Innovations in nutrient management

Gerard Velthof

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INTERREG IVB

BIOREFINE

Outline

- Introduction
  - Need for nutrients in food production
  - Yield gap
- Challenges to decrease yield gap and increase nutrient used efficiency
- Innovations in fertilization
- Conclusions

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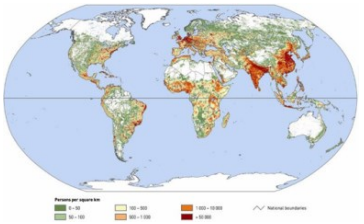
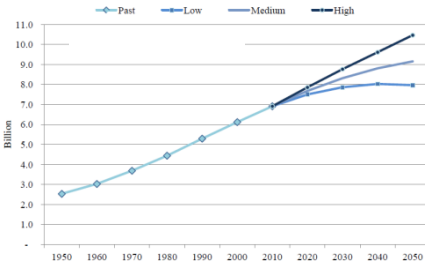
Rapid changes occur in food production

- Increasing population: more food needed
- Urbanisation & wealth: more animal-derived food
- Globalisation: agglomeration & transport
- Technological developments: changing systems
- Policies: agriculture, industry, environment





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Essential nutrients

Plants need 14 nutrient elements (in addition to C, H, O):
N, P, K, Mg, Ca, S, Fe, Mn, Zn, Cu, B, Mo, Cl (Ni)

Animals and humans need 22 nutrient elements:
N, P, K, Mg, Ca, S, Fe, Mn, Zn, Cu, Mo, Cl, Co, Na, Se, I, Cr, Ni, V, Sn, As, F

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Uneven distribution on the globe

- Distribution of food
  - More than 2 billion people in the world suffer from nutrient deficiency (protein N, P, Ca, Zn, Fe, I)
  - In 2008, more than 1.4 billion adults were overweight
- Distribution of nutrients
  - Easy accessible reserves become depleted (phosphorus) P
  - Surpluses lead to pollution



Food has high nutrient cost

- Production of 1 kg N in food on plate: 4-12 kg "new" N
- Production of 1 kg P in food on plate: 4-12 kg "new" P
- High losses of N and P to the environment in system crop production - animal production - food processing - retail – households

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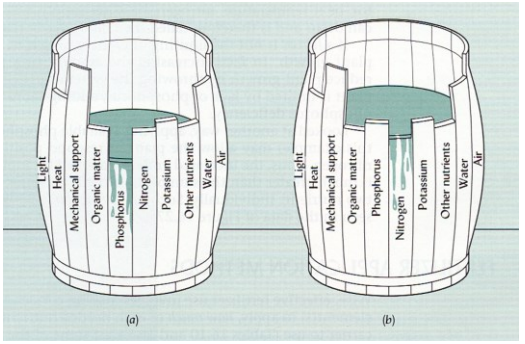
Ma et al., 2010, 2012
Van Dijk et al., 2013

How to increase yields and nutrient use efficiency?

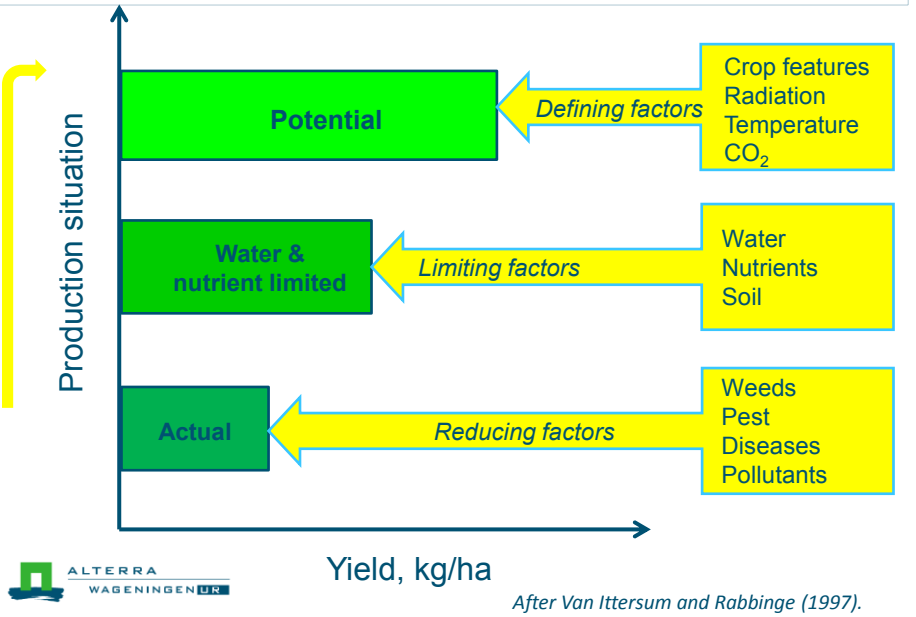
Law of the minimum (1850):

