Prem Bindraban

Executive Director, VRFC

Changing the Fertilizer Game

our Challenges
our Image
our Future

A GROWING RESPONSIBILITY

The Fertilizer Institute
Nourish, Replenish, Grow

Fertilizer Industry Round Table

Towards innovative fertilizers for food and nutrition security

Virtual Fertilizer Research Center

presented by

Dr. Prem S. Bindraban

Fertilizer Industry Round Table

Savannah, 18-20 November 2014

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Virtual Fertilizer Research Center

- The VFRC is
  - A research initiative to foster the creation of the next generation of fertilizers and production technologies
  - to help feed the world's growing population and provide sustainable food security

Semi-autonomous unit of IFDC

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Basic processes

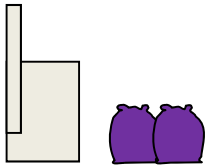
Cereal Yields (ton per hectare)

(N_2O), (NO_x), (NH_3)

Inert N2 into reactive N

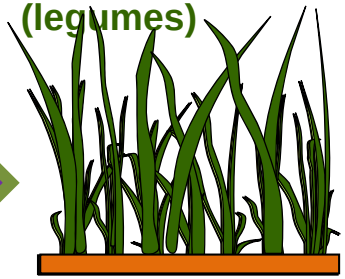
N-fixation (legumes)

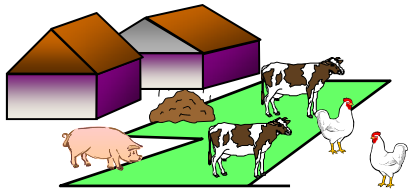
Natural ecosystems



NPK

Fertilizer Manufacture & Mining





Livestock

Inert P, K, … into reactive P, K, …

Soil weathering
P, K, Mg, S, Ca, Fe, Mn, Zn, B, Mo, Cu, Cl, …

20-80% lost

Consumption by humans

(NO_3^-), (PO_4^{3-})

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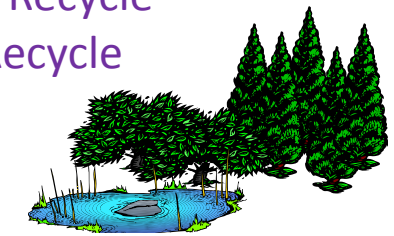
Basic concepts

Cereal Yields (ton per hectare)

