IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Joint Department Seminar Series
College of Agricultural Sciences
Oregon State University
13 January 2014

Nutrient Stewardship for Nutrition Security

Tom Bruulsema, PhD, CCA
Director, Northeast Region, North America Program
Guelph, Ontario, Canada

Agrium Inc.

Arab Potash Company

Belarusian Potash Company

CF Industries Holdings, Inc.

Compass Minerals Specialty Fertilizers

International Raw Materials LTD.

Intrepid Potash, Inc.

K+S KALI GmbH

The Mosaic Company

OCP S.A.

PotashCorp

Qatar Fertiliser Company (QAFCO)

Simplot

Sinofert Holdings Limited

SQM

Toros Tarım

Uralchem

Uralkali

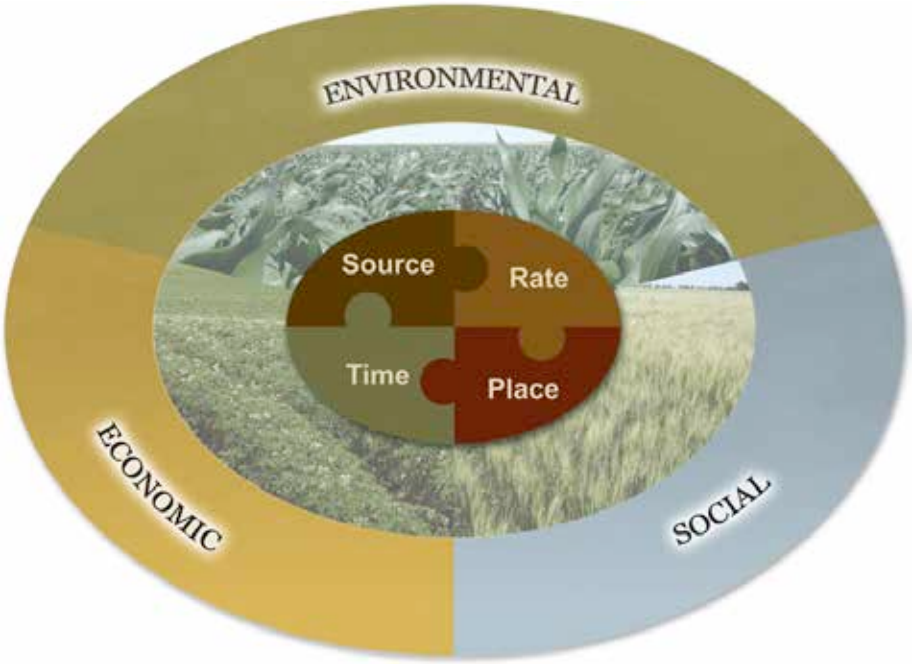
Formed in 2007 from the Potash & Phosphate Institute, the **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

Nutrient Stewardship for Nutrient Security
Outline

- Human Health
  - Food security – calories
  - Micronutrient malnutrition – Zn, Se, I
  - Functional foods and nutraceuticals
  - Plant disease
- Animal Health
  - Milk fever in the Northeast
- Stewardship for Food Security & Sustainability

See http://nane.ipni.net/ for slides

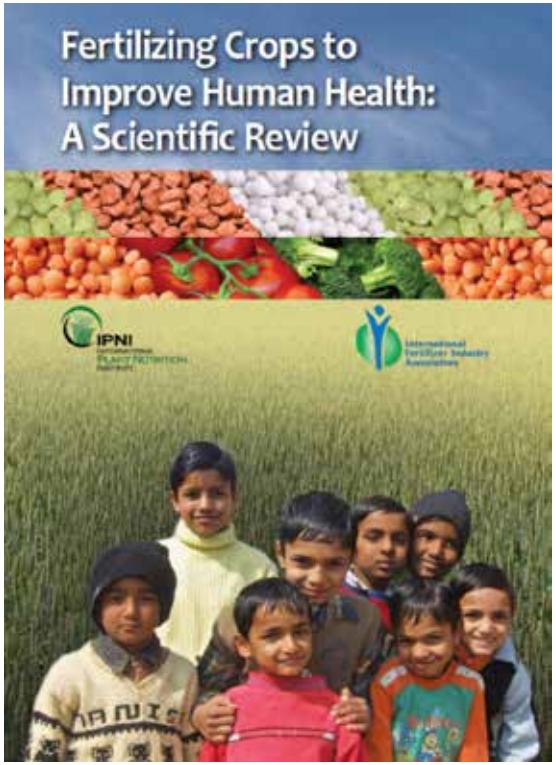
4R Nutrient Stewardship supports human health



nutrient stewardship

Health – WHO definition:

"a state of complete physical, mental and social well-being"

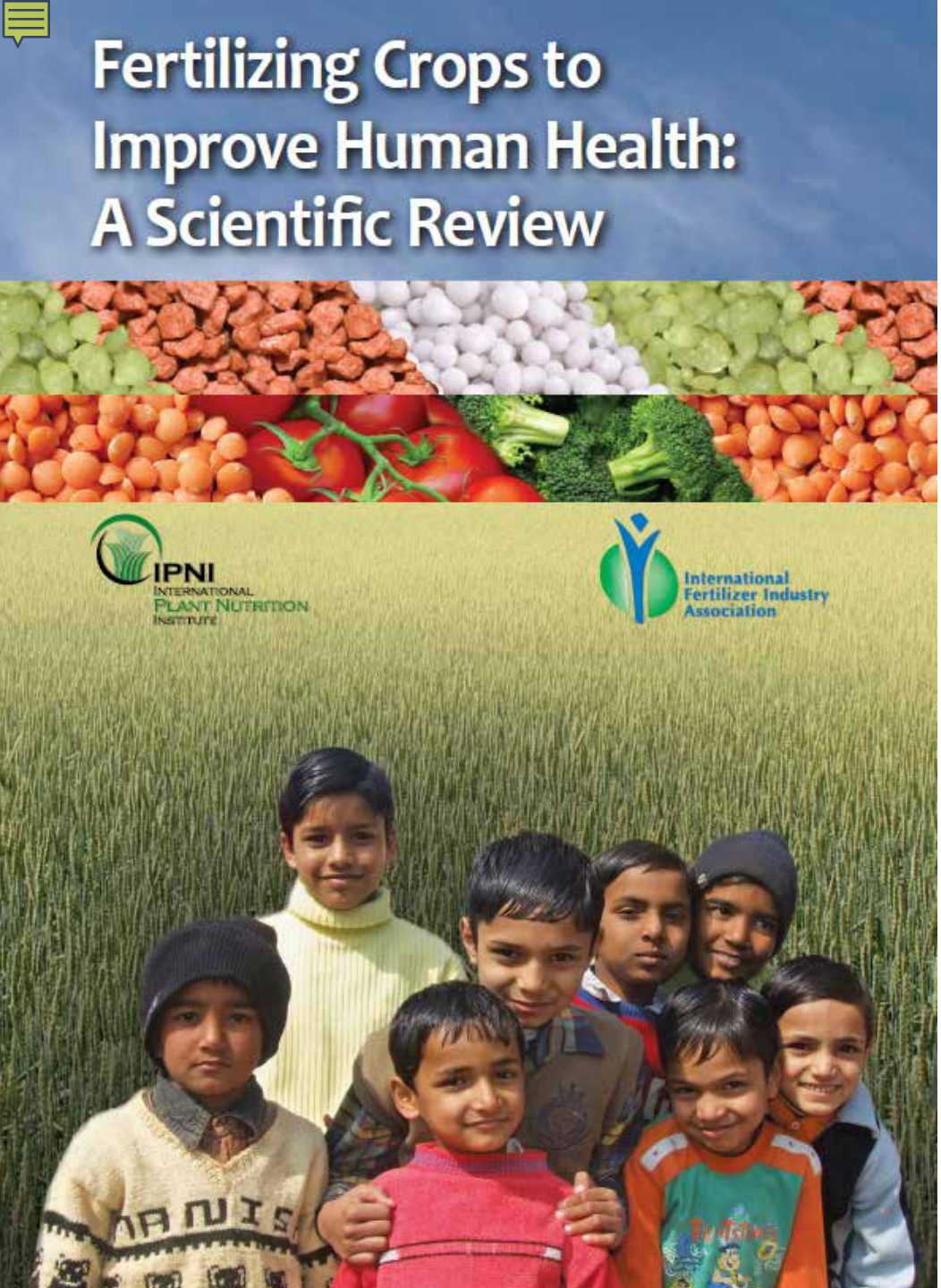


IPNI/IFA, 2012

Editorial Committee:

