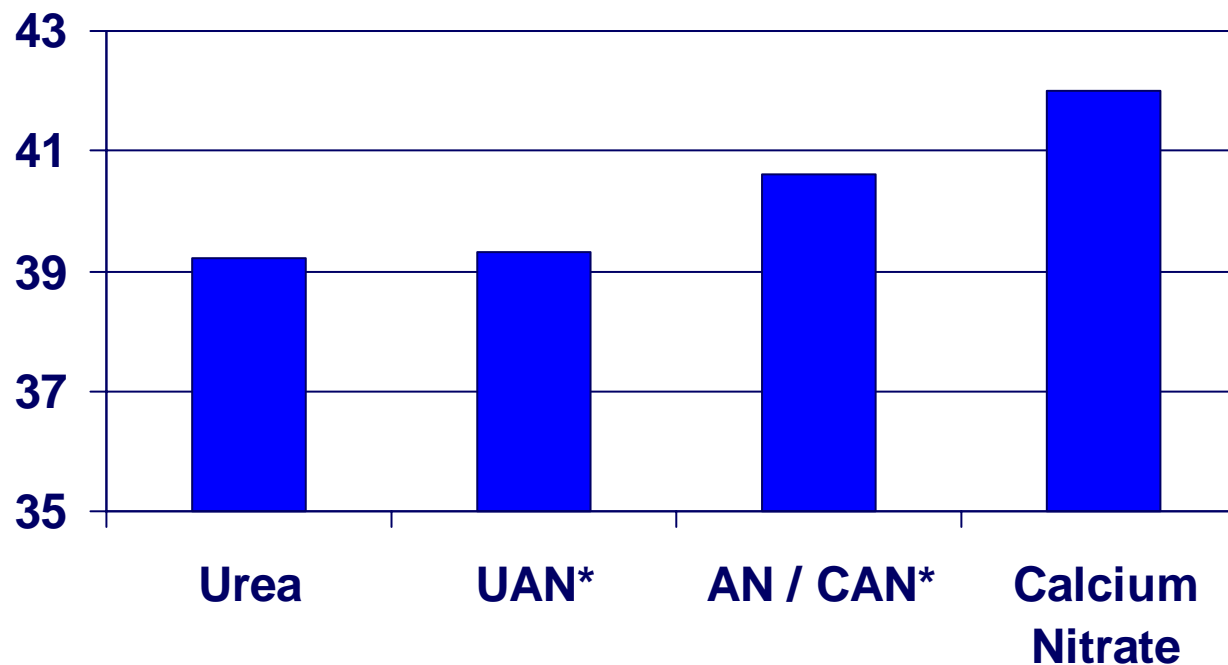
- ✓ efficient fertilizers
- ✓ balanced nutrition
- ✓ advanced nutrient delivery systems
- ✓ diagnostic tools



Nitrate fertilizers are more efficient!

Oil seed rape, UK: average of 15 trials (1994 – 98), N rate: 200 kg N/ha

Yield (dt/ha)