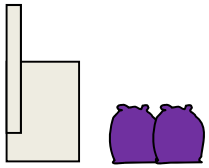
Food
60 Mt N
4 Mt P

Annually
105 Mt N
18 Mt P

Annually
105 Mt N - Recycle
18 Mt P - Recycle

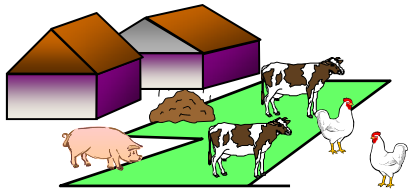


Natural ecosystems



Fertilizer Manufacture & Mining

NPK

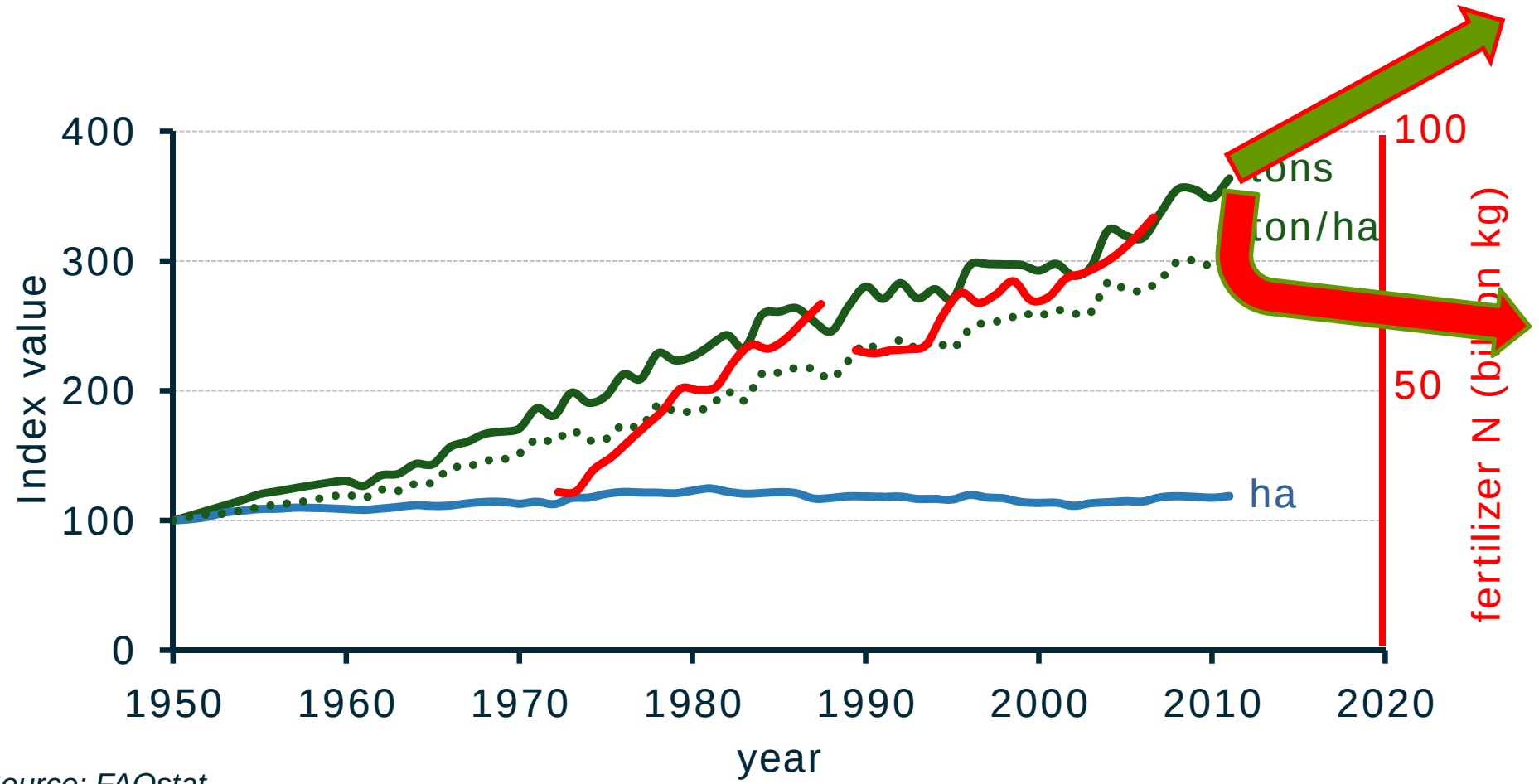


Livestock

Consumption by humans

Instantaneous uptake

Global production, acreage, N-use

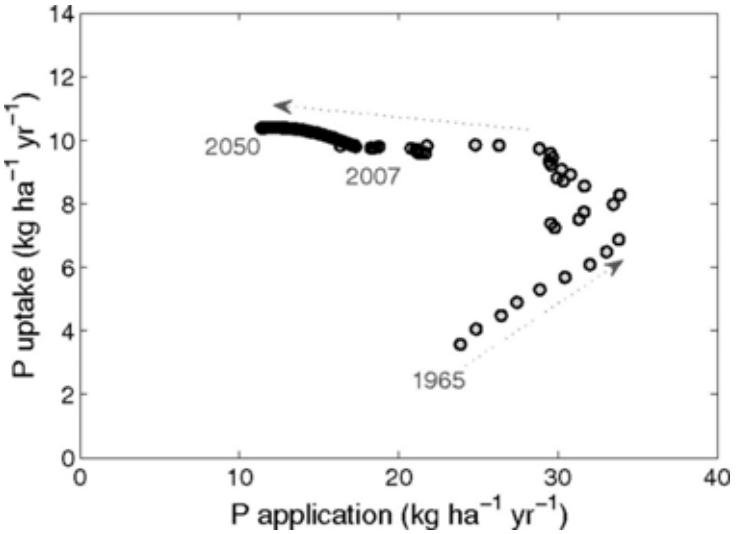


Source: FAOstat

Hysteresis / recycling

Hysteresis in P uptake vs. P application;
1965 and 2007 (Western Europe)

France country-scale P recycling 50%



Hardly any increase in application rate expected up to 2050 (Western Europe)

Sattari et al., 2012. PNAS 109 (16): 6348–6353

Senthilkumar et al., 2014. Resources, Conservation and Recycling 87: 97–108

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Health & yield impacts of deficits

Region	Zn	Fe	I	Vitamin A
North America	8-11	18-29	11	2-16
Latin America	13-37	18-29	11	2-16
Europe	6-16	19-25	52	12-20
Sub-Saharan Africa	13-43	48-66	44	14-44
Southeast Asia	27-39	46-66	30	17-50
South Asia	18-36			
Global	**10-32**	**30-47**	**32**	**15-33**

Bouis, Boy-Gallego and Meenakshi (2011)

Micronutrient Malnutrition (% prevalence)

Zn deficiencies

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(Lack of) Fertilizers and Poverty

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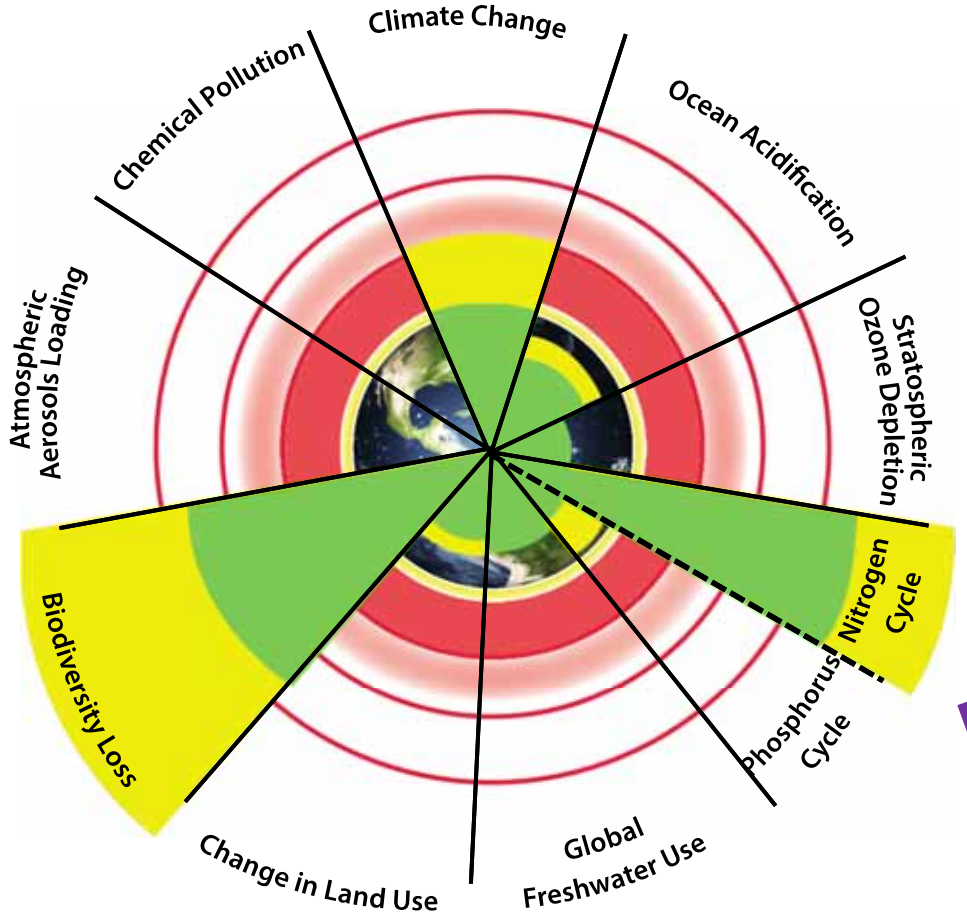
Slide Ken Giller (Wageningen UR)

Planetary Boundaries



From Holocene to Anthropocene

Rockstrom et al., 2009

J.G. Conijn, F.J. de Ruijter, J.J. Schröder and Prem S. Bindraban. 2013. Methodology to assess the impact of fertilizer strategies on planetary boundaries. VFRC Report 2013/3. Virtual Fertilizer Research Center, Washington, D.C. 21 pp.; 1 table; 3 figs.; 38 ref.

Global role for fertilizers / industry

- Food security
  - Increase production volume, reduce risk
- Ecologically sustainable production
  - Maintain soil health, water quality, biodiversity
  - Reduce Green House Gas emissions, ;land expansion
- Poverty alleviation
  - Ensure income and livelihood
- Improvement human health
  - Better food quality

VFRC driver to meet societal objectives of fertilizers

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Industry Research and Development Spending

The pharmaceutical and seed industries spend billions on R&D.