- Patrick Heffer, IFA, France
- Tom Bruulsema, IPNI, Canada
- Kevin Moran, Yara, UK
- Ismail Cakmak, Sabanci Univ., Turkey
- Ross Welch, Cornell Univ., USA

IPNI



Topics

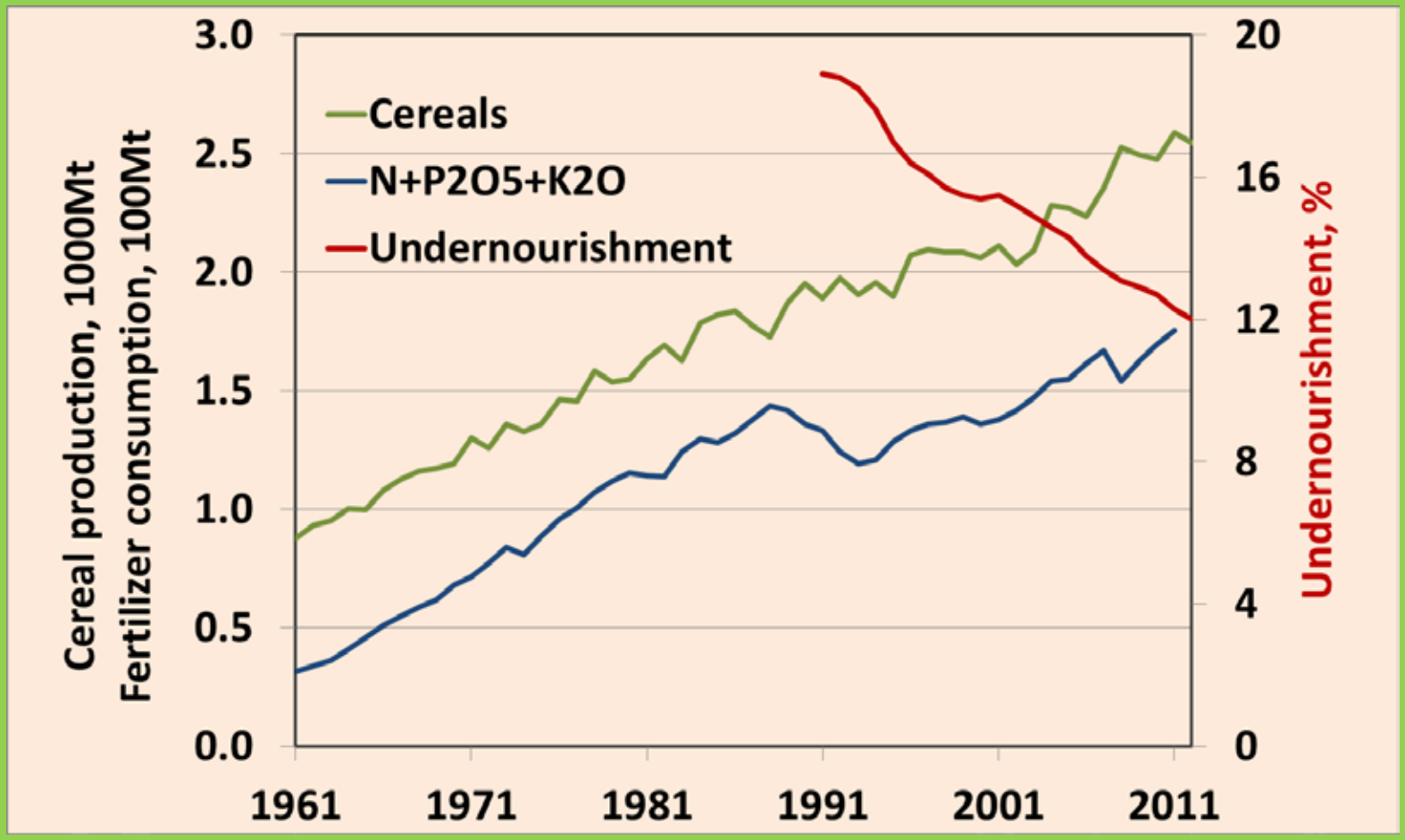
- Food security
- Micronutrients
- Vitamins
- Functional foods
- Proteins, oils and carbohydrates
- Plant disease
- Farming systems
- Remediation of soil contaminated with radionuclides
- 11 chapters

IPNI

Food and Nutrition Security

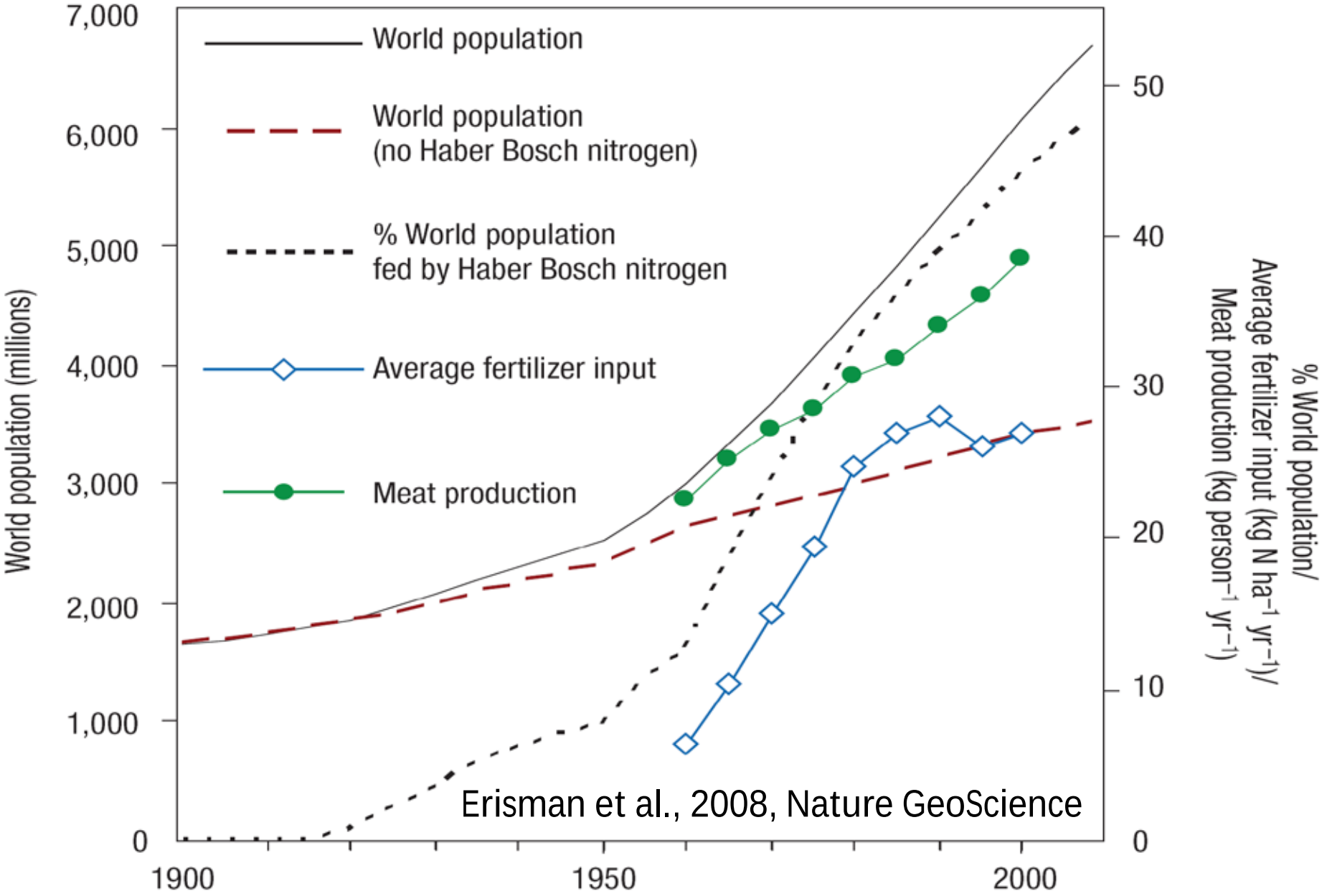
- Food security (CFS, 2012):
  - "freedom from hunger" – emphasis in 1943
  - "exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (World Food Summit 1996, 2009).
- Food and Nutrition Security: triple burden of malnutrition
  1. insufficient intake of dietary energy (hunger)
  2. micronutrient deficiency (hidden hunger)
  3. excess intake of dietary energy (overweight and obesity)
  - depends on sanitation, health care, education, etc., as well as supply of quality food