"Plant production cannot be greater than the level allowed by the growth factor present in the lowest amount"

Justus Liebig
1803-1873



Crop production ecological principles



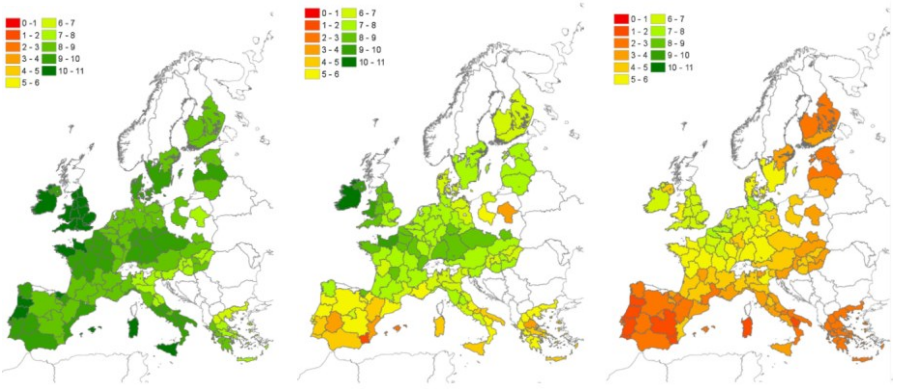
After Van Ittersum and Rabbinge (1997).

Yield gap winter wheat

Potential yield (calculated)

Water limited yield (calculated)

Actual yield (statistic Eurostat)



Boogaard et al., 2013

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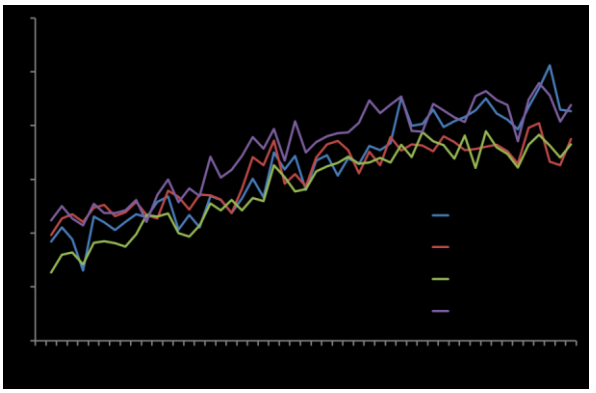
Why are wheat yield levelling off?



Country	Year of yield stagnation
Denmark	1995
France	1996
Germany	1999
Italy	1994
Netherlands	1993
Spain	1989
Switzerland	1990
United Kingdom	1996

Brisson et al. (2010)

Brisson et al. (2010) wheat in France:
Genetic progress may have been counterbalanced by climatic change (heat stress and drought) and agronomic causes (changes in rotation and less N input)

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Challenges to increase nutrient use efficiency

- Existing technologies
  - Education, demonstration, and training needed
  - Tools and instruments needed
  - Incentives needed

- Innovations

Innovations

- Crop: breeding, rotations, protection against diseases

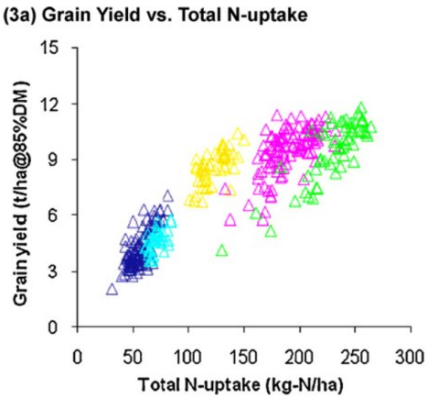
- Soil and water management

- Improved fertilization techniques: 4R strategy
  - right fertilizer source
  - right rate
  - right time
  - right placement