Pfizer, Glaxo, Merck ~ 16% of revenues is invested in R&D spending

Syngenta, Monsanto ~ 9% of revenues is invested in R&D spending

~ 0.1% of revenues in R&D for new products and new technologies

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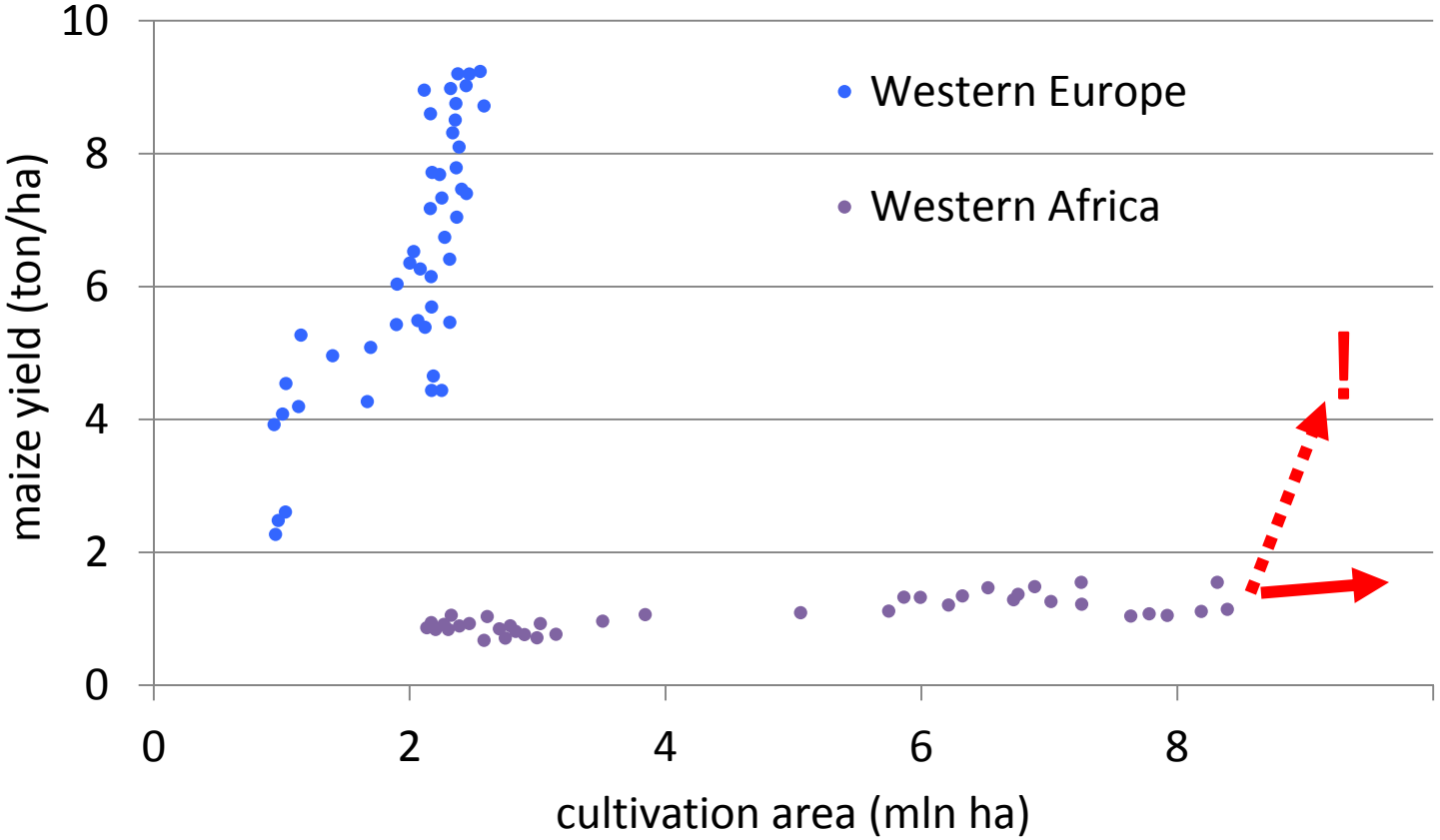
Fuglie et al., 2011. Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide. ERR-130. U.S. Dept. of Agriculture, Econ. Res. Serv. December 2011.

Optimize intensification



Bindraban et al. 2009.
PRI, Wageningen UR, Report 242.

