Newcastle University

Nafferton Ecological Farming Group

Systemic change needed in the food system to obtain sustainability (and future food security?)

Carlo Leifert

"Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist"

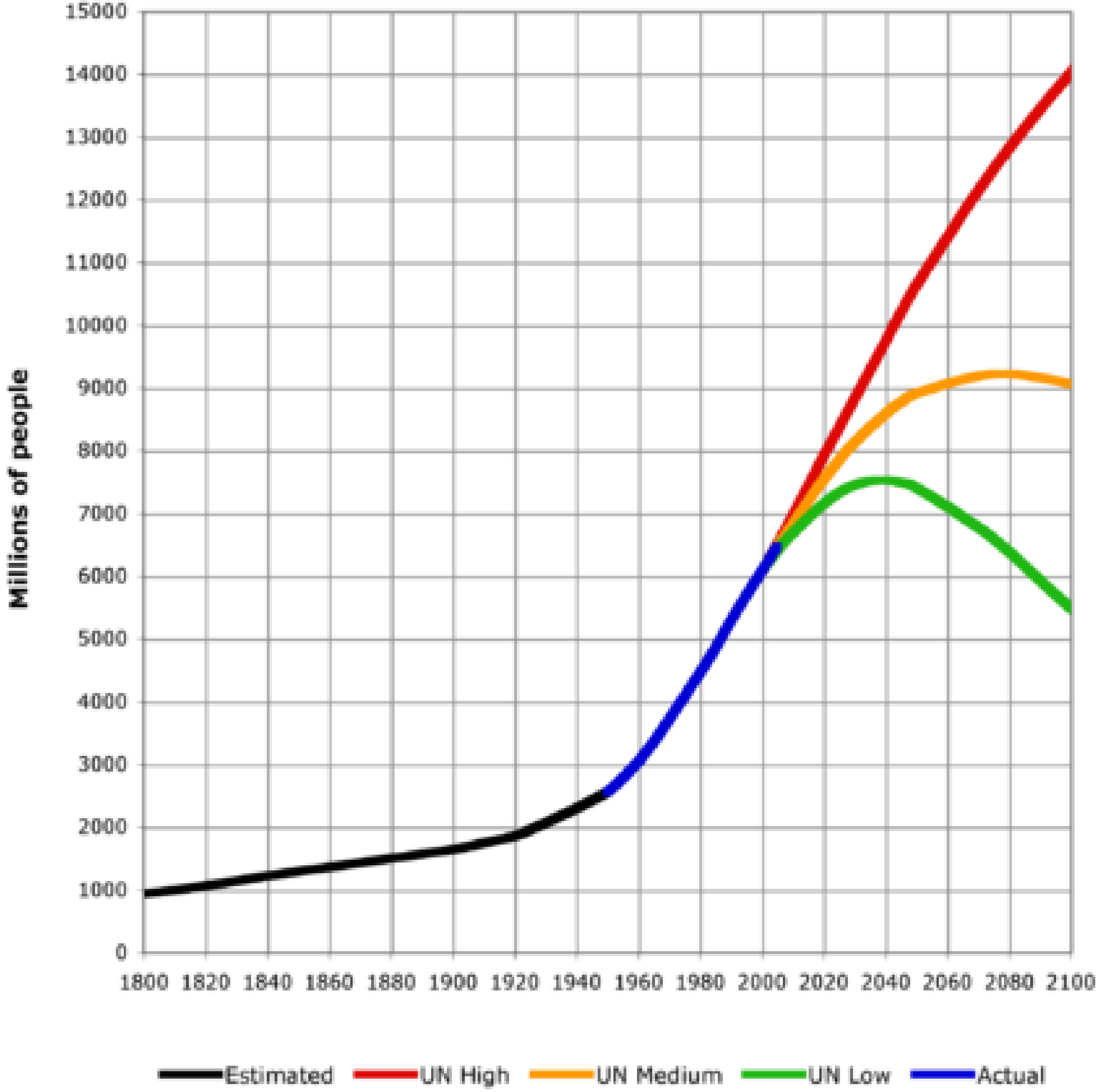
Kenneth Boulding, economist

Contents

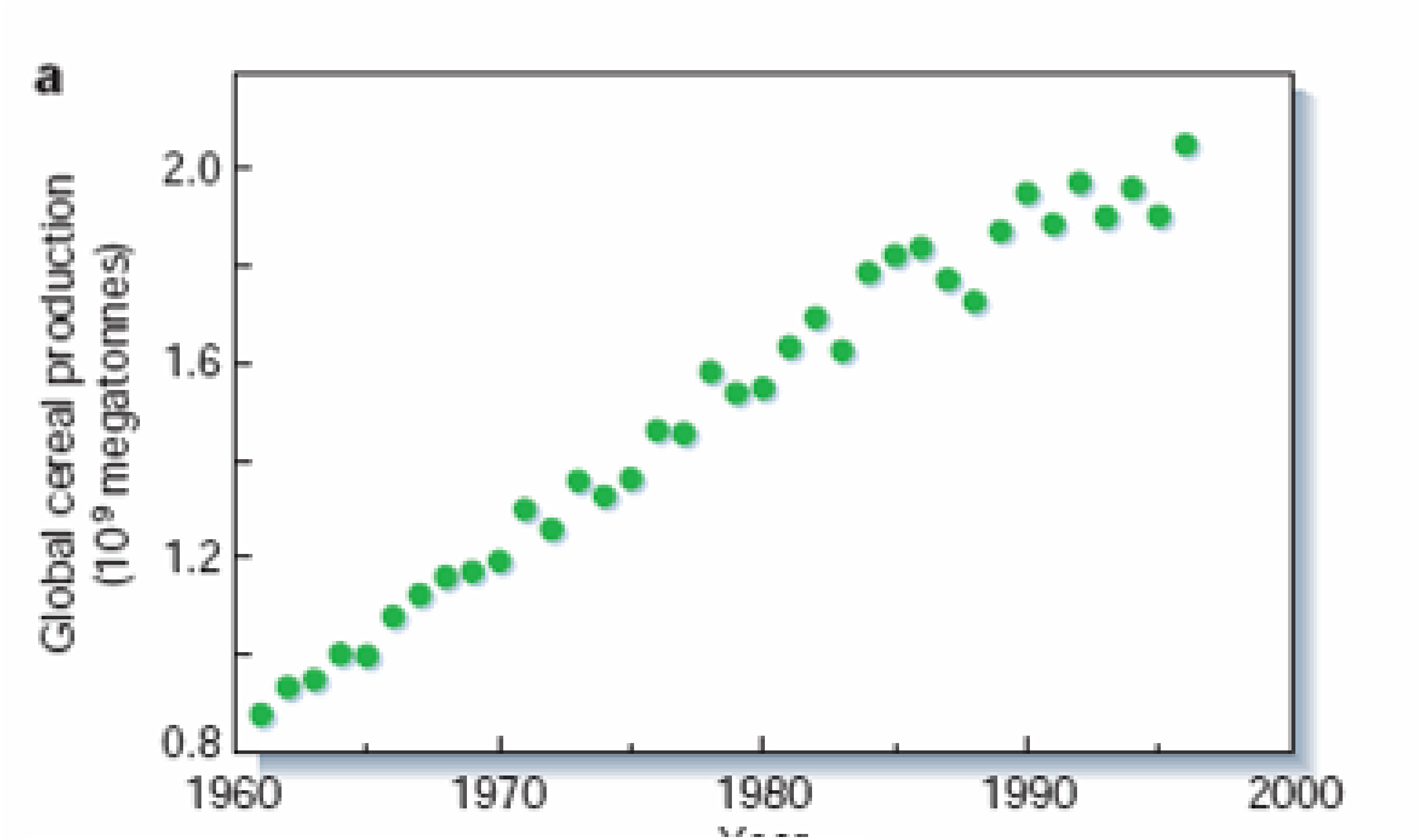
1. Challenge of “Food Security”
2. Global trends in agriculture
   - Yield