*UAN = Urea Ammonium Nitrate solution

*AN = Ammonium Nitrate

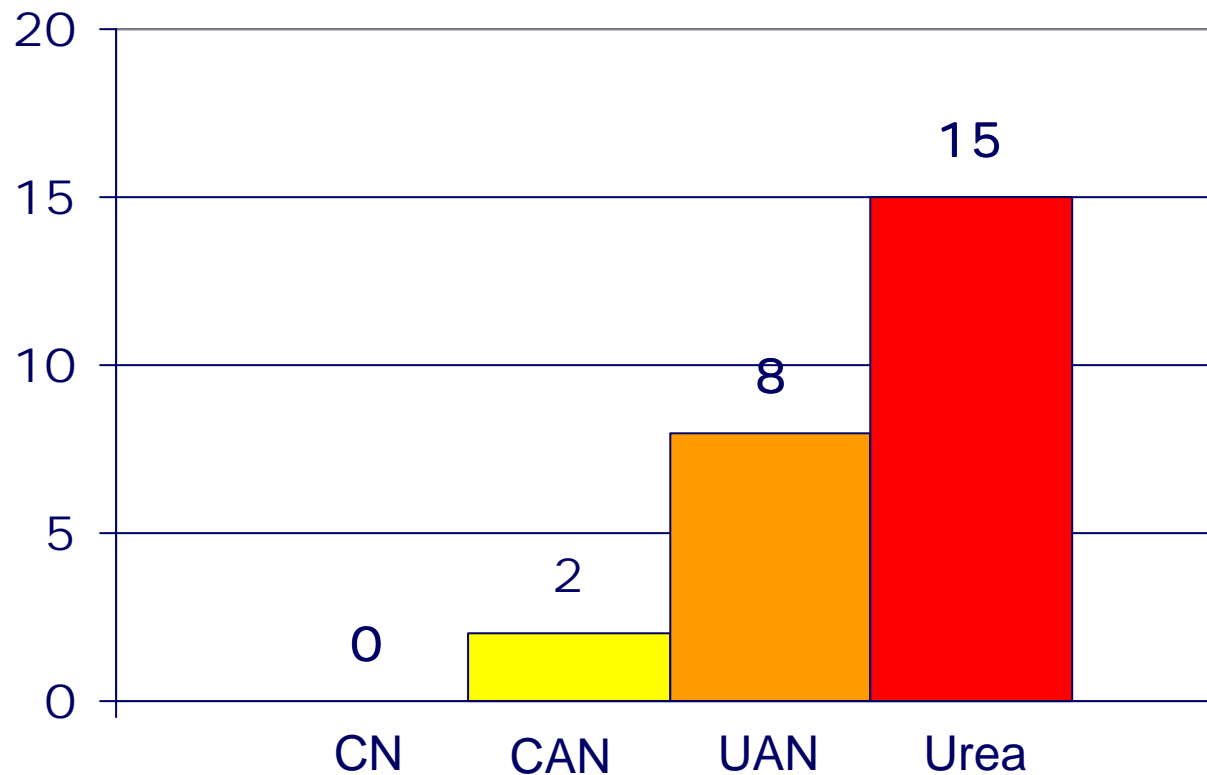
*CAN = Calcium Ammonium Nitrate

Source: Levington Agriculture, UK (1999)

Average ammonia losses from mineral fertilizers Temperate climate



Ammonia losses (in % of the N application)