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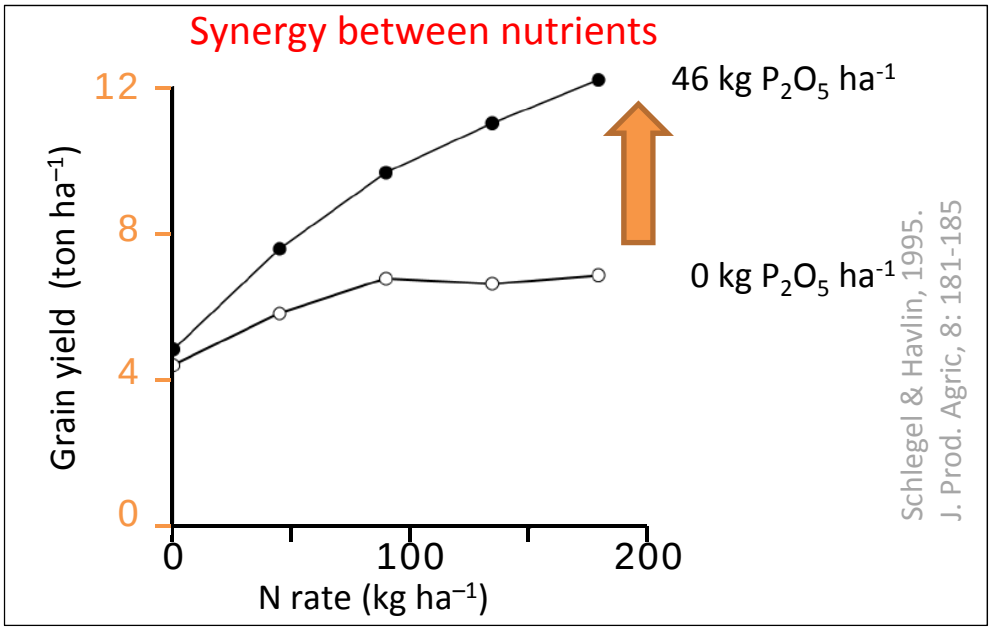
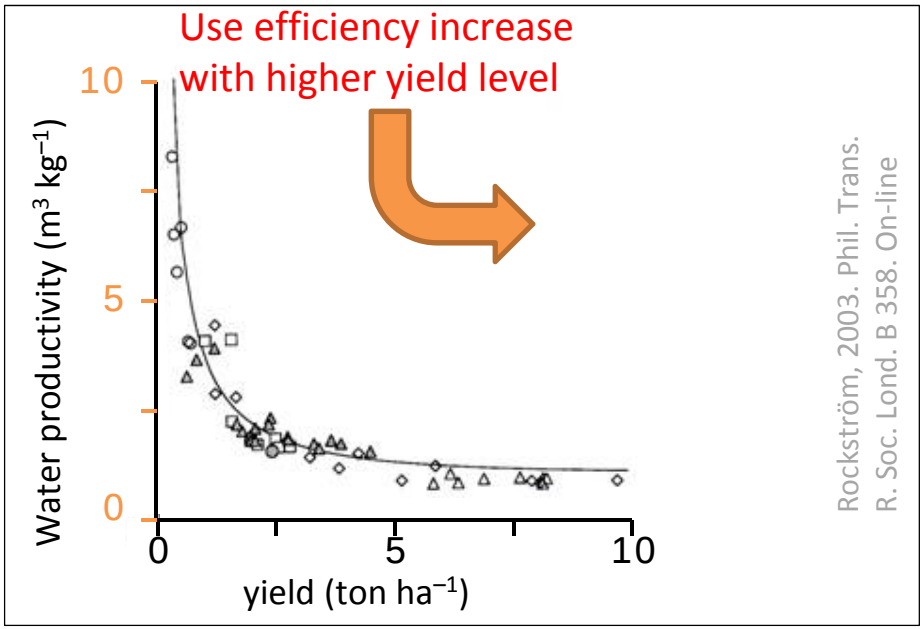
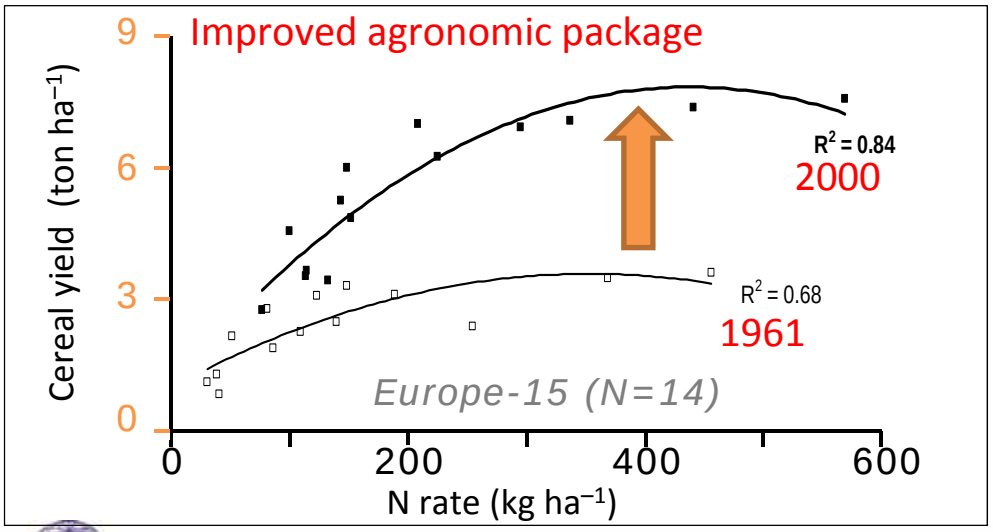
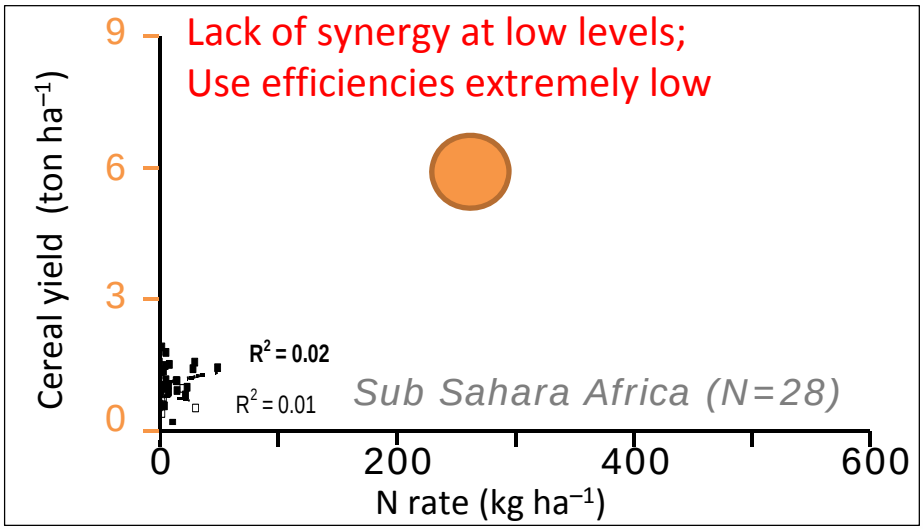
Ecological synergy