   - Resource use (NP-fertilisers/water/pesticides)
   - Resource use efficiency
3. Factors limiting crop yields in the future
   - N-fertilisers
   - P-fertilisers
   - Nutrient use efficiency
4. Strategies to improve the sustainability of food production

Food Security challenge

How can we feed 9 billion people in a sustainable way?



Total global cereal production



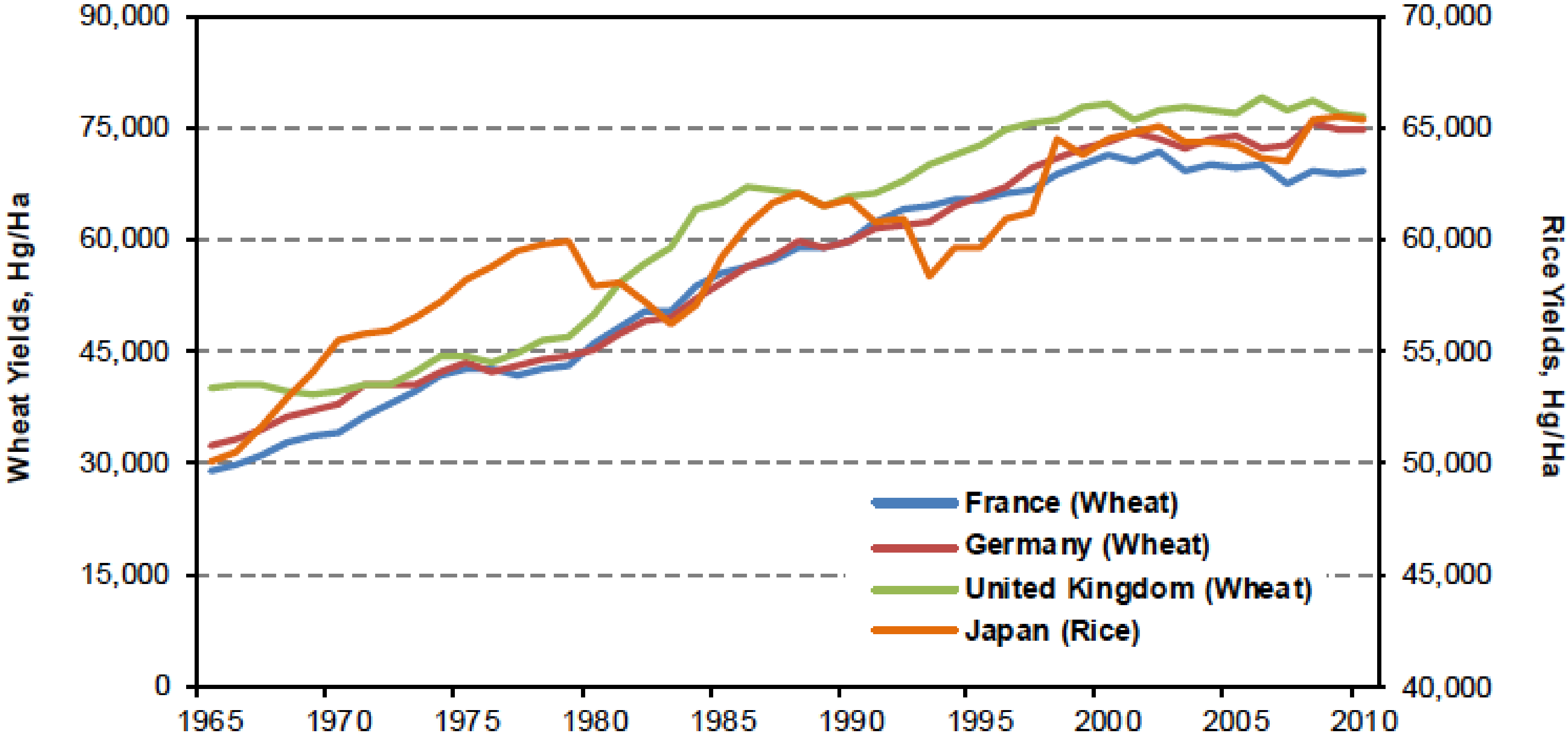
Tillman et al. (2002) *Nature* 418, 671-677