- Recycling of nutrients of manure and wastes

Genetic improvement of crops

- Genotype improvement
- Gene-environment interactions: water-nutrient-soil-root

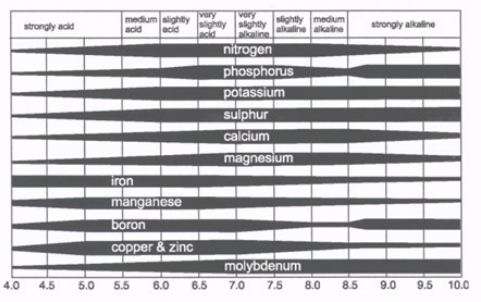


Barraclough et al. (2010)

Improved soil tests

- New and rapid methods to analyse soil samples
  - near-infrared (NIR) spectroscopy
- Simultaneous and rapid analysis of nutrients, pH and soil properties in one soil sample
- Fertilizer recommendations can be based on interactions between nutrients, soil properties, and pH

Blgg Agroexpertus



Precision fertilization techniques

- 3S technology rapidly evolving: GIS, RS and GPS
  - Geographical Information System (GIS)
  - Remote sensing (RS)
  - Global Positioning System (GPS)
- Use of rapid soil and crop tests
- Use with weather data and projections
- Crop growth models
- Development of internet based Decision Support Systems: dynamic fertilization strategies

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But ……

- Availability of data related to soil, crop, field, weather etc. strongly increases, but ……
- Challenge: how can these data be used to derive fertilizer recommendations for the farmers:
  - right fertilizer source, rate, time, placement
  - interactions between factors
- Need of development of models and calculation rules
  - calibration/validation in field and pot experiments

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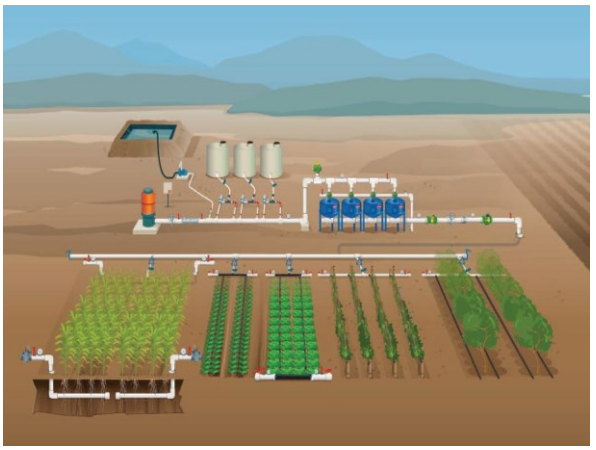
Fertigation = drip irrigation + fertilization



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Innovations in fertilizer types

- Multi-nutrient
  - N, P, and K
  - More focus on: Ca, Mg, S, micro-nutrients, Se
  - Ratio between nutrients dependent of crop → precision agriculture
- Slow-release (coatings), use of inhibitors (urease, nitrification), solid versus liquid (row application)
- Use of recycled nutrients from wastes and by products in fertilizers

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Global amounts of P in by-products and wastes

Sources	Amounts Mt P per year
Animal manures	20 - 30
Sewage sludge	3 – 5
Phosphogypsum	0.3 – 2
Composts from crop residues, processing industry	0.1- 1
Ashes from coal-driven power plants	1 – 10
Ashes from biomass and waste incineration	0.1 – 2
Ashes from the steel industry (basic slag)	0.5 – 1
Animal bones from slaughter houses	0.1 – 1
Fish	0.3 - 0.6
Mining P-rich soils	< 0.1
Dredged sediments	< 0.1
Stone meal, crushed olivine, amphibolites, low-grade P rocks	1-10

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Oenema et al., 2012

Challenges for recycling of P

- Variable composition and P availability
- Potential presence of contaminants
- Unknown legal status
- Low acceptance by farmers
- Lack of a proper marketing and distribution infrastructure

Strategies should be developed for optimal

long-term use of the various possible P and other nutrient sources

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Conclusions

- Innovations in fertilization strategies:
  - Tools for fertilization recommendations
    - Rapid soil and crop tests
    - GIS, RS, and GPS
    - Internet based fertilization tools
    - Need for models and calculation rules
      - calibration/validation in experiments
  - Fertilization (water – nutrients)
  - New fertilizer types and application methods
  - Recycling of nutrients in manure and wastes

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Thank you!

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