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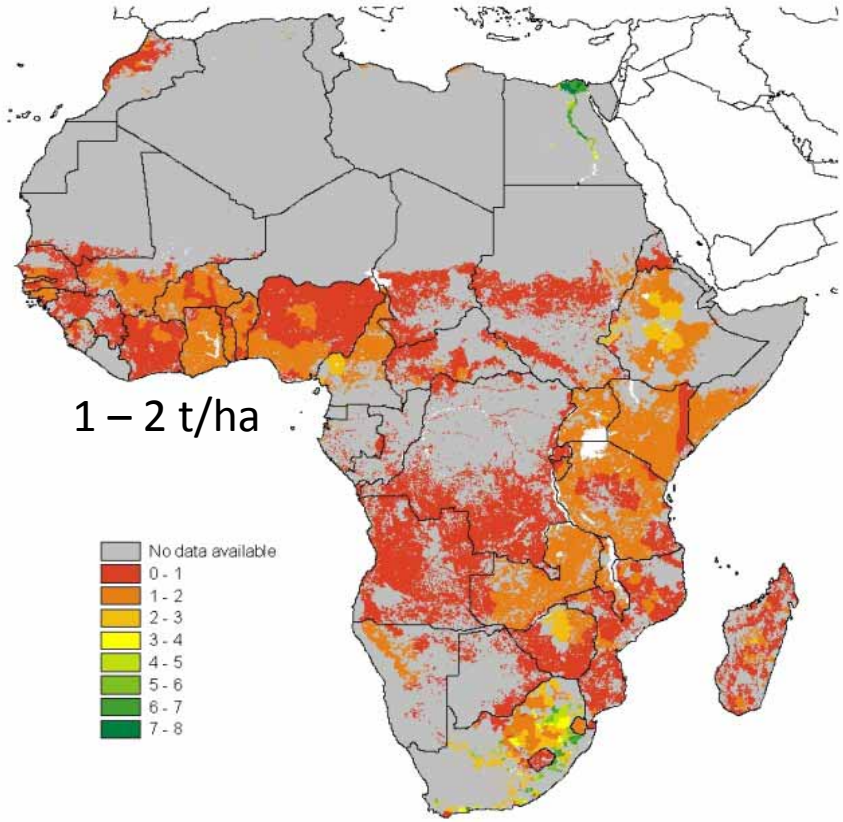
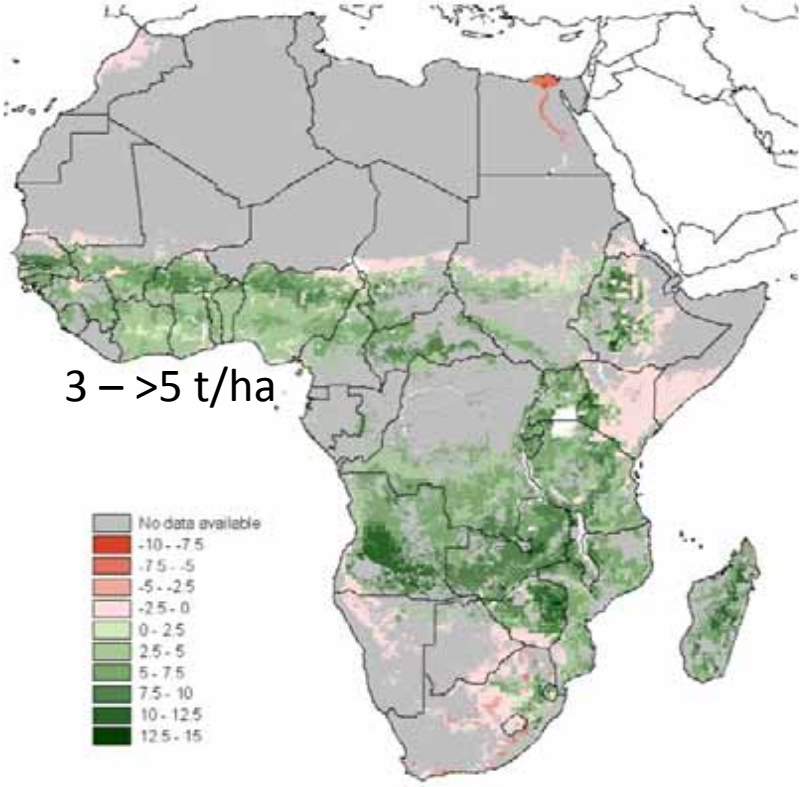
Bindraban, Löffler, Rabbinge, 2008.
Int. J. Techn & Glob, 4 (3): 276–295

Production potentials African continent

Current yield



Yield gap



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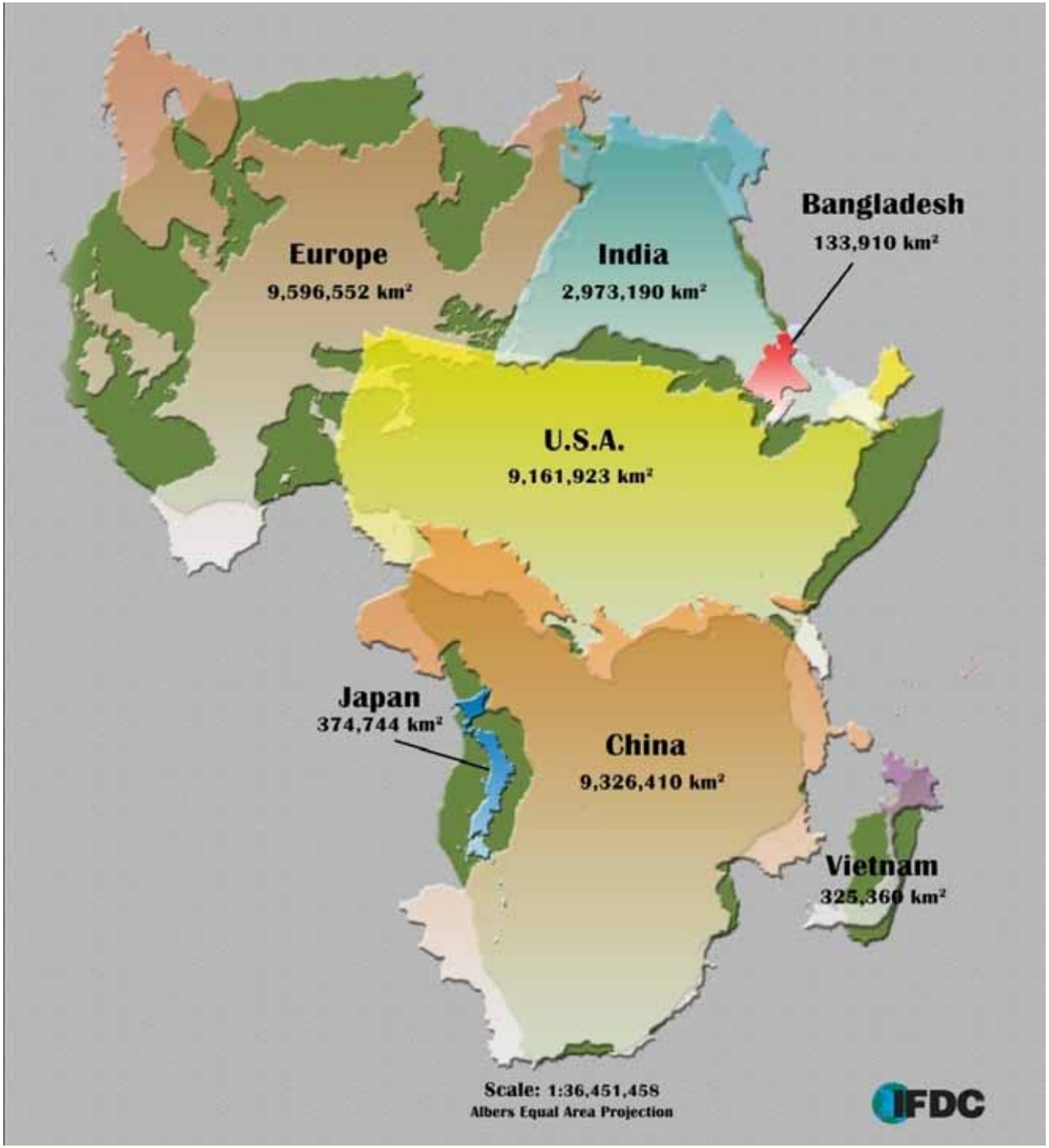
Conijn, J.G., et al., Bindraban., 2011. PRI, Wageningen UR.