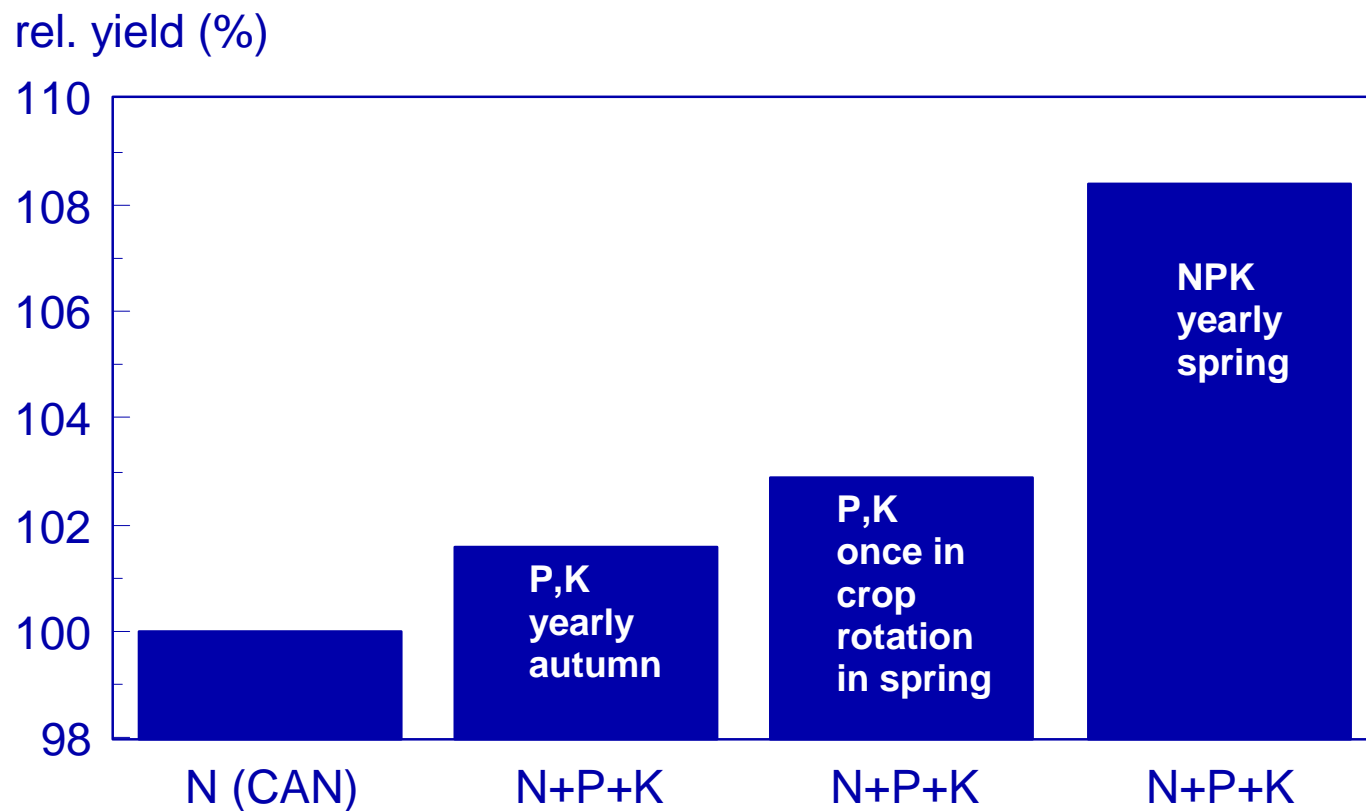


Source: ECETOC study



Balanced nutrition: The Starter Concept

Advantages of an annual application of NPK in spring compared to an application in autumn or once in the crop rotation



(CAN=100 %, average of 7 long-term trials, 6th year)

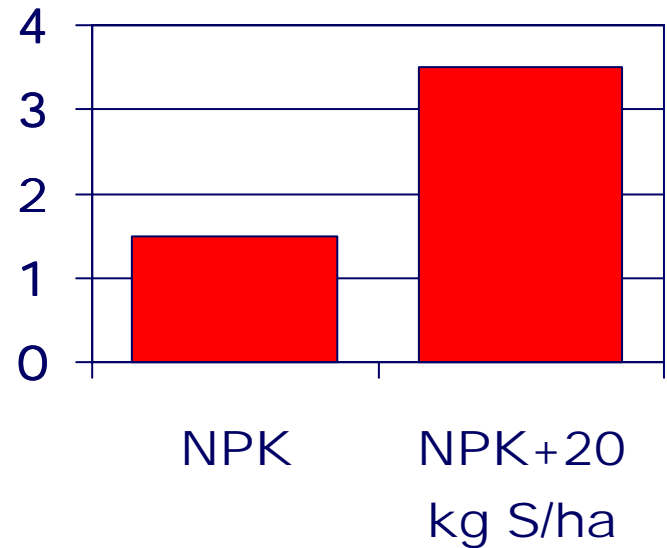
Crops require more than NPK:

"balanced" fertilisation with respect to all macro and micro nutrients



Fertilizer application (kg/ha)	no S Fertilization Yield 1.5 t/ha	20 kg S/ha Yield 3.5 t/ha	increased uptake due to 20 kg S/ha
	Nutrient uptake (kg/ha)	Nutrient uptake (kg/ha)	(kg/ha)
N 200	100	220	+ 120 N
P 50	20	45	+ 25 P
K 220	110	240	+ 130 K
Mg 50	15	40	+ 25 Mg

Oil seed rape yield
(Field trial RC Hanninghof)



Fertiliser rate both treatments:

200 kg N/ha

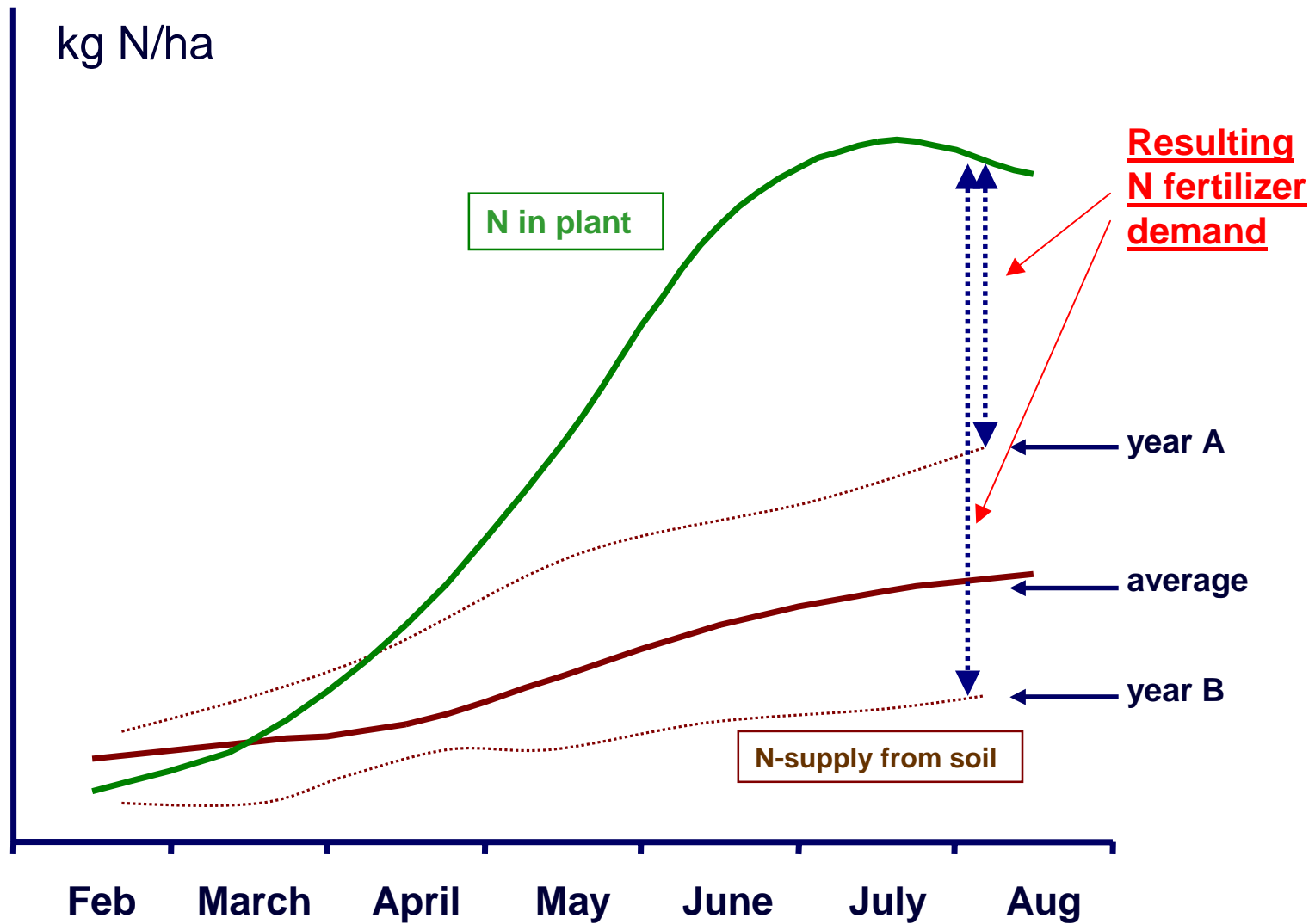
50 kg P/ha

220 kg K/ha

- ✓ increased revenues for the grower
- ✓ Improved fertilizer use efficiency

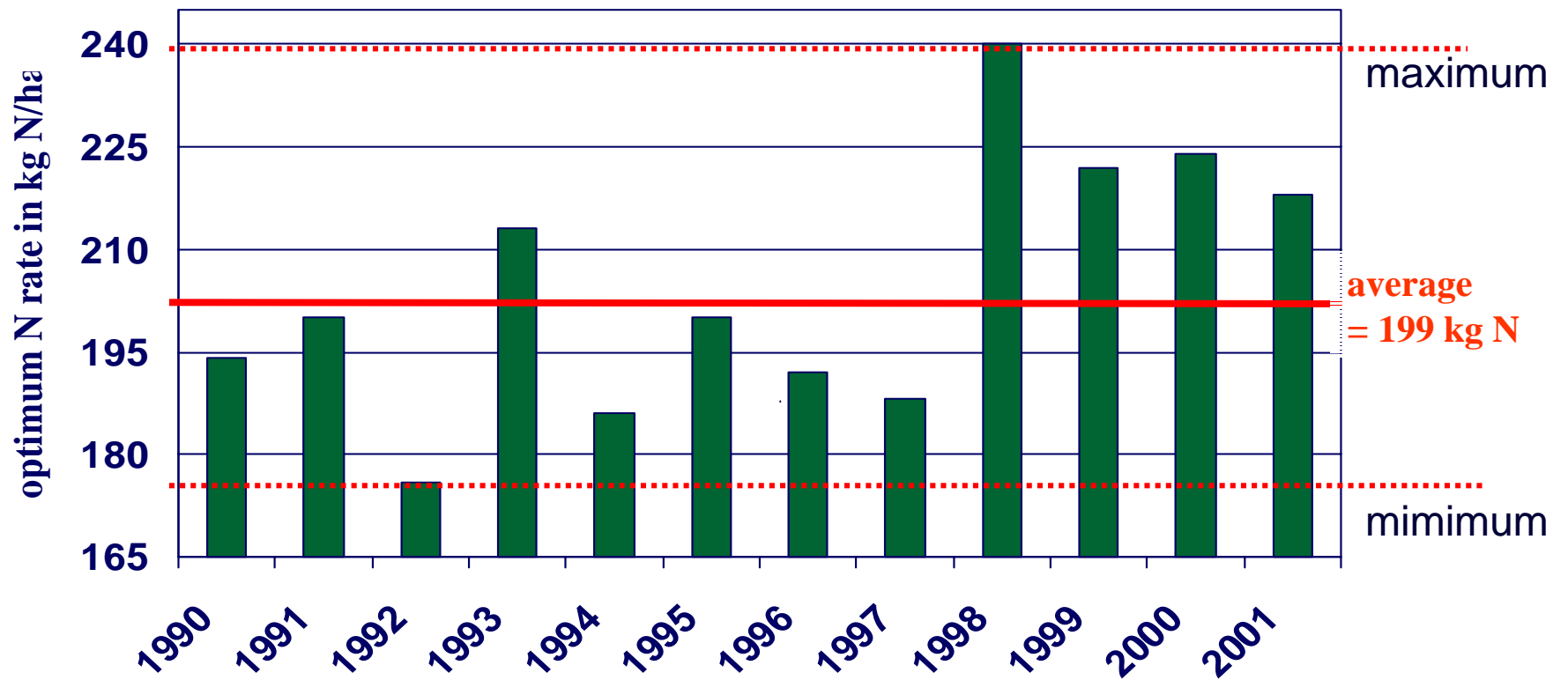


Evaluation of the N fertilizer demand (schematic)





Variation of the economic optimum N rate at one single site in a winter wheat trial during 11 years



Rothamsted, UK



Tools to diagnose the nutritional status of crops

- **lab analysis of plant nutrient content**
- **on-farm chemical tests (e.g. tissue nitrate concentration)**
- **in-field equipment for plant testing (e.g. Hydro-N-Tester)**
- **remote sensing (Hydro N-Sensor)**



Hydro N-Tester

An accurate and convenient tool for nitrogen fertilizer management

- ✓ the N-status is deduced from the chlorophyll content of the leaves
- ✓ the N fertilizer rate is adjusted to the N status
- ✓ the Hydro N-Tester has been well accepted by farmers in several countries
- ✓ the Hydro N-Tester is approved by authorities in several countries