Increased fertilizer use has contributed to cereal production growth and reduced undernourishment

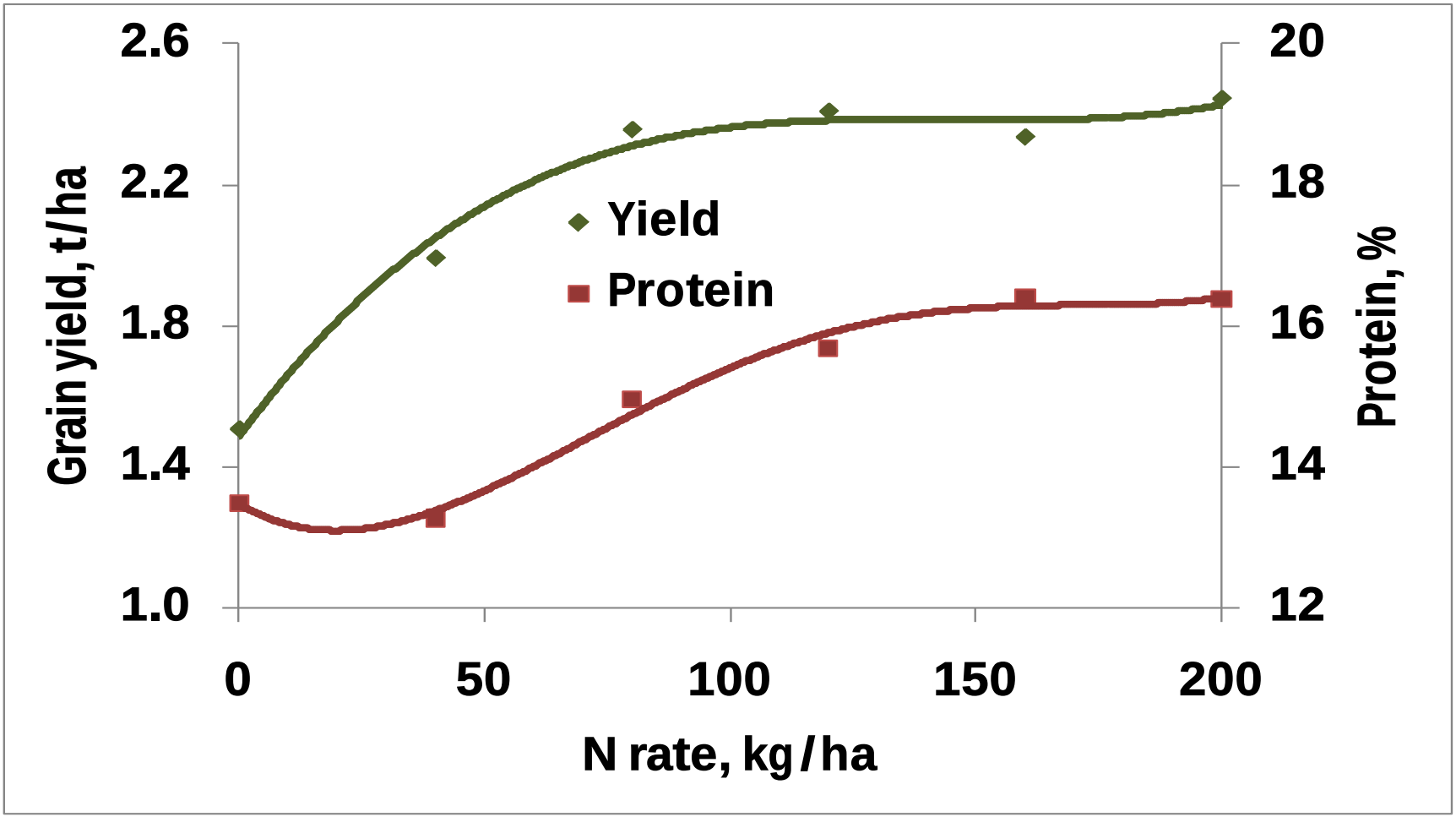


Data sources: FAO, IFA.

Human Population and N Use



Optimum protein requires more N than optimum yield



Katepwa hard red spring wheat

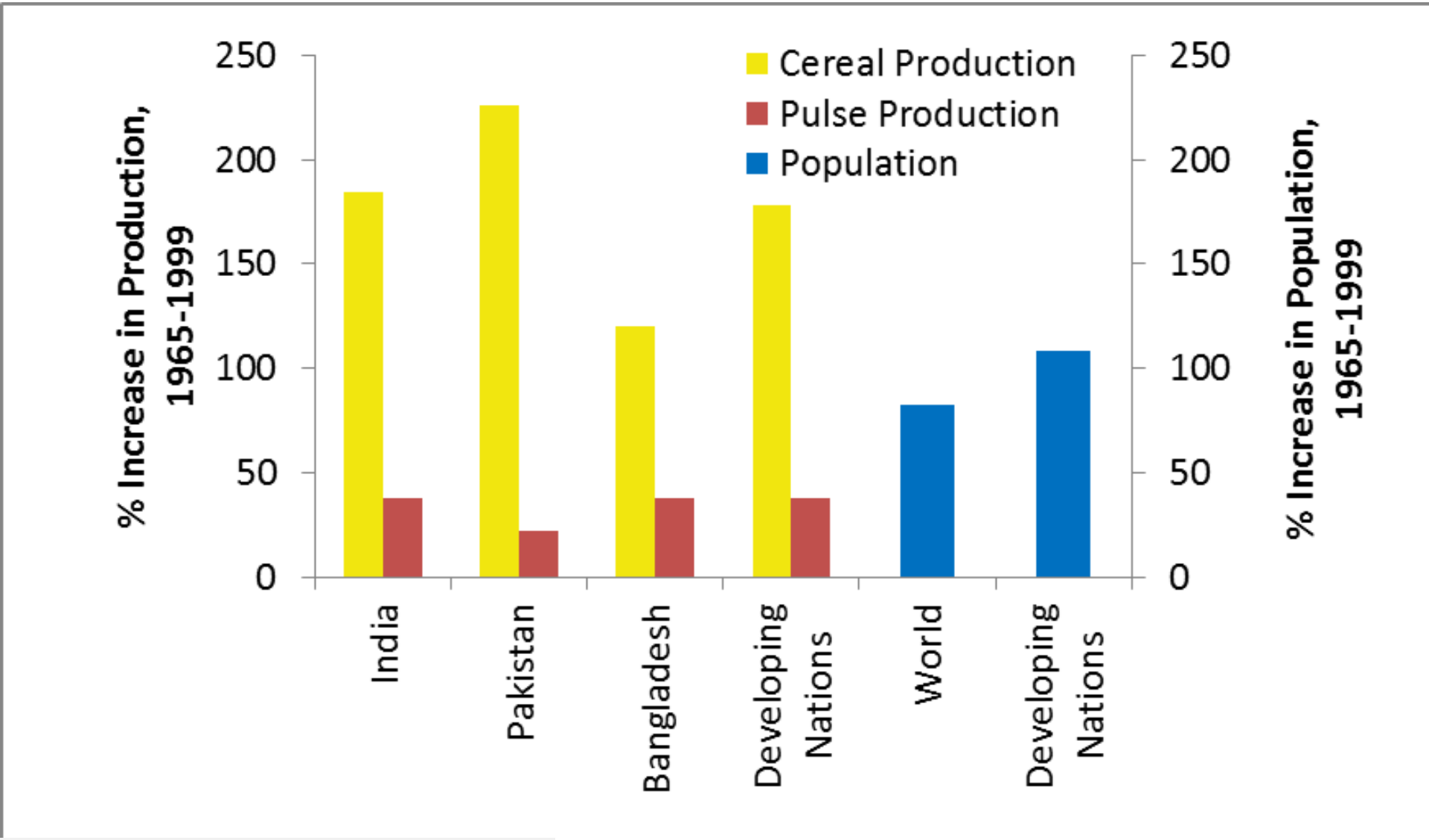
Grant & Bruulsema, 2012

Potato starch and protein influenced by NPKS

N-P-K-S	Potato yield, g/pot	Starch, %	Crude protein, %	Protein biological value, %
2-3-3-3	124	70	8.3	89
4-3-3-3	**317**	**72**	**12.9**	**80**
6-3-3-3	266	69	15.9	75
4-1-3-3	134	68	14.9	74
4-4-3-3	**454**	**74**	**10.3**	**81**
4-3-1-3	50	59	22.9	65
4-3-4-3	**332**	**68**	**11.5**	**82**
4-3-3-0	173	65	14.7	45

Eppendorfer and Eggum, 1994

Trend 1965 to 1999: more cereals per capita, less pulses



Bouis, Boy-Gallego & Meenakshi

1986 – Bangladeshi farmers: *rabi* soybeans or *boro* HYV rice?