Rothamsted Research, BBSRC Institute, UK

Target: 20 t ha^{-1} for wheat in UK by 2020

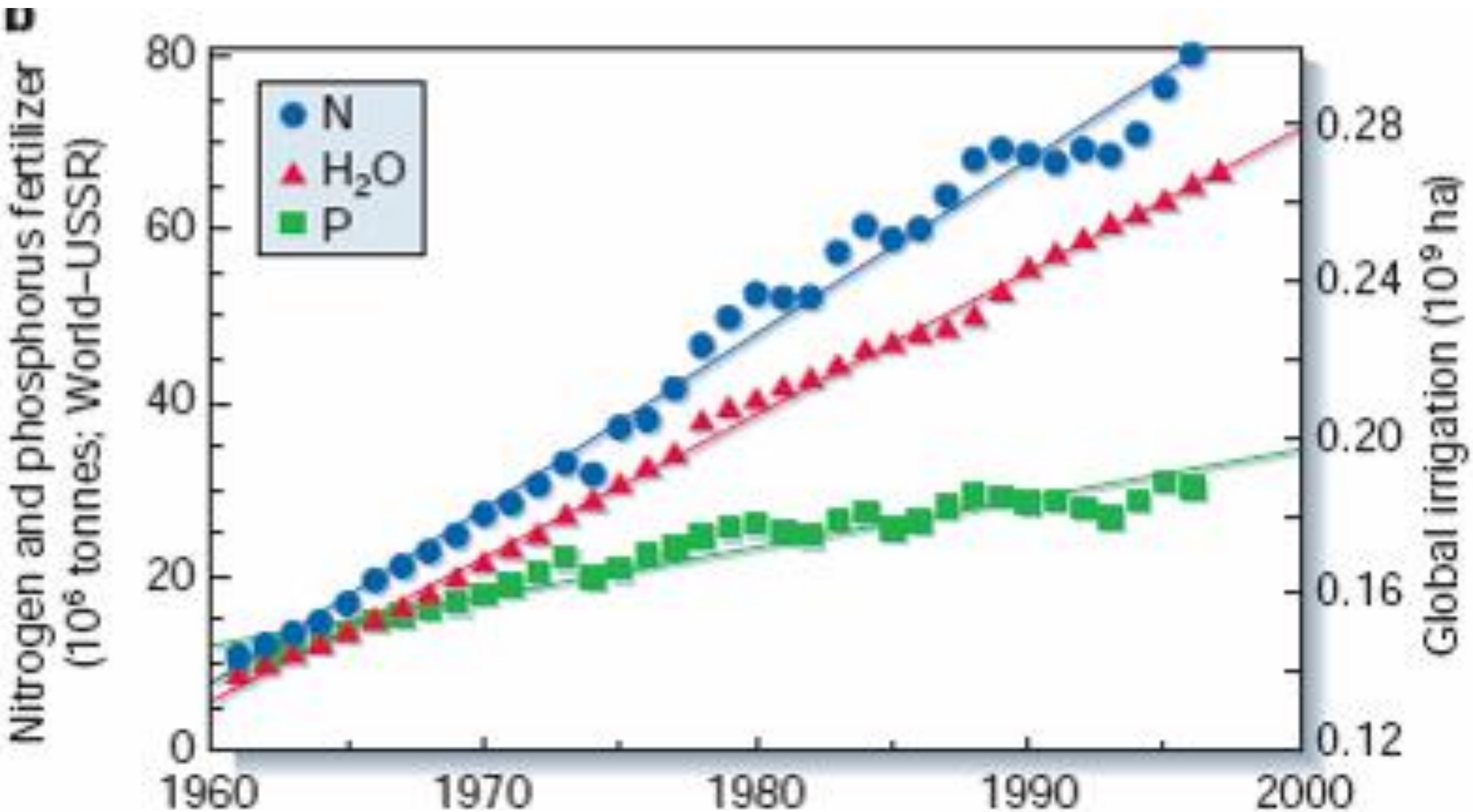
Method: GMO-technology + more agrochemicals

Exhibit 1
Crop Yields (5-year moving average)
Wheat – France, Germany, United Kingdom; Rice – Japan