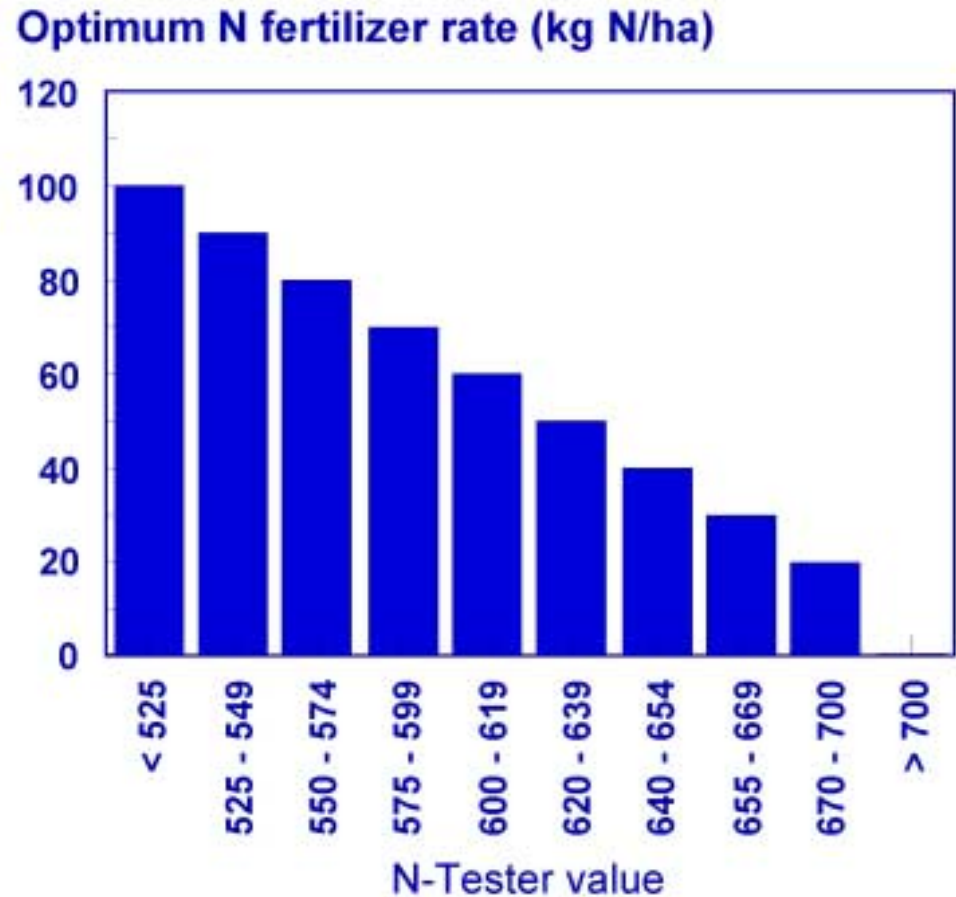




Hydro N-Tester

Nitrogen fertilizer management - Example

To conclude from the Hydro N-Tester reading on the nitrogen fertilizer demand (kg N/ha), cereals, Example Germany