Prevalence (%) of micronutrient malnutrition is high in developing regions and substantial in developed

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 & Meenakshi

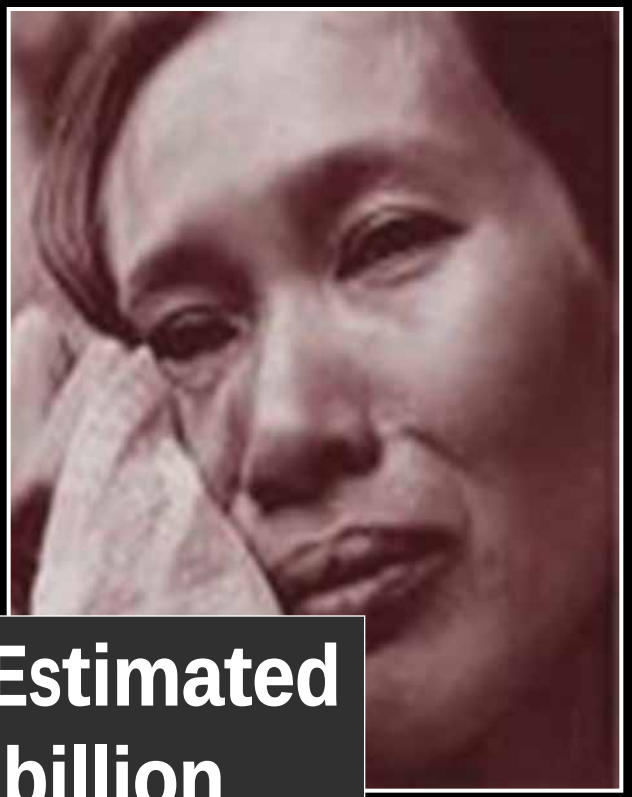
Almost as many soils are deficient in Zn as in K

Table 1. Proportion of agricultural soils deficient in mineral elements (based on a survey of 190 soils worldwide – Sillanpaa, 1990).

Element	%
N	85
P	73
K	55
B	31
Cu	14
Mn	10
Mo	15
Zn	**49**

Welch and Graham, 2012

Zn and Fe Deficiencies: Global Malnutrition Problem



Iron Estimated 2 billion

Zinc Estimated 2 billion

www.harvestplus.org

Zinc Deficiency… a Global Issue

2 BILLION

People worldwide who don't get enough zinc

1.5 MILLION

Children who die each year from diarrhea

800,000

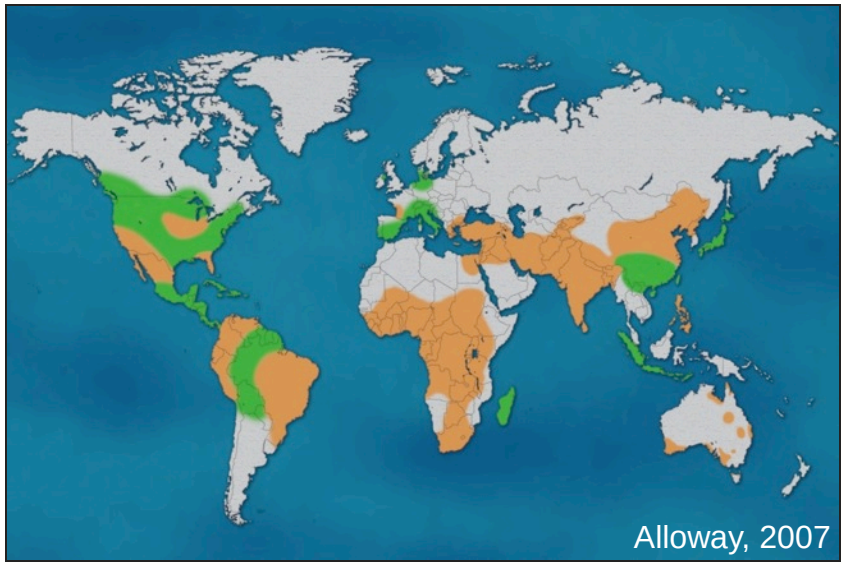
People at risk of dying each year from zinc deficiency

450,000

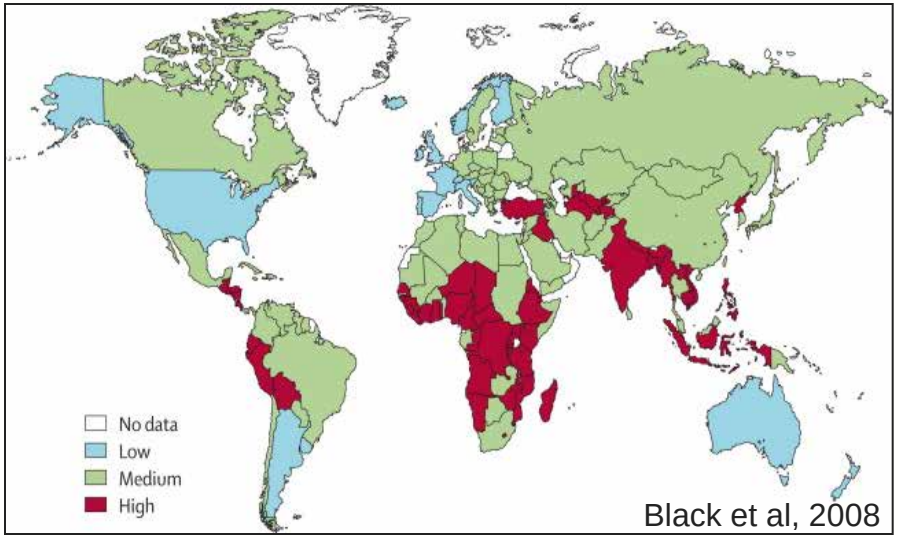
Children at risk of dying every year due to zinc deficiency