The enormity of Africa



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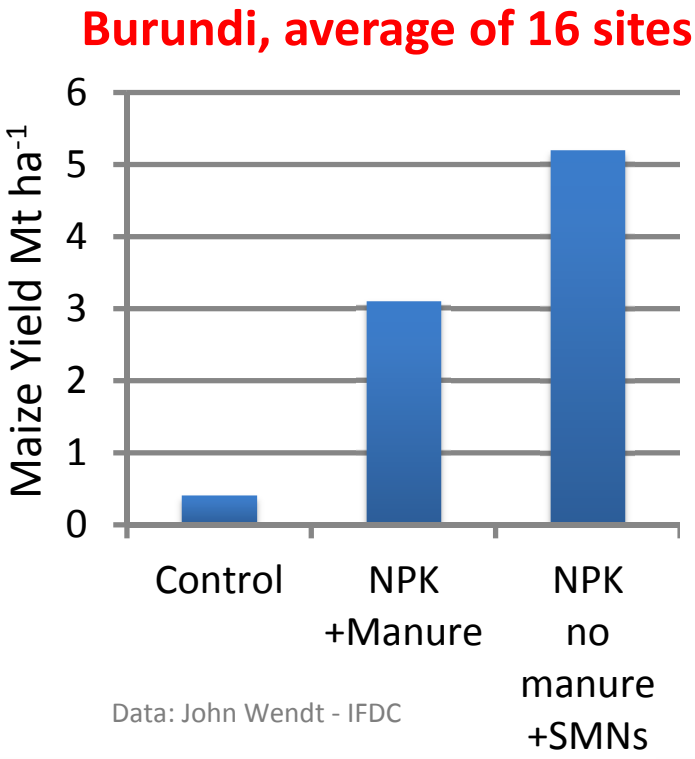
Fertilizer Nutrient Composition

- Well-endowed soils: NPK suffice to increase yield
  - Europe, Coastal regions US, Coastal regions China, Indo-Ganges India, Indonesia → **Green revolution**
- Poor soils
  - No/poor crop response to NPK
  - Soil amendment needed (Organic Matter, Lime, …)
  - Micronutrient deficiencies
- ISFM to include micronutrient containing fertilizers
- Human induced micronutrient deficiencies (India, …)



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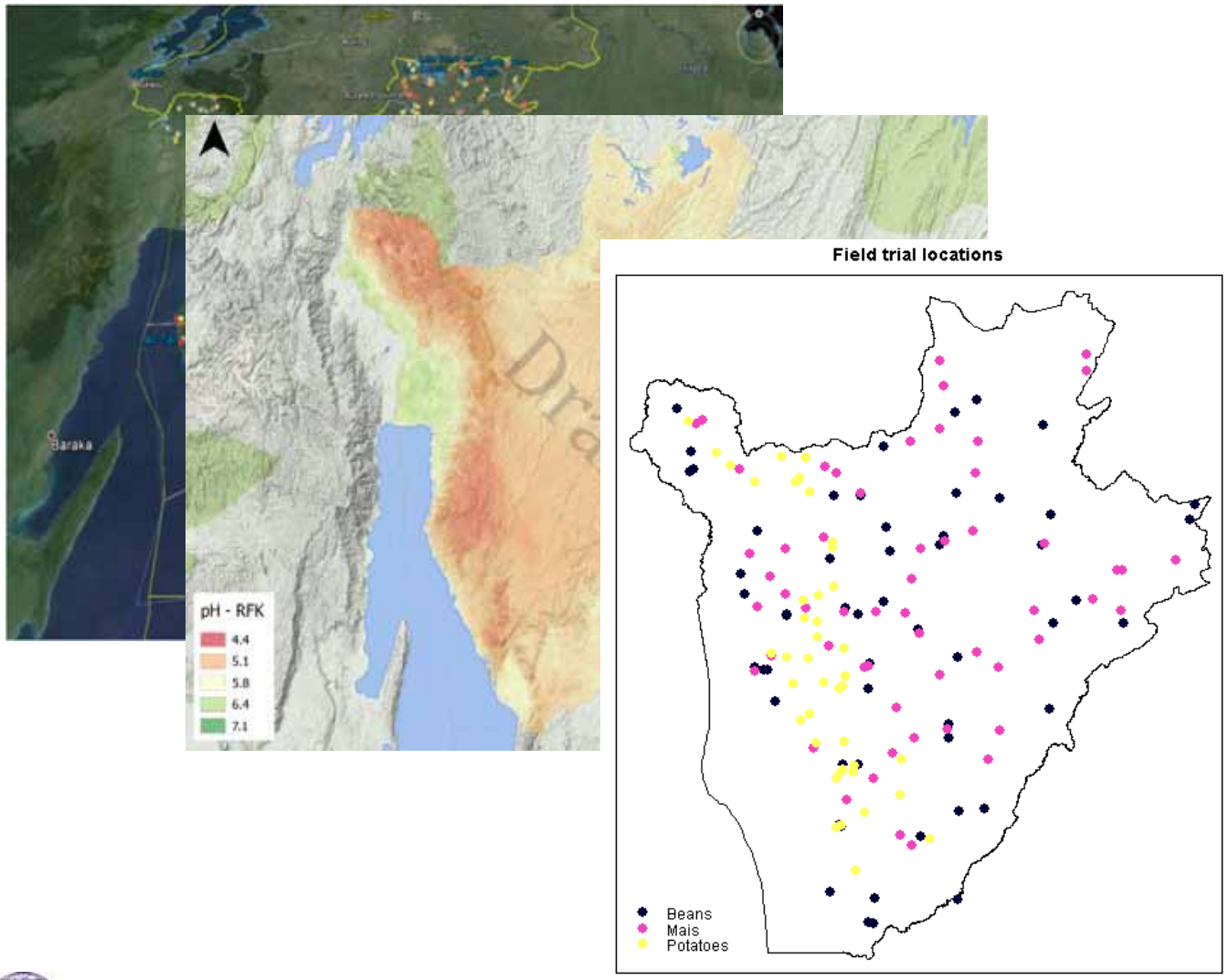
Spatial ground rules



Generic modelling

(micro-) nutrients recommendations

Farm experiments

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(Micro) nutrient uptake

- 10 kg S/ha
- 2-3 kg Zn/ha
- 1 kg B/ha

Uptake efficiency?