Winter wheat, 2nd N dressing at stem elongation, Germany, 2001



Hydro N-Sensor

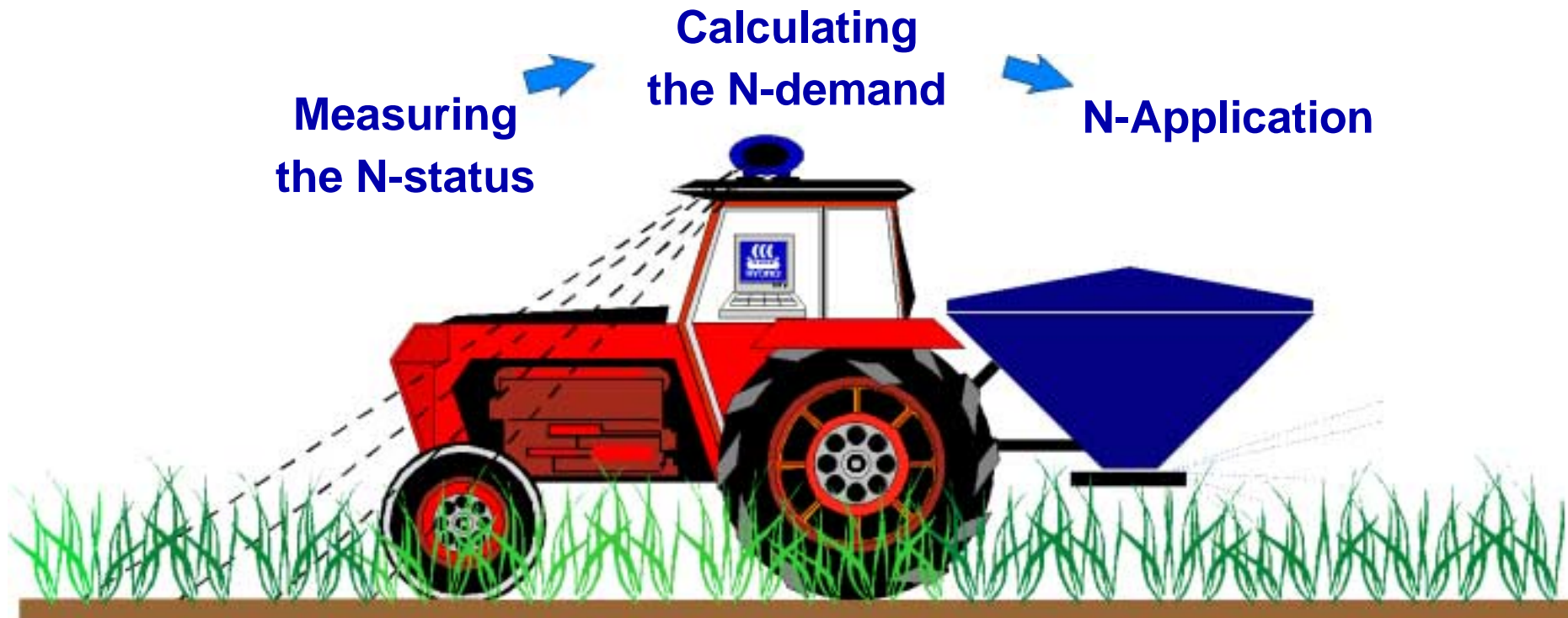
The Challenge for the Grower is to respond to variation within a field



Hydro N-Sensor



A unique system to measure the N-status, to calculate the N-demand and to apply the right amount of N on every spot of the field





Hydro N-Sensor

Higher yield and quality → More profit for the grower

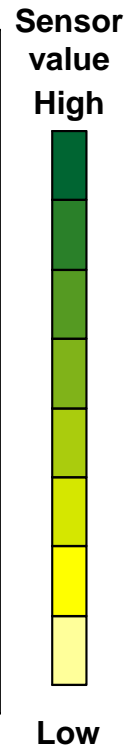
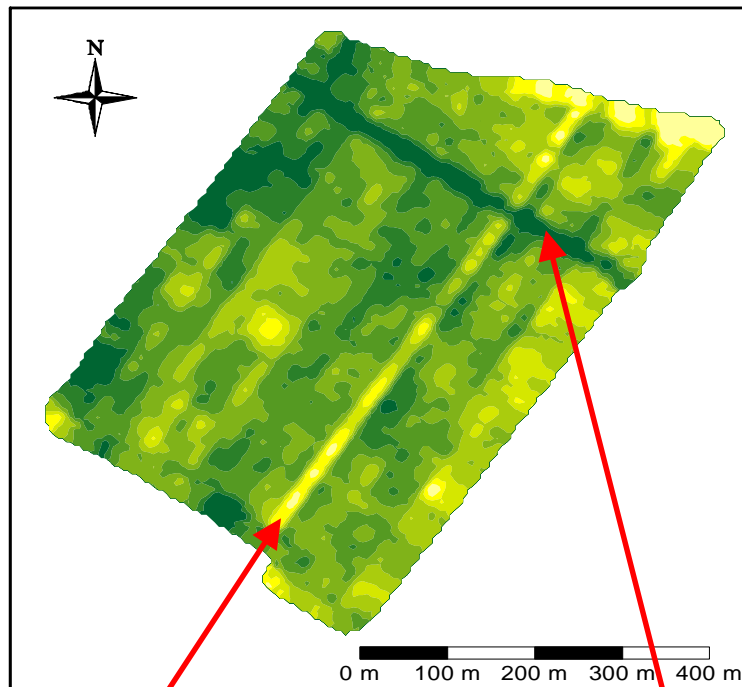
- ✓ Mountable on every tractor and truck
- ✓ Compatible with all spreader manufacturers
- ✓ Data-logging on data card
- ✓ Farmers can generate N-application maps on Hydro Agri's internet software *Sensor Office*