Andrew Green, PhD, Zinc Nutrient Initiative

Zinc Deficiency in Soil Links Directly to Zinc Deficiency in Humans



Zinc deficiency in soils



Zinc deficiency in humans

Andrew Green, PhD, Zinc Nutrient Initiative

Major Reason: Low Dietary Intake

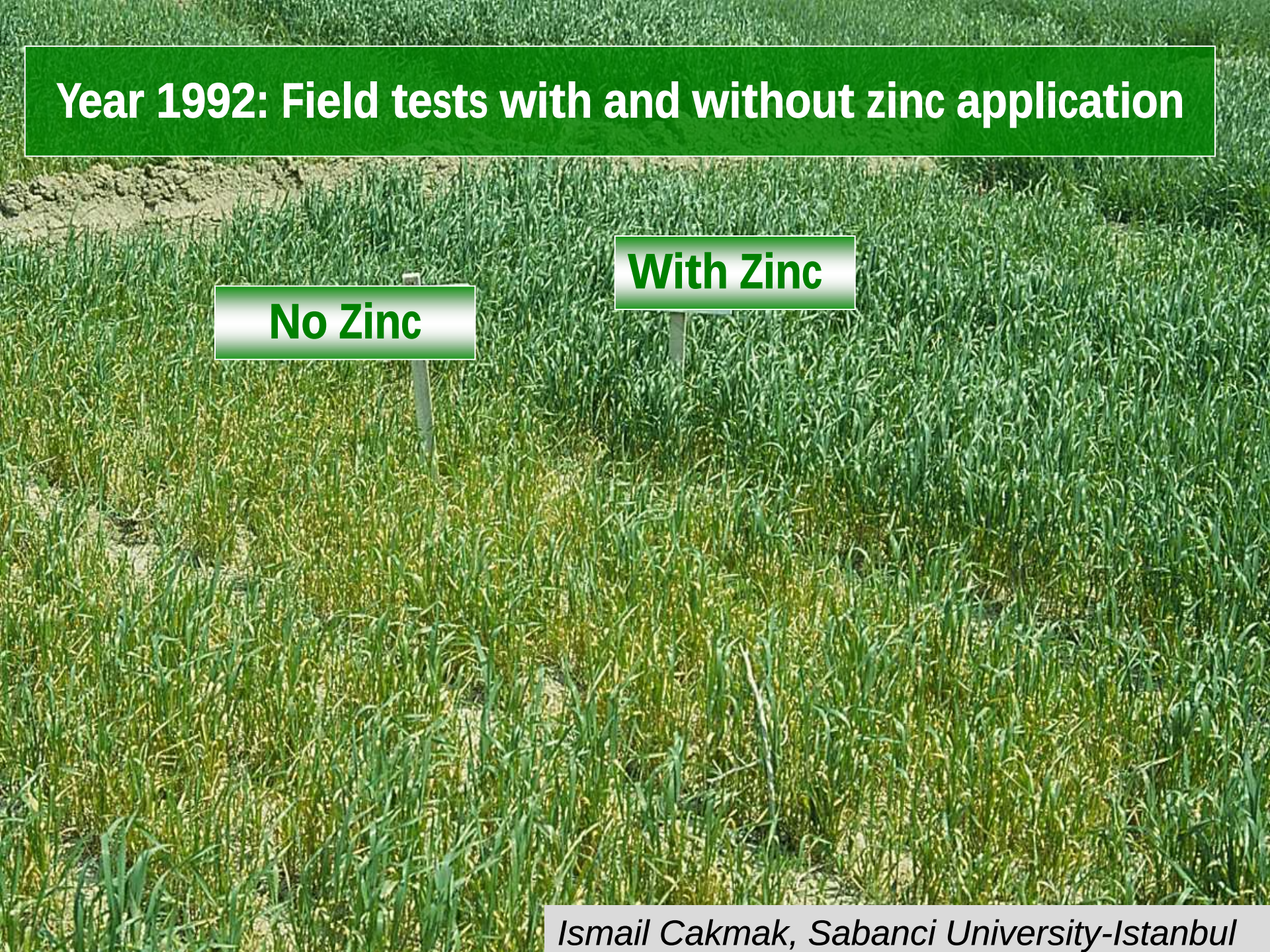
High Consumption Cereal Based Foods with Low Zn and Fe Concentrations

In a number of developing countries cereals contributes nearly 75 % of the daily calorie intake.

For better Zn nutrition of human beings,
cereal grains should contain around
40-60 mg Zn kg^{-1}

Current Situation:
10-30 mg kg^{-1}

Year 1992: Field tests with and without zinc application



Pictures from NATO-Zinc Project in Central Anatolia.

Green Areas show the areas treated with Zinc Fertilizers.

Project was supported by NATO Science for Stability Program (NATO-SFS)

NATO-Science for Stability (NATO - SFS)

Ismail Cakmak, Sabanci University-Istanbul

Global Zinc Fertilizer Project
II. Phase

HarvestPlus
Breeding Crops for Better Nutrition

HarvestZinc
exploring fertilizer use to increase zinc in cereals

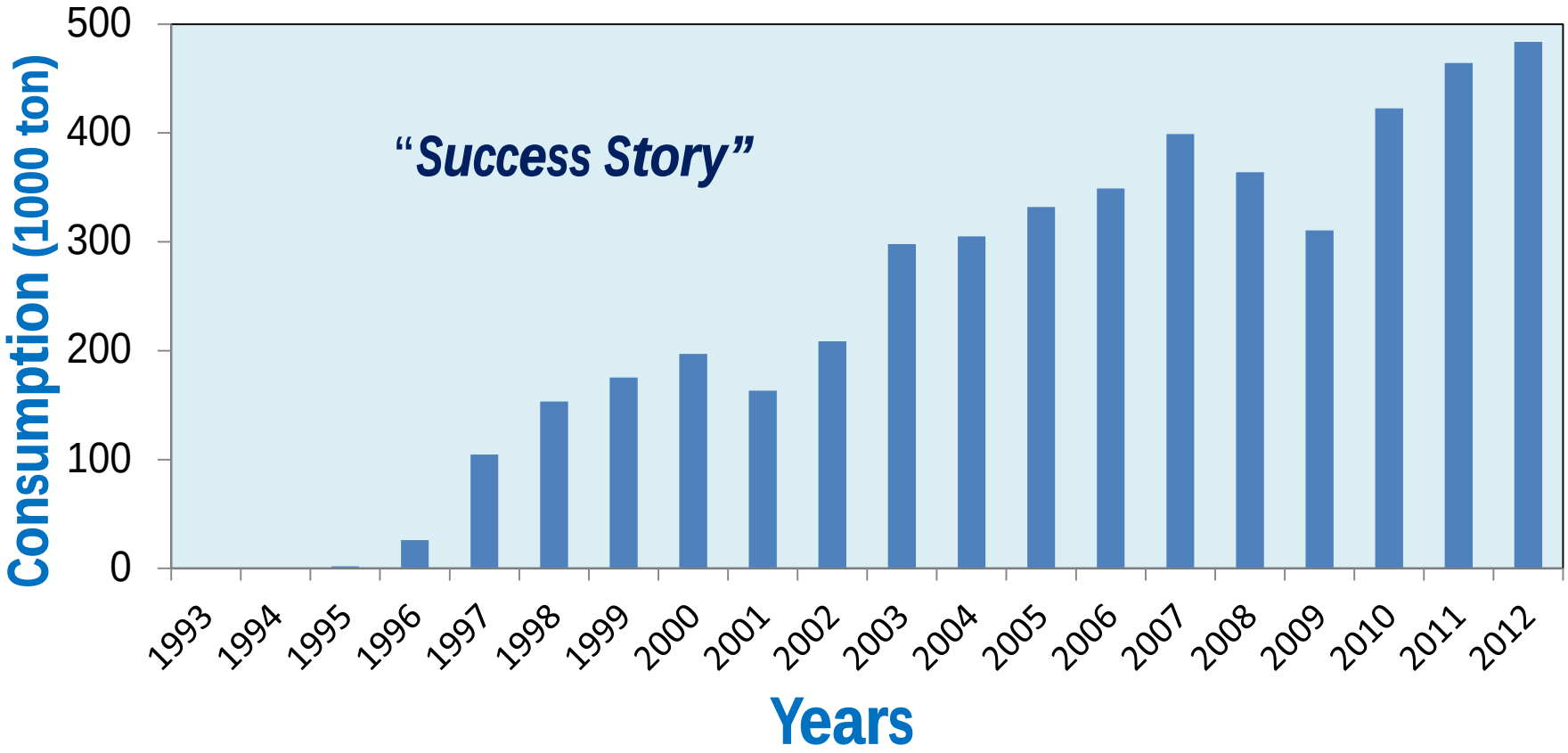
www.harvestzinc.org

Mosaic · KALI · Zinc ...essential for life
OMEX · ifa · Bayer CropScience
ADOB · Valagro · fbsciences · IPNI · ATP NUTRITION Powering Growth with Science™

Sabancı Üniversitesi

Ismail Cakmak,
Sabanci University-Istanbul

Use of Zinc Containing Compound Fertilizers after NATO-Zinc Fertilizer Project in Turkey



Source: Ministry of Agriculture and Toros Fertilizer

Selenium-Enhanced Foods in Cancer Prevention

- Selenoproteins – Se essential to the antioxidant enzyme glutathione peroxidase (Combs, 2011, 2012)
- In 1983, Finnish Ministry of Agriculture and Forestry directed that all agricultural fertilizers contain Se.
- By 1990, the per-capita intake of Se in the Finnish diet more than quadrupled.
- Average serum Se in Finnish adults increased from 70 to nearly 119 ng/ml
- Large epidemiological studies have found Se status to be inversely associated with cancer risk. Relatively few clinical trials have been conducted, and the evidence for cancer risk reduction due to Se is not conclusive (Dennert et al., 2011).