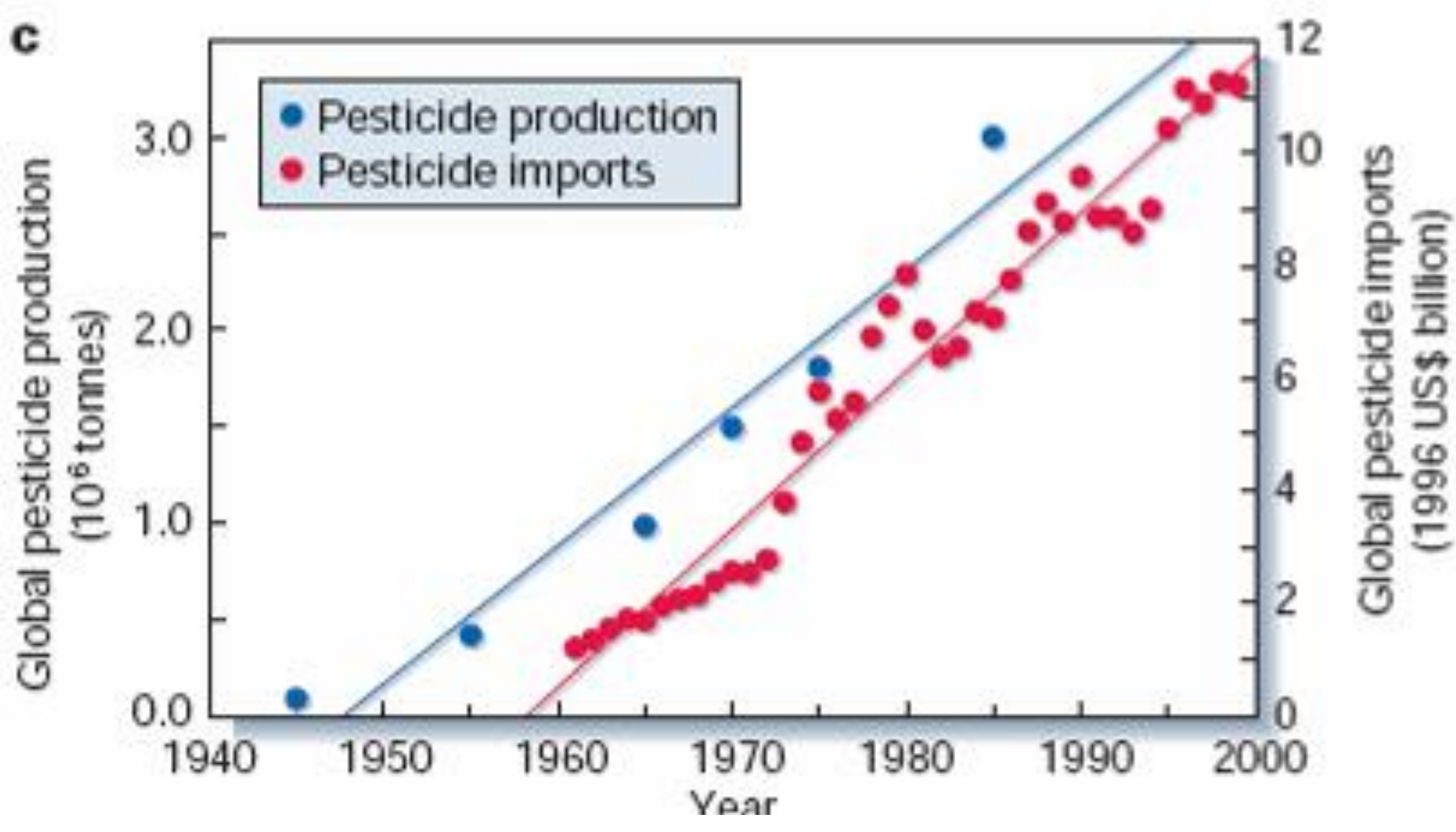
Source: UN Food and Agriculture Organization *As of 12/31/10*

Total global use of nitrogen, phosphorus and area of irrigated land



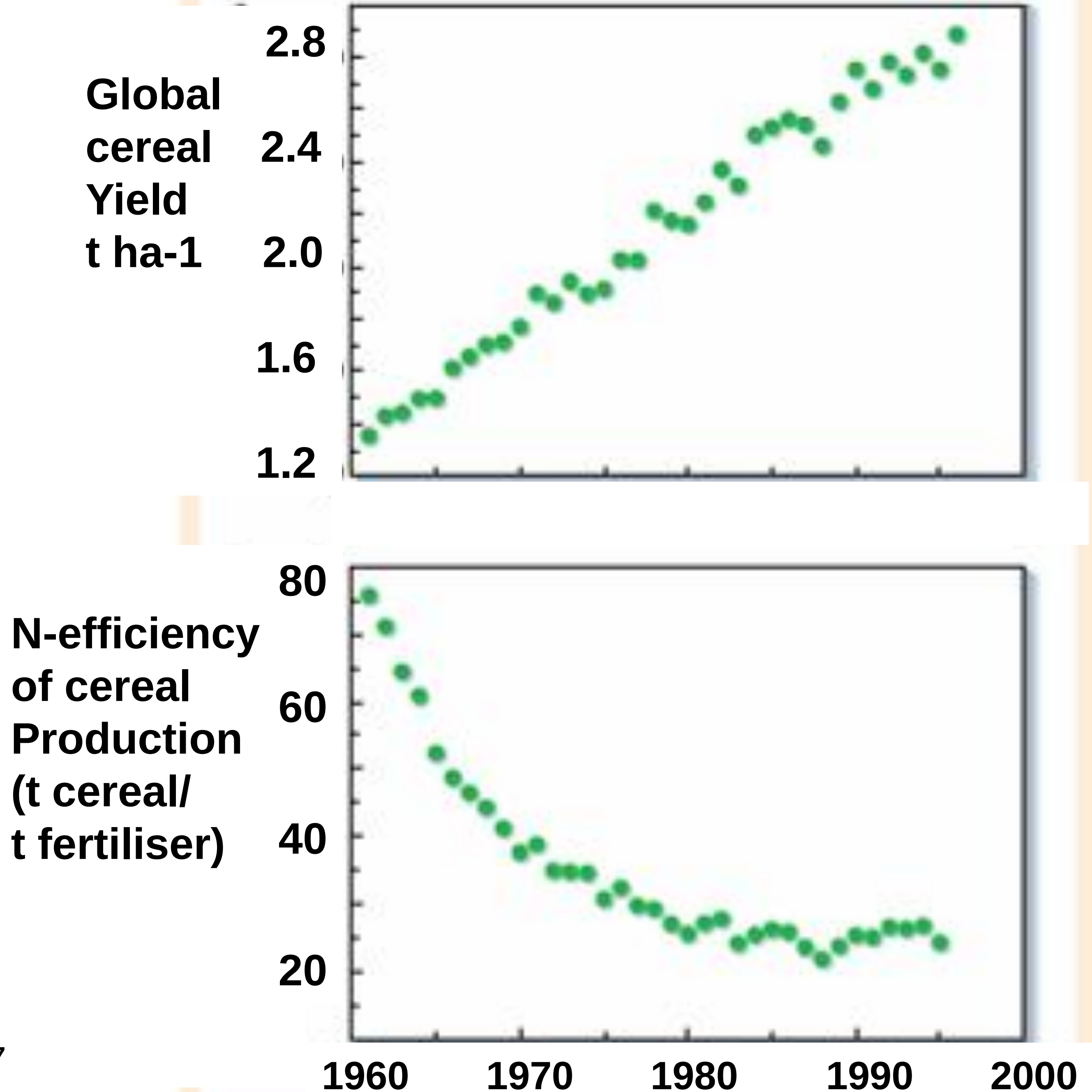
Tillman et al. (2002) ***Nature*** 418, 671-677