Gram per Ton Maize

- N – 23500
- P – 3700
- K – 12600
- Mg – 1400
- Ca – 100
- S – 1500

- Fe – 175
- Mn – 8
- Zn – 26
- Cu – 4
- B – 5
- Mo – 0.6

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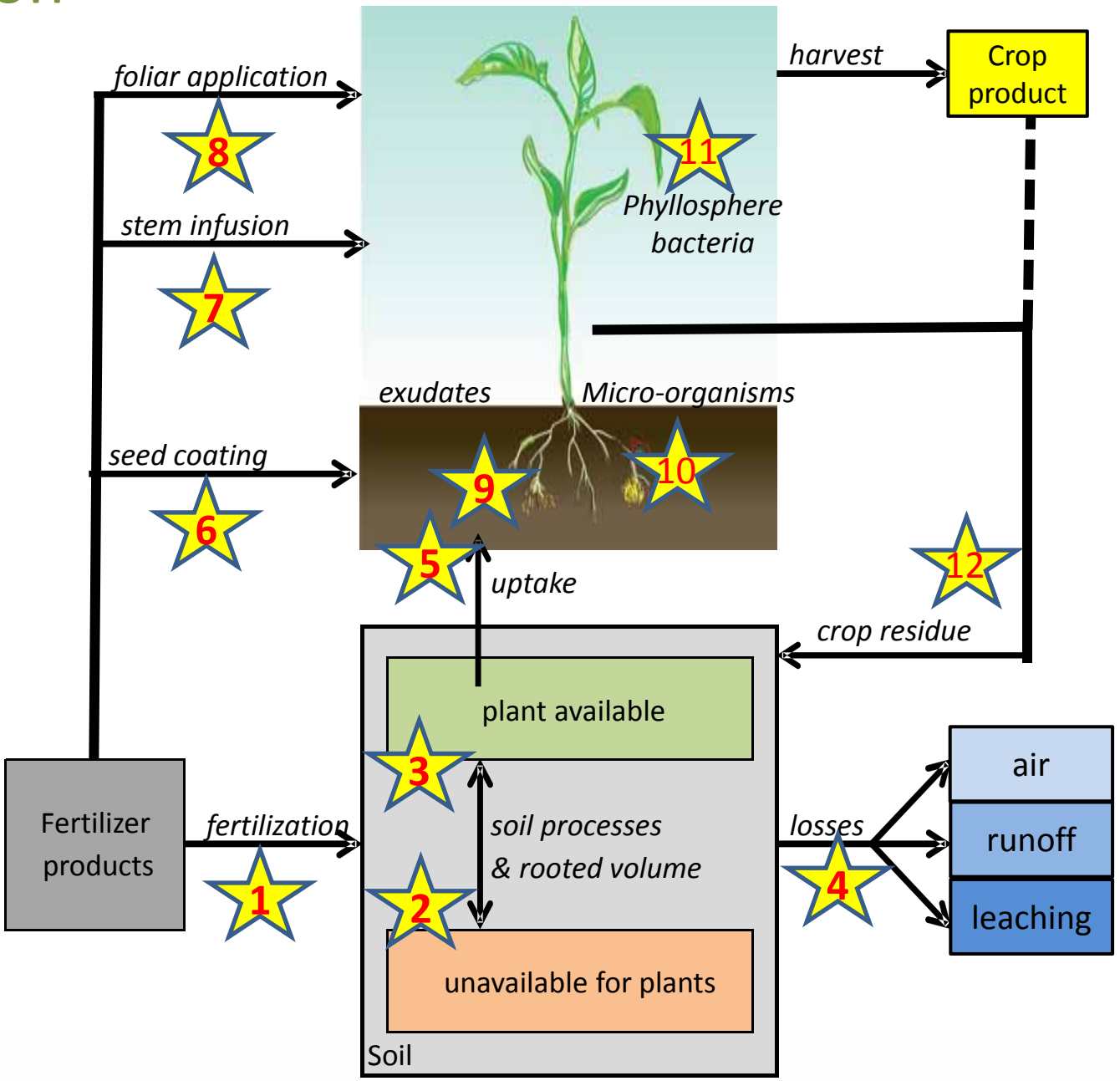
Intervention Options



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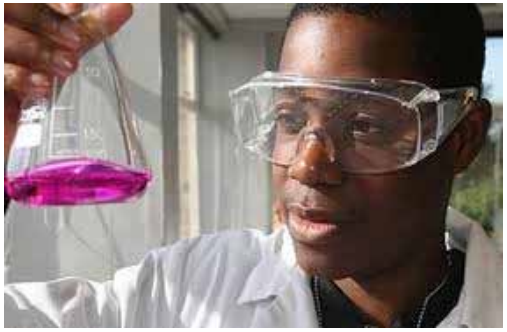
From bulk chemistry to fine-, bio- and nano-bio-chemistry

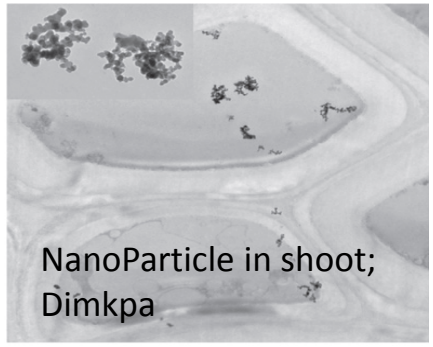
Bulk Chemistry

Recycling



Bio-, bio-nano-chemistry

Delivery mechanisms



Intake/Uptake

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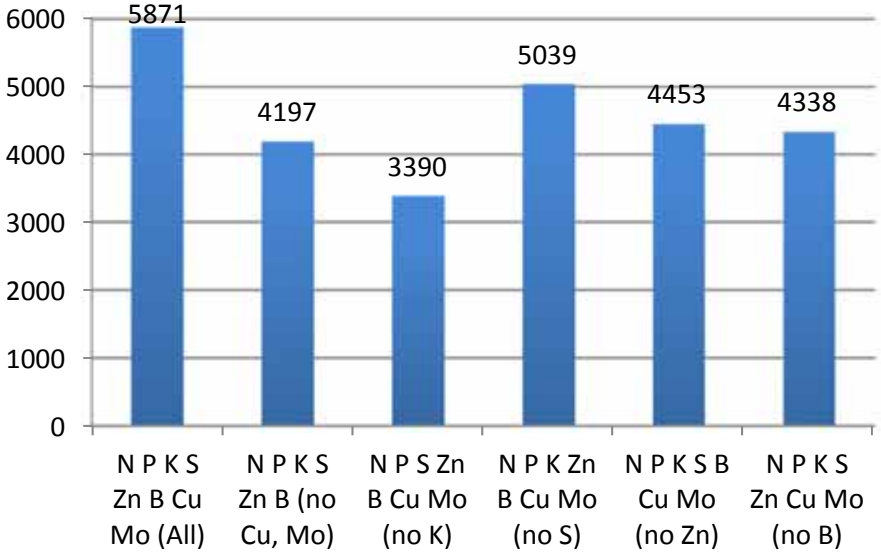
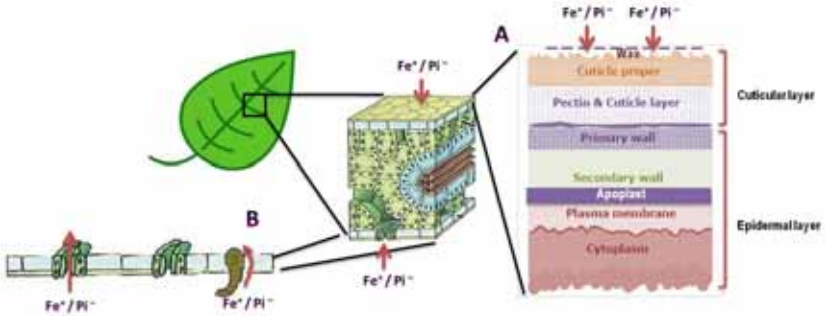
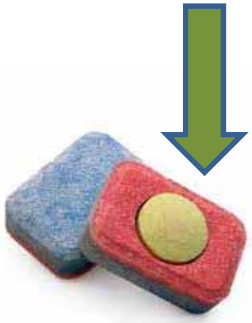
Leapfrog development