Iodine

- In many countries, iodized salt effectively eliminates iodine deficiency disorders
  - In some places, infrastructure or culture limits success
- In Xinjiang province in north-west China, potassium iodate (5%) was dripped into irrigation canals and resulted in:
  - a three-fold increase in soil iodine levels
  - a two-fold increase in wheat straw iodine
  - a 50% reduction in infant mortality
  - elimination of iodine deficiency disorders
- Fertilization increases iodine in leaf, not grain

Lyons and Cakmak, 2012

Potassium (K) improves functional quality of fruits and vegetables

- Foliar K with S enhanced sweetness, texture, color, vitamin C, beta-carotene and folic acid contents of **muskmelons**
- In pink **grapefruit**, supplemental foliar K resulted in increased lycopene, beta-carotene, and vitamin C concentrations
- Several studies have reported positive correlations between K nutrition and **banana** fruit quality parameters such as TSS, reducing sugars, non-reducing sugars, total sugars and ascorbic acid, and negative correlations with fruit acidity

Jifon, Lester, Stewart, Crosby & Leskovar, 2012

Applying potassium (K) fertilizer increased the concentration of isoflavones in soybeans

K_2O application	Genistein	Daidzein	Glycitein	Total[1]
Spring banded	938	967	146	2,051
None	831	854	130	1,851
Increase due to K, %	13	13	12	13

[1] Total isoflavone concentration expressed as aglycone; sum of three components; parts per million (ppm)

Vyn et al., 2002. Journal of Agricultural and Food Chemistry, 50: 3501-3506.

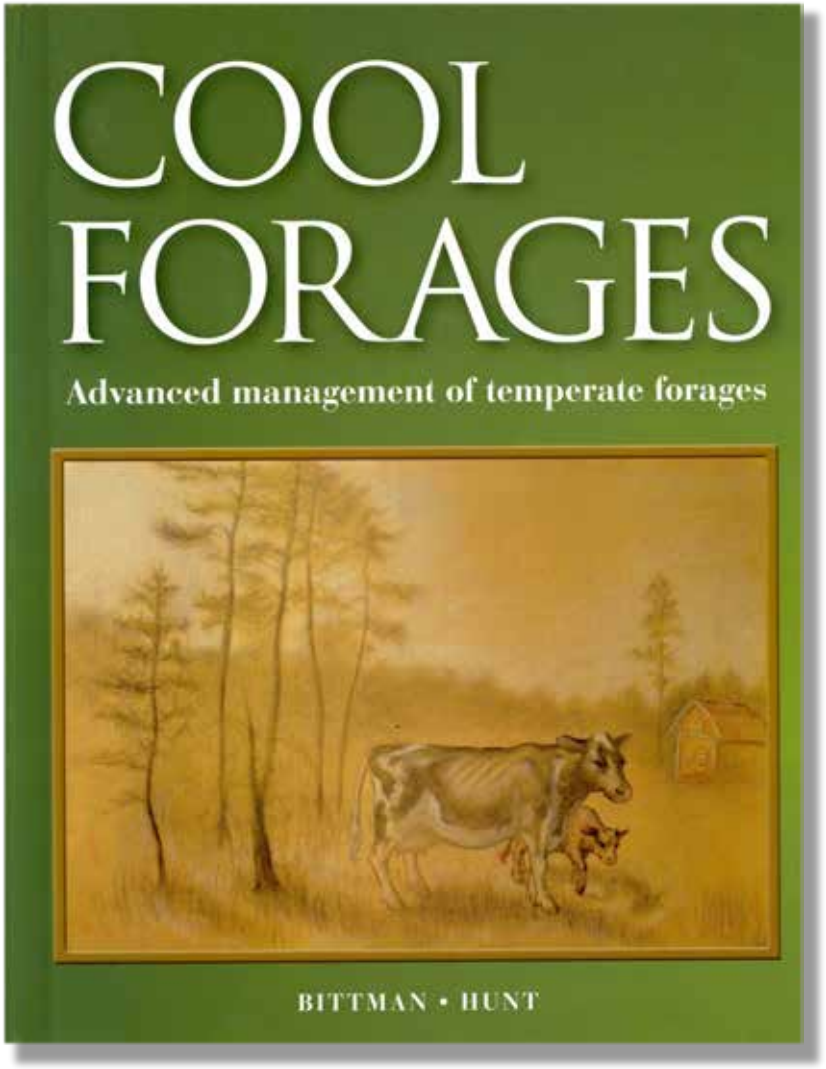
Plant nutrition suppresses plant diseases, reducing mycotoxins and increasing food safety

Crop	Disease	Toxin	Nutrient
Cereals	Ergot (*Claviceps sp*)	Ergotamine (alkaloid)	Cu
Grain, peanuts	*Aspergillus*	aflatoxin	Mn + ?
Cereals	*Fusarium graminearum* (*Gibberella zeae*)	deoxynivalenol zearalenone trichothecene	Mn + ?

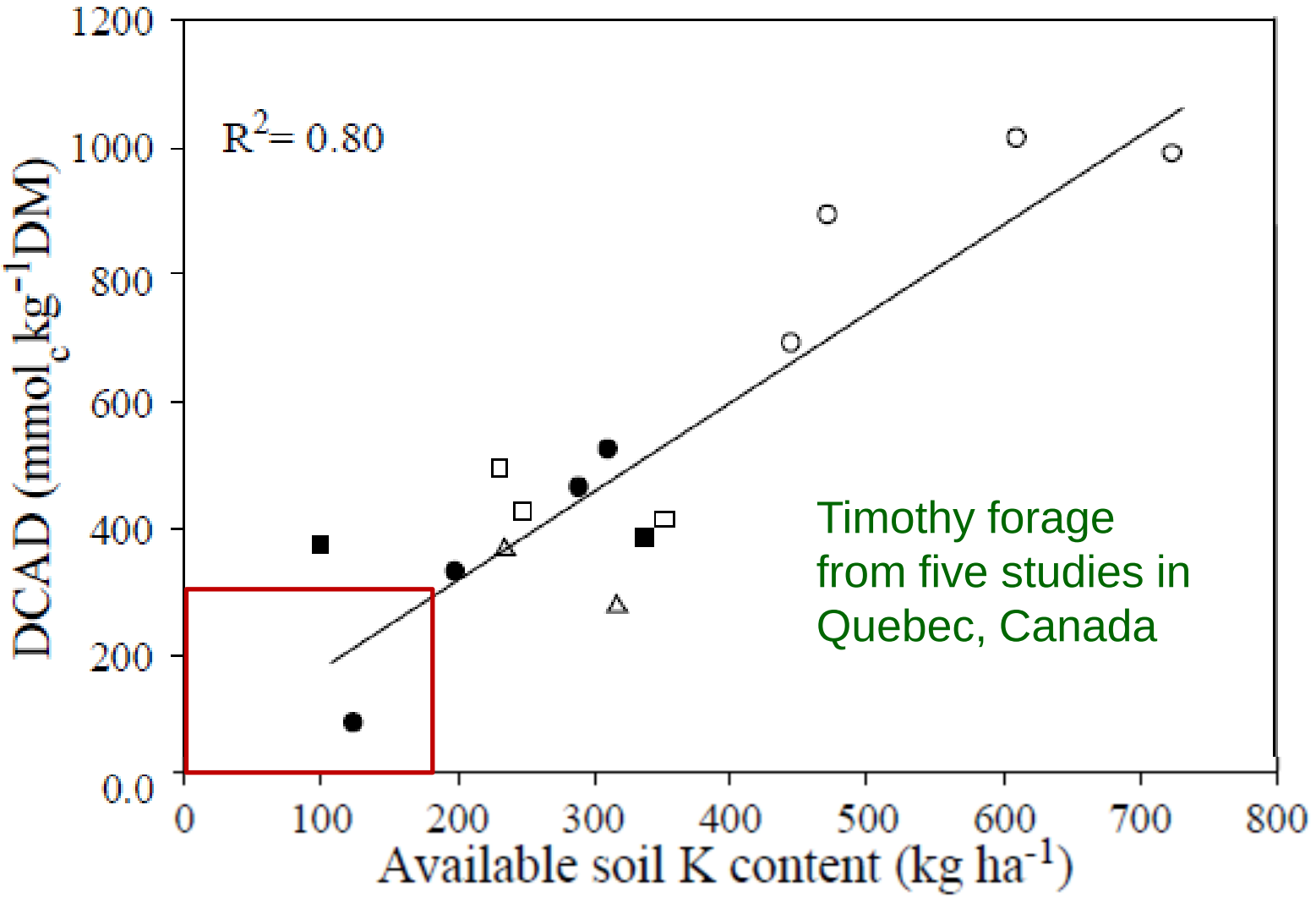
Huber, 2012

Plant Nutrition links with Animal Health

- ©2013 Pacific Field Corn Association
- Chapter 40 & 41 – forages for cows in the transition period, dietary cation-anion difference (DCAD)
- Chapter 50 high forage diets improve quality of beef for consumers



Dietary cation-anion difference (DCAD) increases with soil K



Pelletier et al., 2012

Forage DCAD in the northeast often exceeds levels recommended for dry cows

Mineral nutrient concentration in farm forages analyzed by Dairy One Laboratories, Ithaca, NY from 2000 to 2008.