Total global pesticide production and global pesticide imports



Tillman et al. (2002) *Nature* 418, 671-677

Diminishing returns of fertiliser applications



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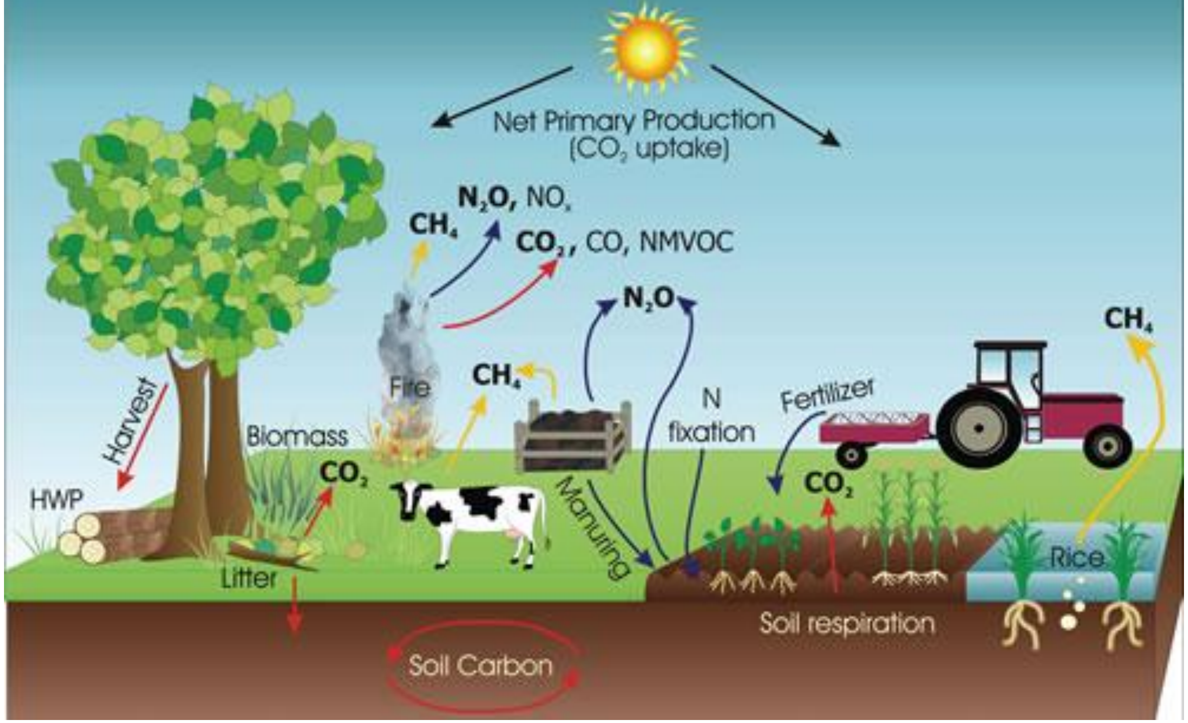


What will limit crop yields in the future?

Availability and costs of:

Nitrogen (N) = energy

Phosphorus (P)