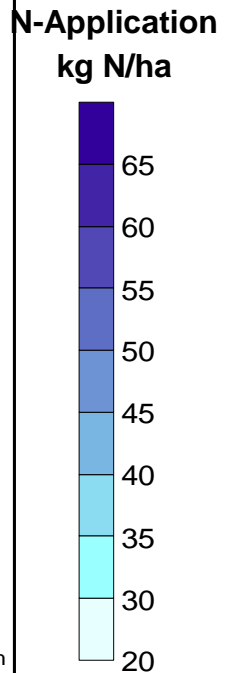
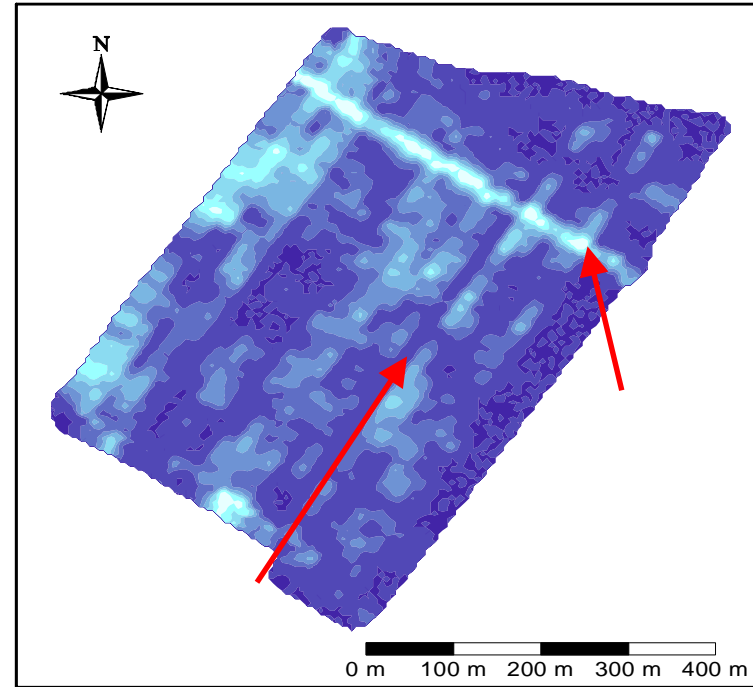
The Hydro N-Sensor detects areas of different N supply



Sensor Map



N-Application Map



reduced N-Application
(-35 kg N/ha), at 1st N Rate

Additional N-Application
(+35 kg N/ha) at 1st N Rate

Winter Wheat Field
N-Sensor Measurement and N
Application 30. 04.02
Source: Leading Farmers,
Czech Republic



Agronomic use of the Hydro N-Sensor

✓ Commercial use on farms

- Cereals (Europe)
- Oil seed rape (Europe)
- Maize (Europe)
- Rice (Japan)

✓ Testing and adaptation

- Wheat, Maize (Canada)
- Cotton (North America)
- Wheat, Corn (South America)
- Sugar cane (South America)
- Potatoes (Europe)



➔ More than **270** Hydro N-Sensors are in use on practical farms



Summary

- Plant nutrients will continue to be the most important input into agricultural production
- Mineral fertilizers are a necessity for sustainable agriculture
- The additional energy yield from nitrogen fertilizer use is seven times the energy input
- Arable farmer in Europe may explore the potential to produce renewable energy and to reduce CO₂ emissions
- To further increase the fertilizer use efficiency, Hydro is currently developing tools and products for a “just-in-time” plant nutrition management