		K, %	DCAD, meq/kg	GT, meq ratio
Hay	Legume	2.4	422	0.6
	Grass	1.9	298	1.1
Silage	Legume	2.8	502	0.8
	Grass	2.5	420	1.2
	Corn	1.1	192	1.1

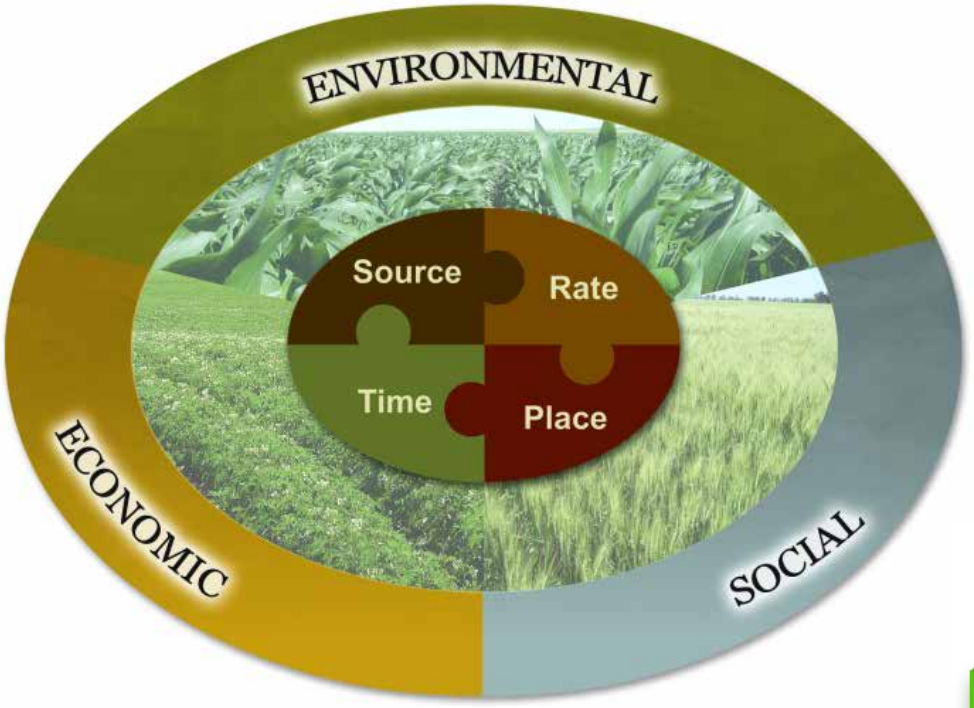
DCAD calculated as K+Na-Cl-0.6S. GT = grass tetany index, calculated as K/(Ca+Mg). Forage DCAD should be below 290 for dry cows, and GT should be below 2.2 (Pelletier et al., 2008).

Bruulsema and Belanger, 2009

Potassium & Dairy Forages

- Liquid manure systems
  - efficient K cycling within the farm
  - Carefully manage K balance
- Dry cow diet (transition, 2-4 weeks before calf)
  - to grow low DCAD forage: species, harvest timing, Cl fertilization, K management
  - timothy, corn silage, grains, brewers & distillers grains, anionic salts
- Most other cattle require more K

4R: “right” means sustainable



Field to Market™
The Keystone Alliance for Sustainable Agriculture

THE SUSTAINABILITY CONSORTIUM

Walmart SustainabilityHUB

Home | Our Goals | How To Make A Difference | Share What You've

Home > How To Make A Difference > Fertilizer Optimization

How to Make a Difference - Fertilizer optimization

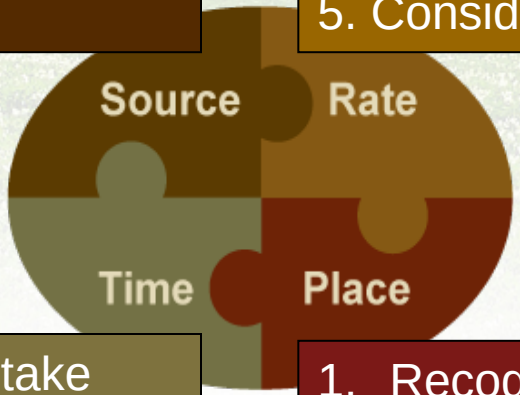
4R PLANT NUTRITION

4 nutrient stewardship

The basic scientific principles of managing crop nutrients are universal

1. Provide essential elements
2. Supply plant-available forms
3. Suit soil properties
4. Synergisms, blend compatibility
5. Associated elements

1. Assess plant demand
2. Assess soil supply
3. Assess all available sources
4. Predict fertilizer use efficiency
5. Consider resources and economics



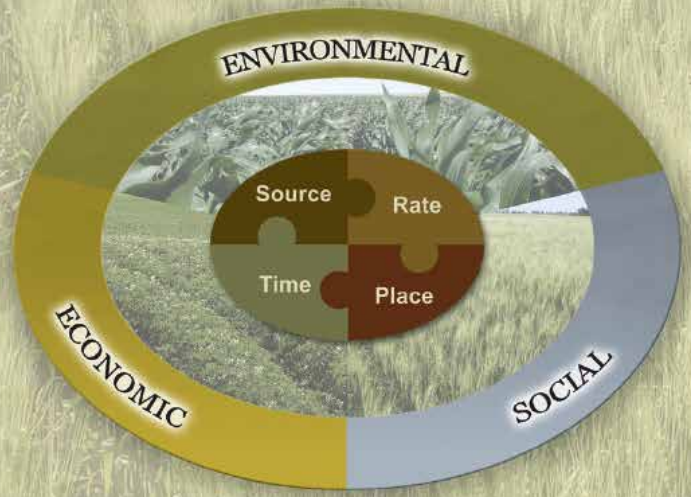
1. Assess timing of crop uptake
2. Assess dynamics of soil supply
3. Assess timing of weather factors
4. Evaluate logistics

1. Recognize root-soil dynamics
2. Consider soil chemical reactions
3. Manage spatial variability
4. Fit needs of tillage system