Potassium (K)?, other minerals and **WATER**

Energy use – CO_2 emissions

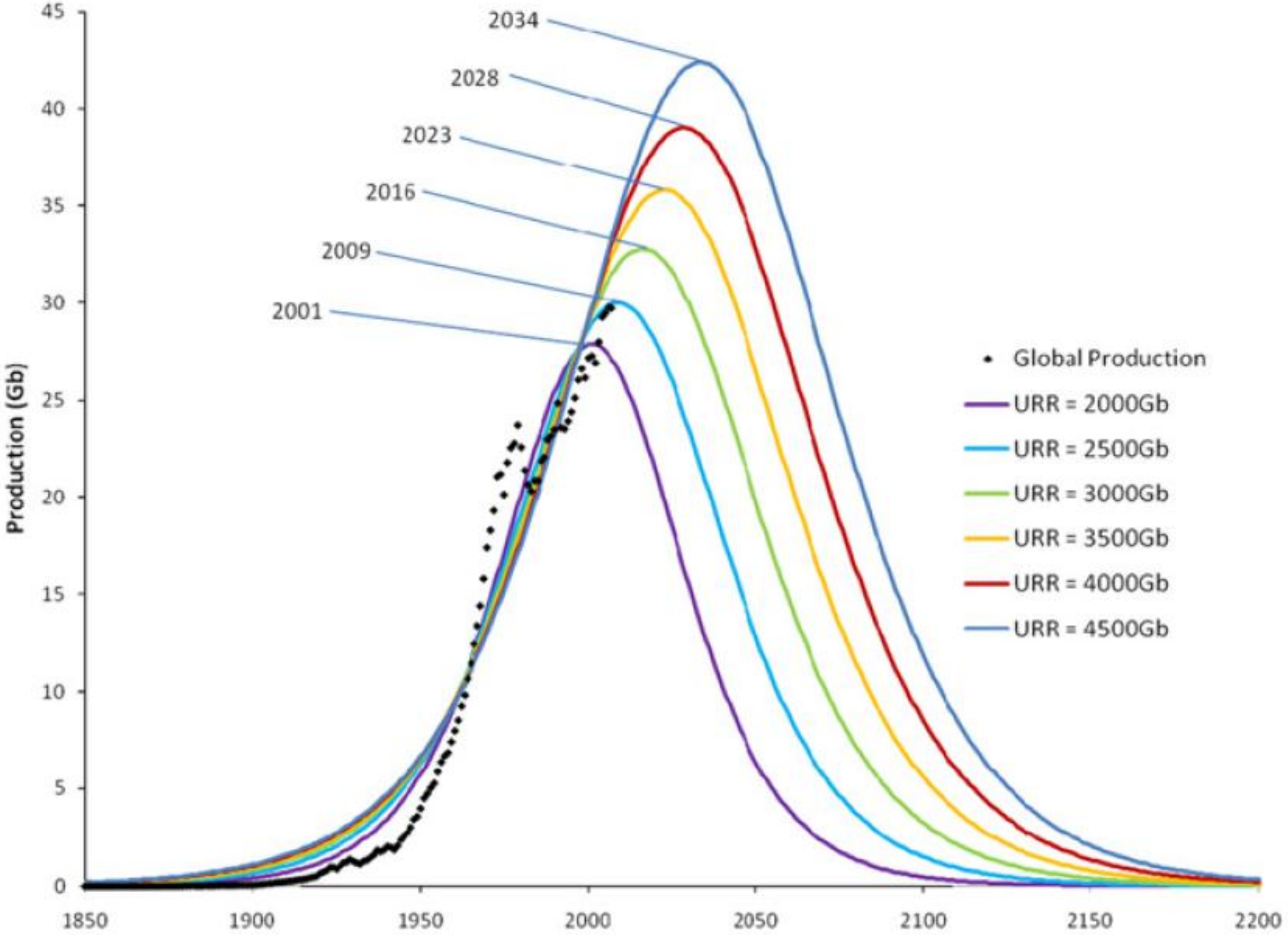
Mineral N-Fertiliser

- 1 kg Nitrogen-fertiliser = 36,000kJ = 1 L fuel
- 1 kg nitrogen fertiliser (NH_3NO_3) results in
  = 2.38 kg CO_2 (equivalents of CO_2, CH_4 and N_2O)
- UK Farm level = 100 ha cereals x 200 kg N/ha/annum
  = 20,000 Litre fuel used
  = 47,600 kg CO_2 into the atmosphere

- European level = 11 Million t N/annum*
  = 11,000 Million Litre fuel used

* Fertiliser Europe (2009) Annual Forecast 2009. www.fertilizereurope.com

Peak of Oil Production



URR= Ultimate Recoverable Resource (Proved + Provable)

(Sorrell et al.,2010)

<u>Proved</u> global reserve: **1,333Gb: 45.7 years-consumption** of 2009
(BP, 2010)

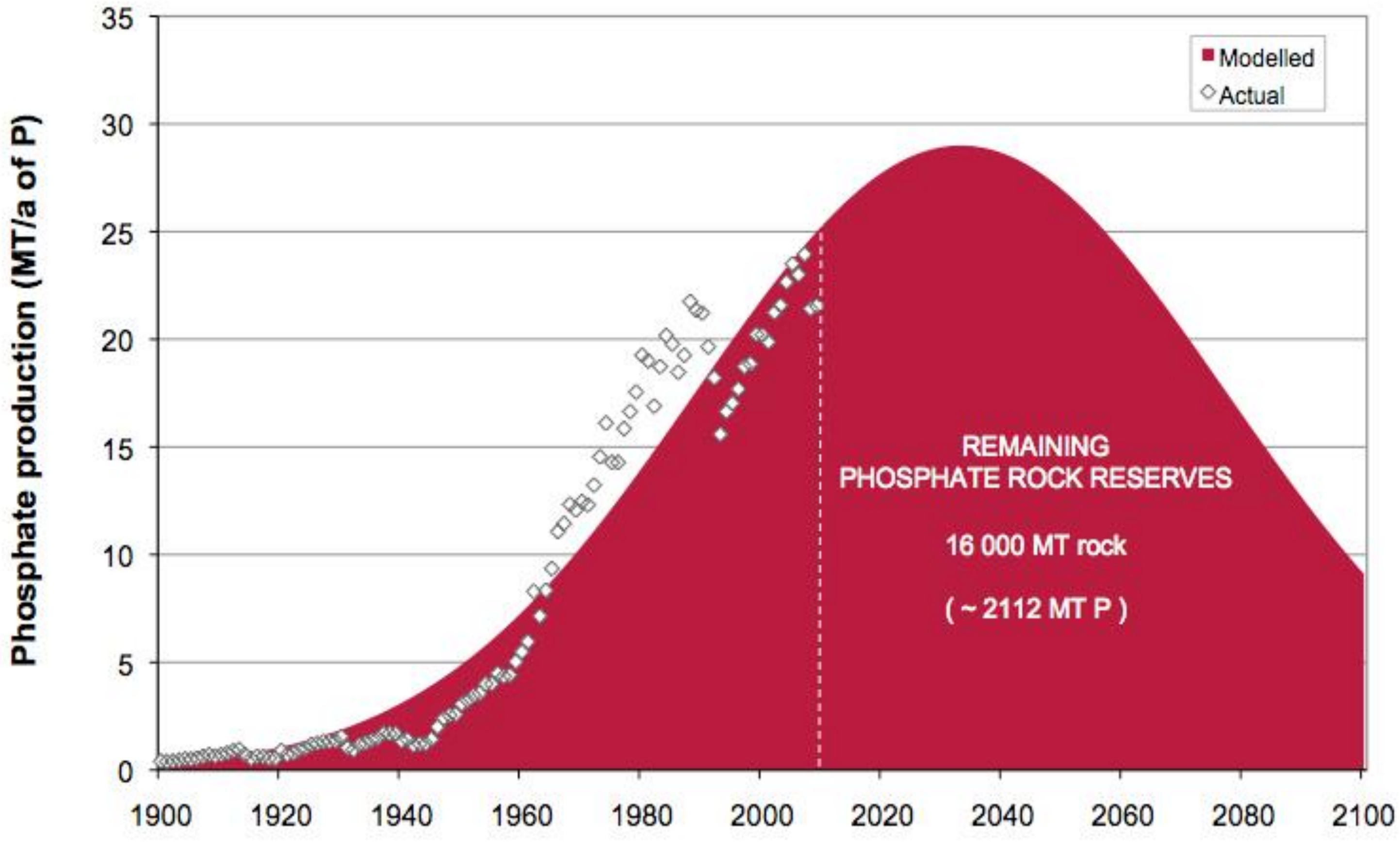
Why will Phosphorus become a bottleneck for productivity?

