

What future for agriculture and agri-food in an increasingly globalized world?

Competing claims:
mineral resources for agriculture and forestry

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Overview

1. Background

2. Reserve availability

3. Macronutrient: Phosphorus

4. Micro-nutrients

1. Background

Diminishing resource availability:

- Together with good land, water and biodiversity, availability of minerals for fertilizers grows scarce
- Land degradation goes on as well
 - soil erosion, salinization, nutrient mining

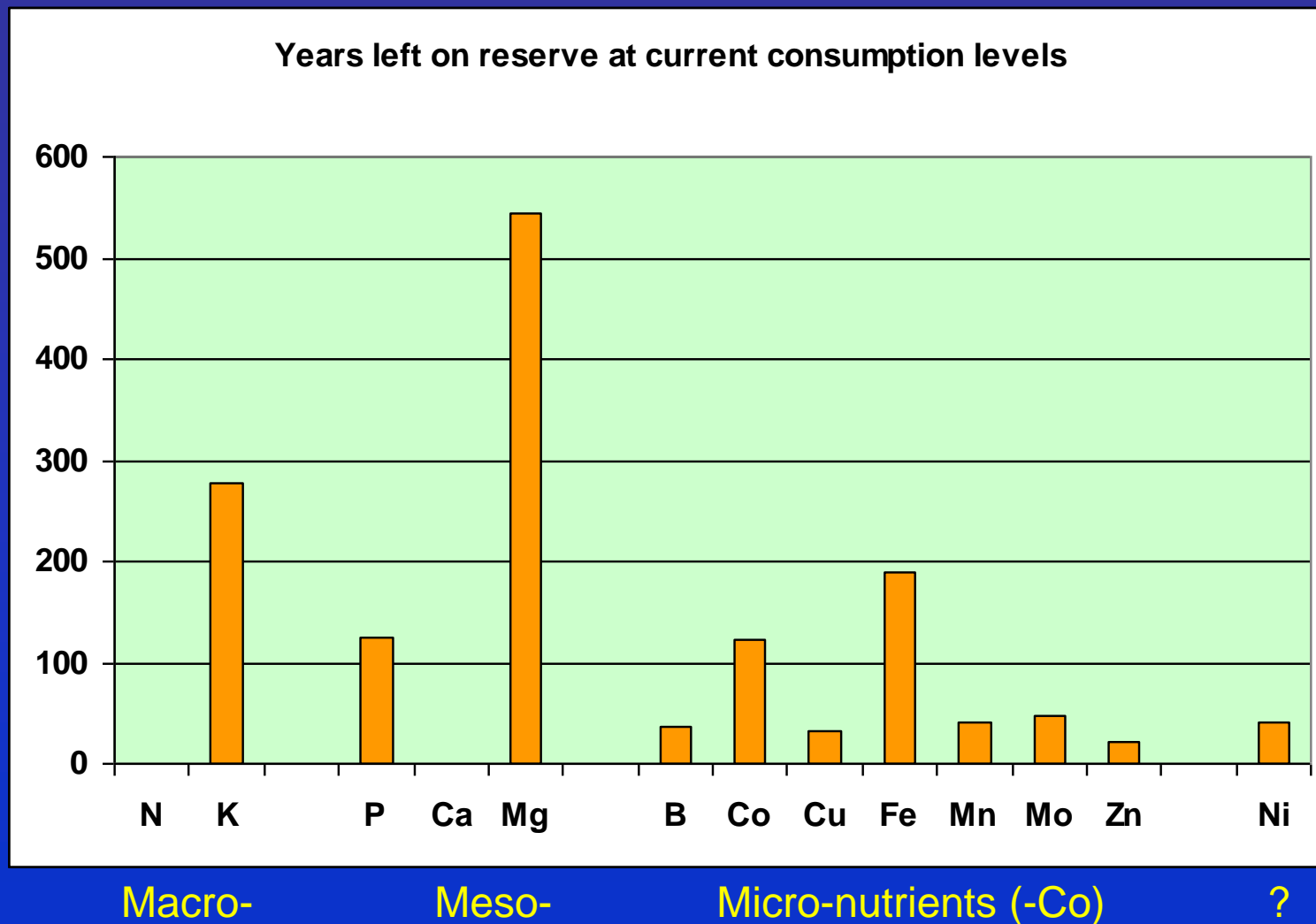
Rising demand:

- Growing world population and changing diets call for increased food and feed production through:
 - Area expansion:
 - poorer soils by definition have higher nutrient deficiencies
 - affects biodiversity
 - Intensified land use:
 - higher nutrient requirements
 - reduces water availability (Falkenmark and Rockström, 2008)
- Additional demand: energy from biomass
 - for biofuels (liquid fuel) from crops
 - biofuels would need: 194 million tons nutrients/year (source: Keyzer et al., 2008, partly based on Fischer and Schrattenholzer, 2001)
 - but also from forestry products, industrial waste for electricity production

Thus, for agriculture and forestry ample availability of mineral fertilizers should no longer be taken for granted:

- Macro-nutrients P and K, and various micro-nutrients will get scarce very soon

2. Reserves



3. Phosphorus

- **Agriculture as main user**
- **Reserves are limited:**
 - **At current consumption level 124 years from known reserves** (Source: USGS)
 - **Under continued growth in demand: 50-100 years** (Source: Cordell et al., 2009)
 - **Estimated upper bound (reserve base) 345 years, but this is highly uncertain, because**
 - **it is a quantity estimate that disregards quality aspects, such as:**
 - **Variation in P-content and contamination (e.g. U and Ca)**
 - **technical feasibility and profitability of mining and processing is unclear**
(e.g. van Straaten 2002)
 - **deposits at sea bottom are not mineable currently, and their mining has unclear impacts on marine ecosystems**
- **High regional concentration of deposits may limit availability**
 - **60 percent of reserves in China and Morocco & W. Sahara** (Source: USGS)
 - **China in 2008 already levies 135% export tax on phosphate rock** (Source: Cordell et al., 2009)

Scope for containing P-demand: positive impact not so sure

- **Phosphate facts:**
 - Phosphate fertilizers contain: equal amounts of P, Ca and S and micro-nutrients
 - Positive yield effects are often attributed to P only even though plant uptake of applied P usually low (10-20%) [Baligar et al., 2001]
 - Large doses result in eutrophication of surface waters
- **Africa: yield response to fertilizer on not previously fertilized soils**
(Voortman 2009):
 - In cases of positive response yields highest at 10-20 kg P/ha, decreasing beyond
 - By contrast recommended P doses are in the order of 60 kg/ha
 - Often negative responses to P fertilizer, essentially because other essential plant (micro-)nutrients soon become deficient (antagonism)
 - Micro-nutrients can have very large positive yield impacts
- **Asia: yield response on previously fertilized soils (green revolution):**
 - Stagnant or declining yields; next to N the most widespread deficiency is Zn, possibly because of excessive use of P (e.g. Pingali and Shah, 2001; Aggarwal et al., 2004)
 - P is antagonistic with Zn and also: K, Ca, Cu, Fe and Mn (Landon, 1991)

Addressing phosphorus scarcity

- **Save on P use:**
 - Mine P on P-intoxicated land
 - Apply small, effective doses elsewhere
 - Micro-dosing
 - Precision agriculture
 - Reduce losses in the chain from field to fork (55%)
[Source Cordell et al., 2009]
- **Recycle P:**
 - Recover P from urban human waste and animal waste; use waste directly
 - Return ashes from biomass use in e.g. electricity plants
 - Use by-products of e.g. biofuel production
 - Reduce geographical length of chain, to ease return of nutrients to the source

4. Micronutrients

- **Essential plant micro-nutrients, particularly in Africa**
 - Many old, weathered non-alluvial and non-volcanic soils
- **Competing uses from non-agricultural applications**
- **Years reserve at current consumption levels (Source USGS)**

Zinc:	22 years
Copper:	31 years
Boron:	36 years
Manganese:	40 years
Molybdenum:	48 years

Addressing micronutrient scarcity

- similar to P: better dosages and more recycling
- but in addition:
 - replace scarce essential plant nutrients by less scarce elements in non-agricultural uses
 - stop dissipative uses like galvanizing in zinc: of the cumulative world production of zinc only about 30% is stored without chemical transformation (Gordon et al., 2006)

More generally, for both macro- and micro-nutrients:

- improve knowledge on how soil-chemical complexities affect crop yield and nutrient use efficiency, such as:
 - nutrient interactions, effect of cation ratios on P and micro-nutrient uptake, role mycorrhizae, non-*Rhizobia* Nitrogen fixation etc.