4R PLANT NUTRITION

A Manual for Improving the Management of Plant Nutrition

NORTH AMERICAN VERSION



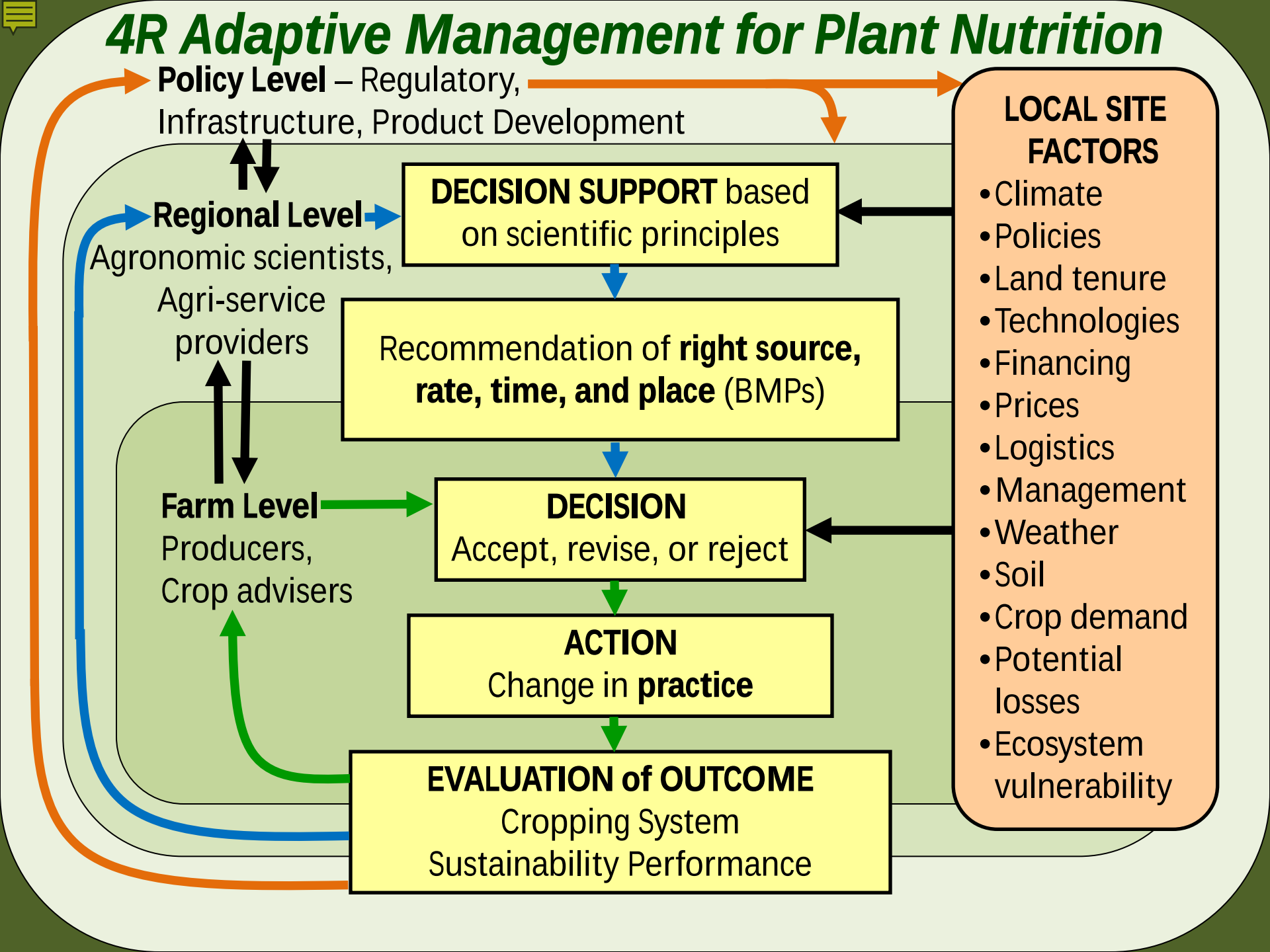
IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

4R nutrient stewardship

http://nane.ipni.net

IPNI

4R Adaptive Management for Plant Nutrition



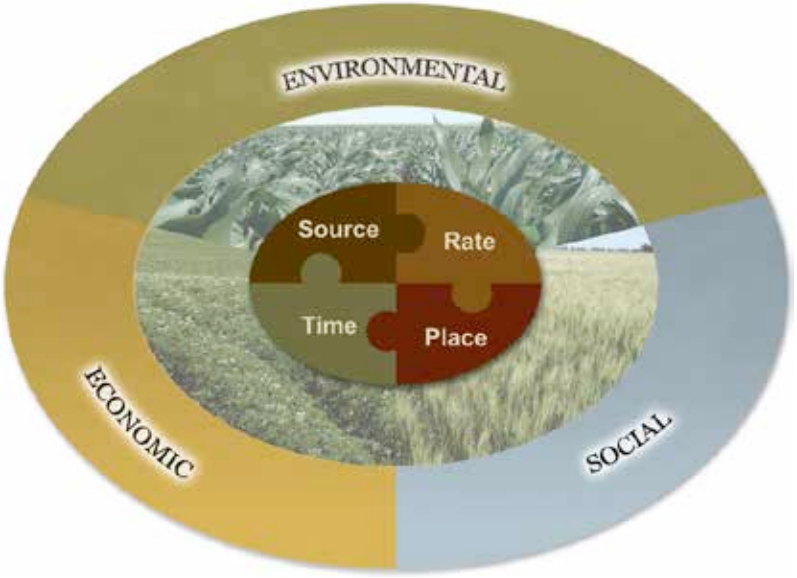
4R Research Fund – *environmental, social, economic impacts of 4Rs on sustainability*

- **$7M** over 5 years across North America
- **Meta-analyses:** Review and analysis projects.
- **New Projects** – Measurement.
- Both to contribute measures of performance for 4R Nutrient Stewardship.
- For additional information: www.nutrientstewardship.com/funding

nutrient stewardship

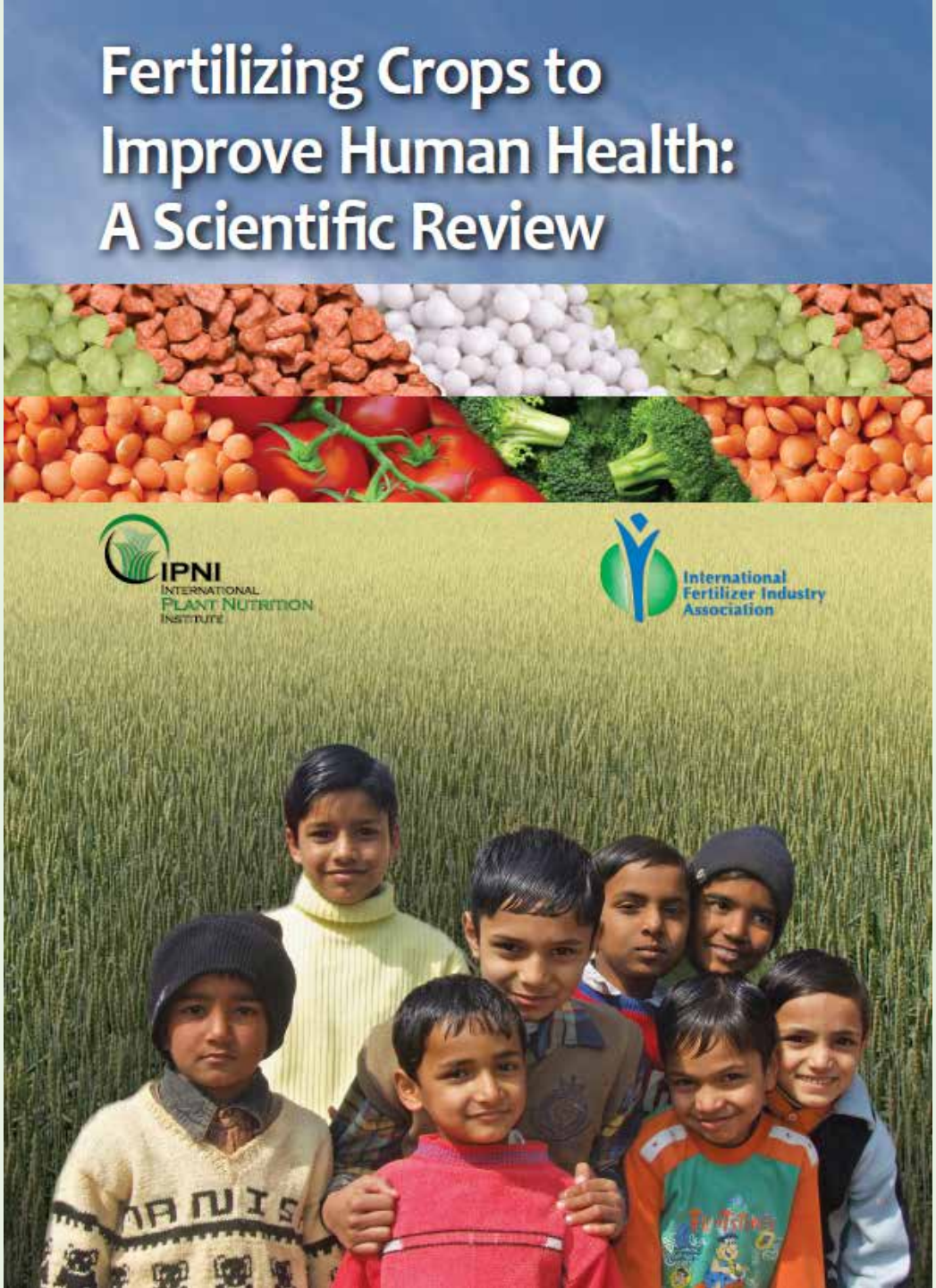
Summary

- Plant nutrient stewardship has immense impact on human nutrition security
  - Quantity and quality of food
  - Protein, Zn, Se, I, Vitamins A&C, and nutraceuticals
- Research and investment has great potential to continue improving human health.



4 nutrient stewardship

IPNI



Thank You

www.ipni.net