Phosphorus (P) fertiliser is a mined mineral

- **Currently known P-deposits are estimated to last for between 30 and 100 years**
  - **300 years based on mining/fertiliser industry estimates**
  - **Total annual extraction rates: approx. 150 M tons**
- **World population predicted to rise from 6 to 9 billion**
  - **Phosphorus use is likely to at least double**
  - **We are likely to run out of P much earlier**

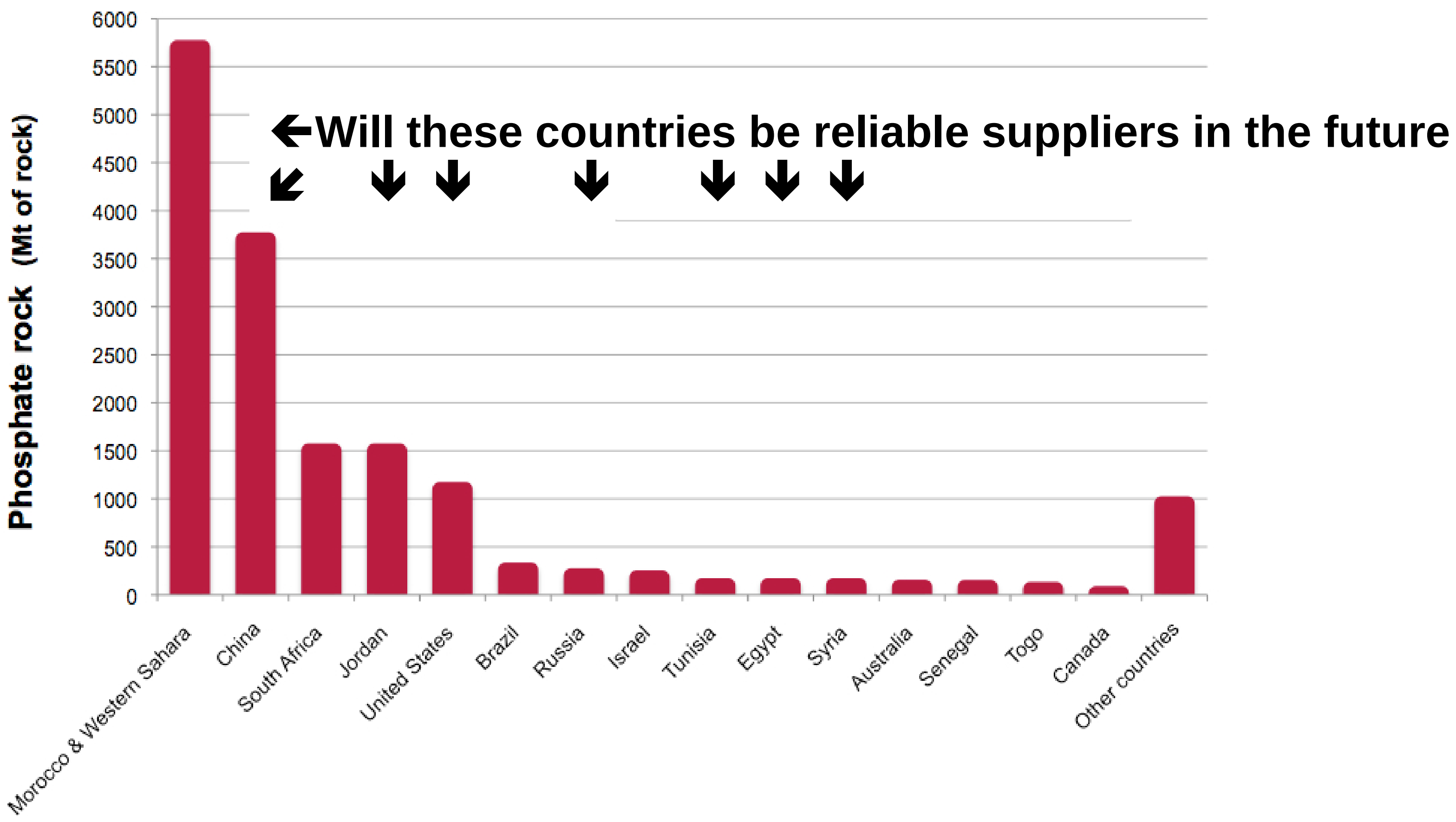
  (certainly earlier than the fertiliser industry estimates)

Peak Phosphorus Curve



Source: Cordell, D, Drangert, J-O & White, S (2009) *The Story of Phosphorus: Global food security and food for thought*. Global Environmental Change, 19 (2), p292-305

World Phosphate Rock Reserves by Country



Data: Jasinski, S (2010) *Phosphate Rock*, *Mineral Commodity Summaries*, US Geological Survey.

Can current farming practice deliver food security?