Micro / secondary

+

Primary / secondary

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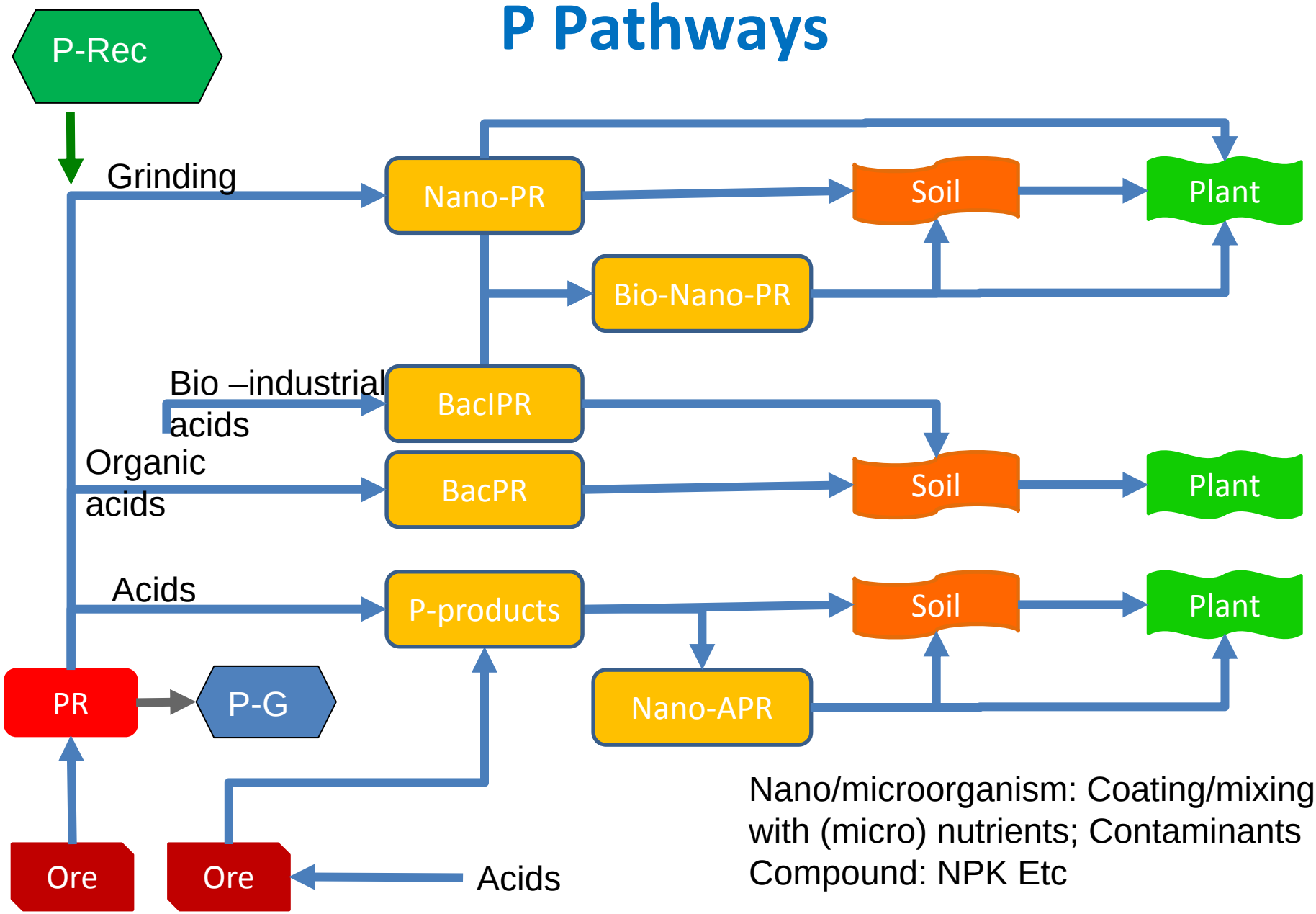
P Pathways



Nano/microorganism: Coating/mixing with (micro) nutrients; Contaminants Compound: NPK Etc

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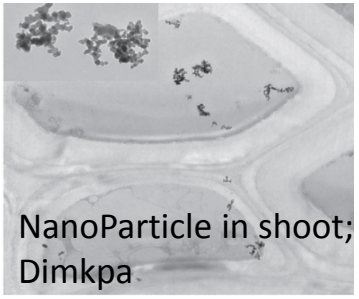
Research Areas


NanoParticle in shoot; Dimkpa

1. Plant nutrient dynamics & metabolism
   timing and amount; entry point plant, exudates, micro-organisms, …
2. Fertilizer bio-chemical packaging nutrients
   chemical, bio-, bio-nano, micro-organism,
3. Delivery mechanisms
   spray, infusion, seed coating, granules, prills, bio-trigger, applicators

4. In the context of selected
   a. Geo-spatially specific fertilizer nutrient combinations and amounts
   b. Cropping system (vegetables, legumes, cereals, trees, tubers, fiber, plantain, grass, …)
   c. Agro-production system (wet/dry/cold, good/poor soil health, microbes)

VFRC Innovative fertilizers

1. Reduce poverty (profitable)
2. Ensure food security (quantity)
3. Fight hidden hunger (quality)
4. Minimize risk (targeted)
5. Reduce environmental impact
6. Sustain production base (soil, water, biodiversity)
7. Support inclusive growth (women, young people)
8. Minimize resource use (efficiency, re-use)

- Fail-safe
- Adaptive
- Eco-sensitive
- Economical

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Innovative fertilizers…
A winning game for all

Thank You

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