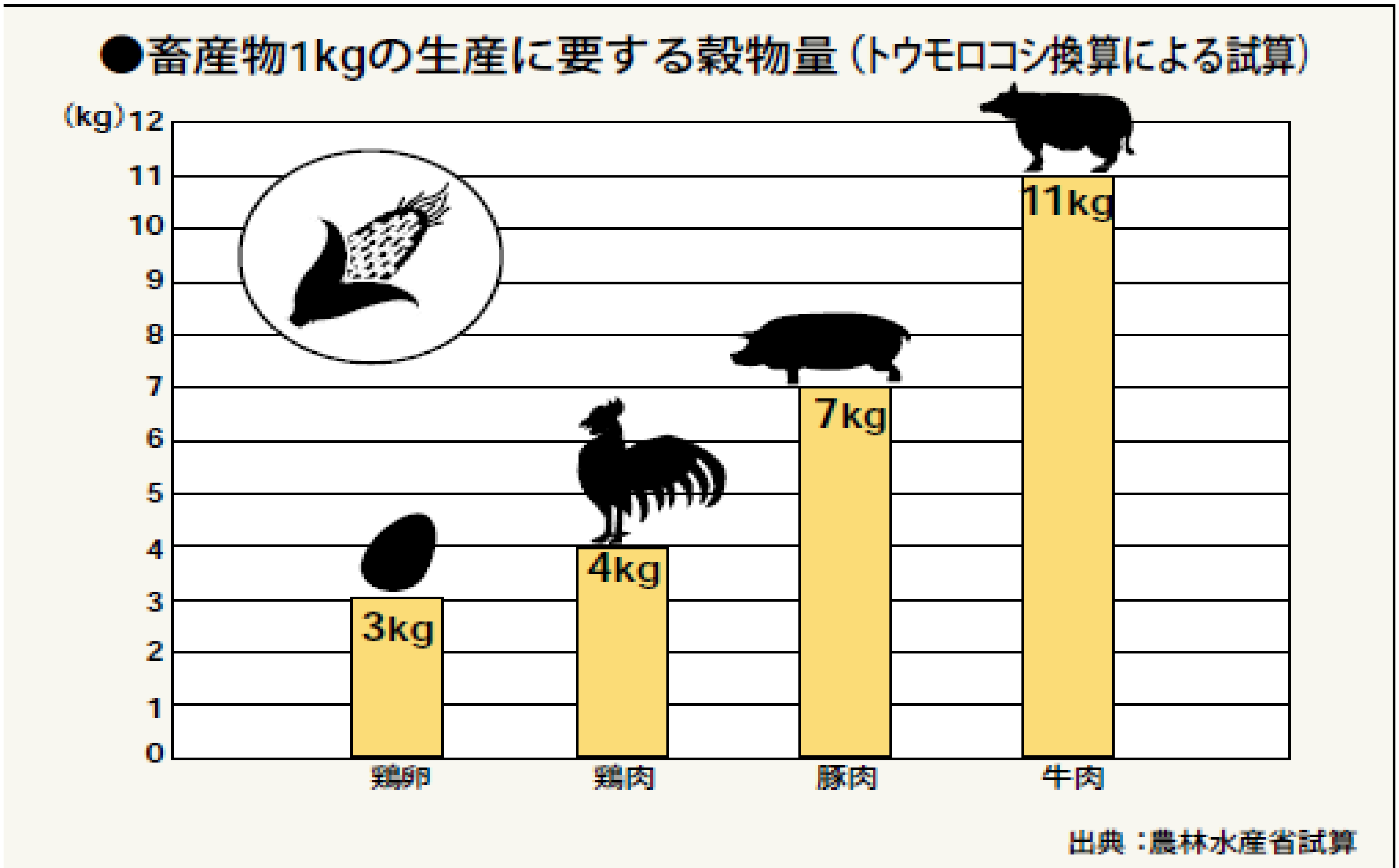
- **High yields** in conventional systems rely on **mineral NPK fertiliser inputs** and **are not sustainable**
  - Mineral **N-fertiliser** manufacture is estimated to account for 10% of total greenhouse gas emissions from agriculture
  - Mineral **P-deposits** will be depleted in 30-100 (300?) years
- **Without mineral P-inputs yields in conventional farming will decline by more than 50%**
- **In the future** mineral fertilisers will need to be replaced by
  - **organic fertilisers** made from both **agricultural and domestic/communal organic waste (= recycling of NPK)**
  - the use of **legume crops** to increase **N-inputs** into soils
- **Currently mineral NPK fertilisers are still too cheap**
  - **BUT mineral fertiliser prices have increased by more than 8-fold in the last 10 years**

What are the solutions?

The main approaches available are:

1. **More efficient recycling of NPK via**
   - **animal and green manures,**
   - **crop residues, food processing waste**
   - **communal and domestic organic waste**
   - **human toilet waste/sewage**
2. **Reduction of losses of fertiliser from soils**
3. **Breeding/selection of more nutrient (especially N and P) efficient crop varieties (EU-NUE crops project)**
4. **Reduce meat, egg and dairy production and consumption**

Amount of cereal (corn-equiv.) necessary to produce 1 kg of livestock products



Can organic farming deliver food security?

- **Crop yields** in organic farming systems are lower
  - by up to **40%** in arable crops such as cereals/potato
  - yields in many horticultural crops are only slightly lower

- There is **great potential to increase yields** in **organic farming** systems by **optimising/increasing organic fertiliser inputs regimes**
  - Evidence from **long term trials in China** suggest that when used **at the same mineral input level,** mineral and organic fertilisers (e.g. manure) will produce **similar yields**

- **There is increasing amount of organic waste !!!!!**
- **Need to integrate better soil management with innovations in other areas (e.g. breeding, crop protection, tillage)**

Barriers for “eco-functional intensification”

- **Organic standards/legislation** which
  - **restrict “imports” of fertility** (principle of on-farm sustainability)
  - **prohibit the use of certain organic wastes** (night soil, sewage, animal processing waste) as fertiliser

- **Environmental legislations** which
  - **restricts organic fertiliser inputs** to **170 kg N ha^{-1} $annum^{-1}$** although the **nitrate leaching and P-run-off risk** differ greatly between organic fertilisers

Issue associated with the "eco-functional intensification" of organic crop production

- **Food safety**
  - Is there an increased risk from food pathogen, heavy metals, other pollutants when using organic waste based fertilisers?
- **Crop health and nutritional quality**
  - will pest, disease and weed pressure increase?
  - will the nutritional value of crops decrease?
- **Environmental impact**
  - Will nitrate leaching and P-run off increase?
  - Will greenhouse gas emissions from fertiliser inputs increase?
- **Consumer perceptions**
  - will organic consumers accept the use of night soil/sewage based fertilisers?


Thank you

We gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,

FP6-FOOD-CT-2003- 506358.