IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

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Fertilizing Crops to Improve Human Health: a Scientific Review

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Director, Northeast Region, North America Program

Agrium Inc.

Arab Potash Company

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CF Industries Holdings, Inc.

Compass Minerals Specialty Fertilizers

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PotashCorp

Qatar Fertiliser Company (QAFCO)

Simplot

Sinofert Holdings Limited

SQM

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

Fertilizing Crops to Improve Human Health: a scientific review, edited by IFA & IPNI

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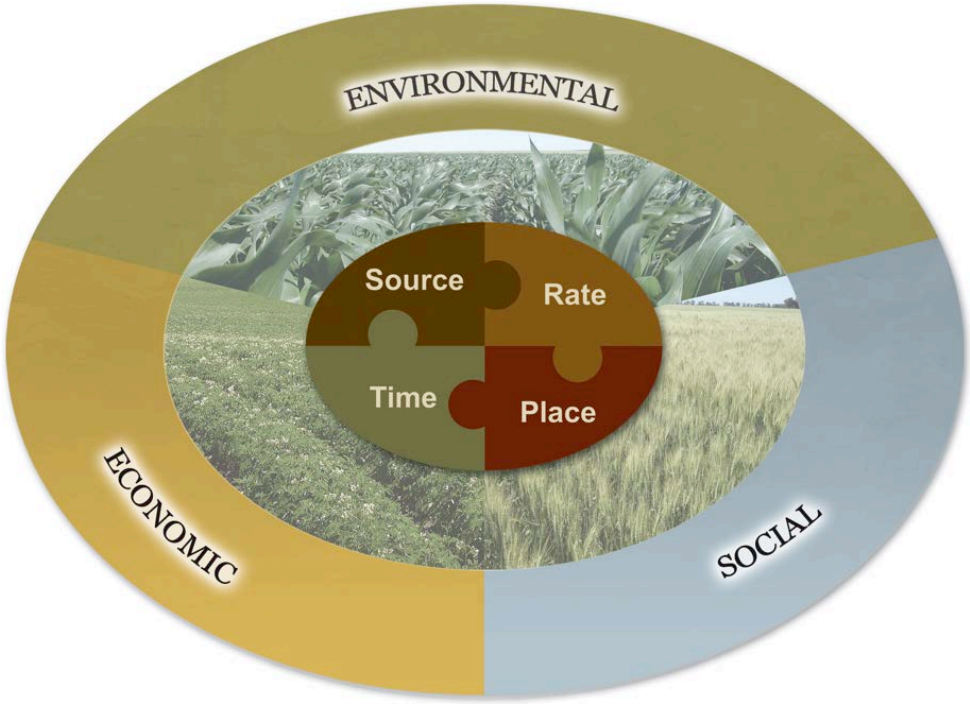
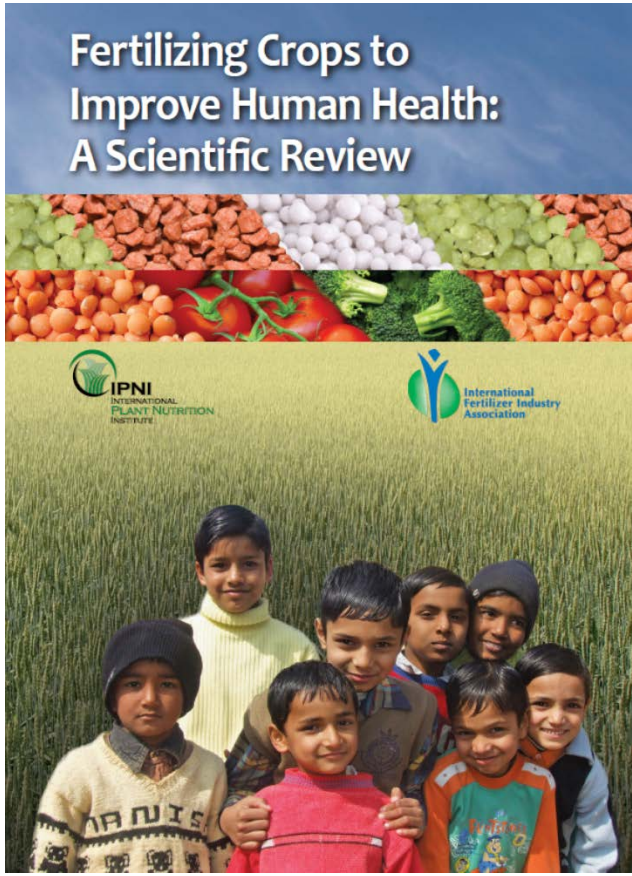
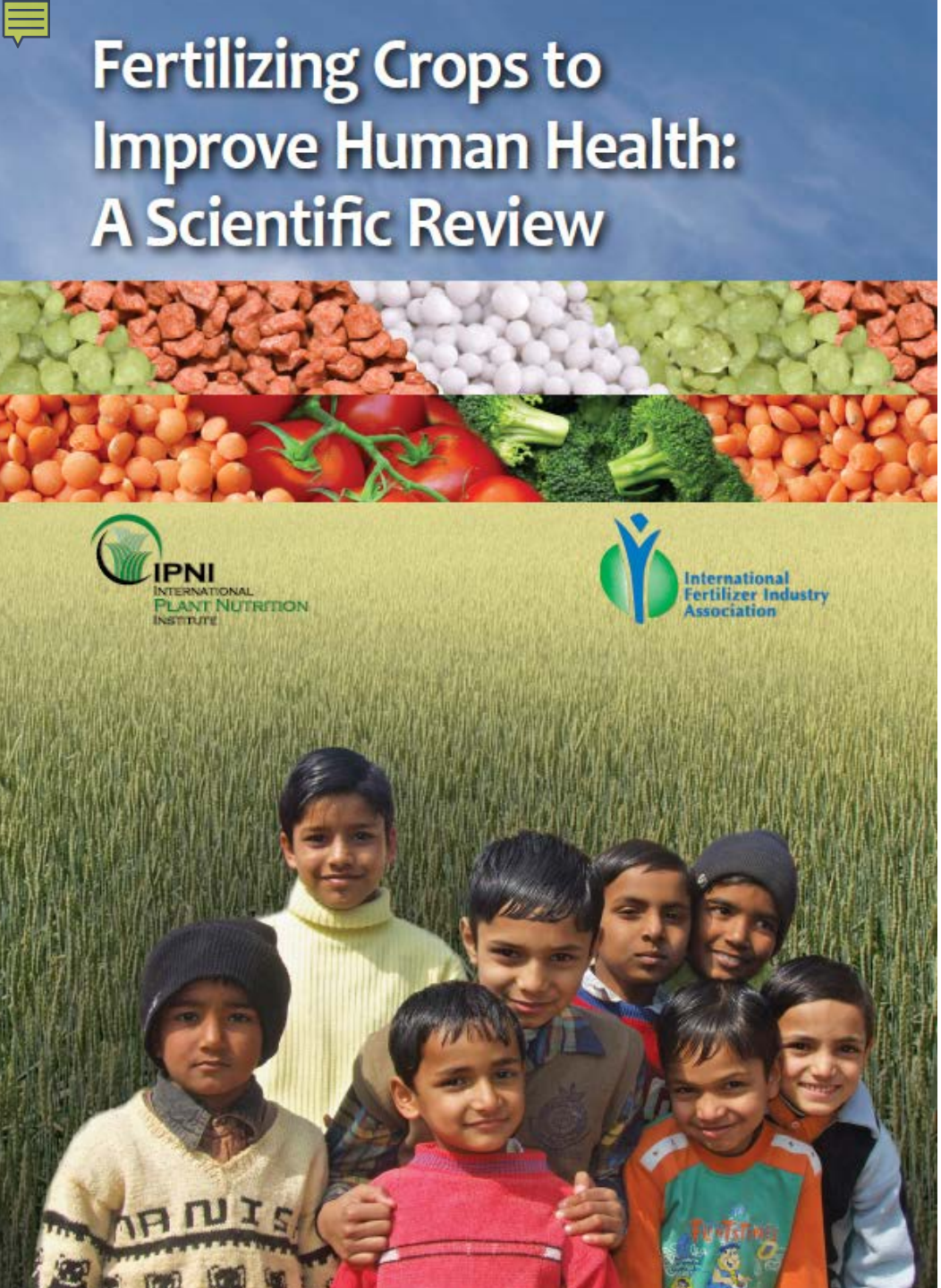




4 nutrient stewardship



Topics

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

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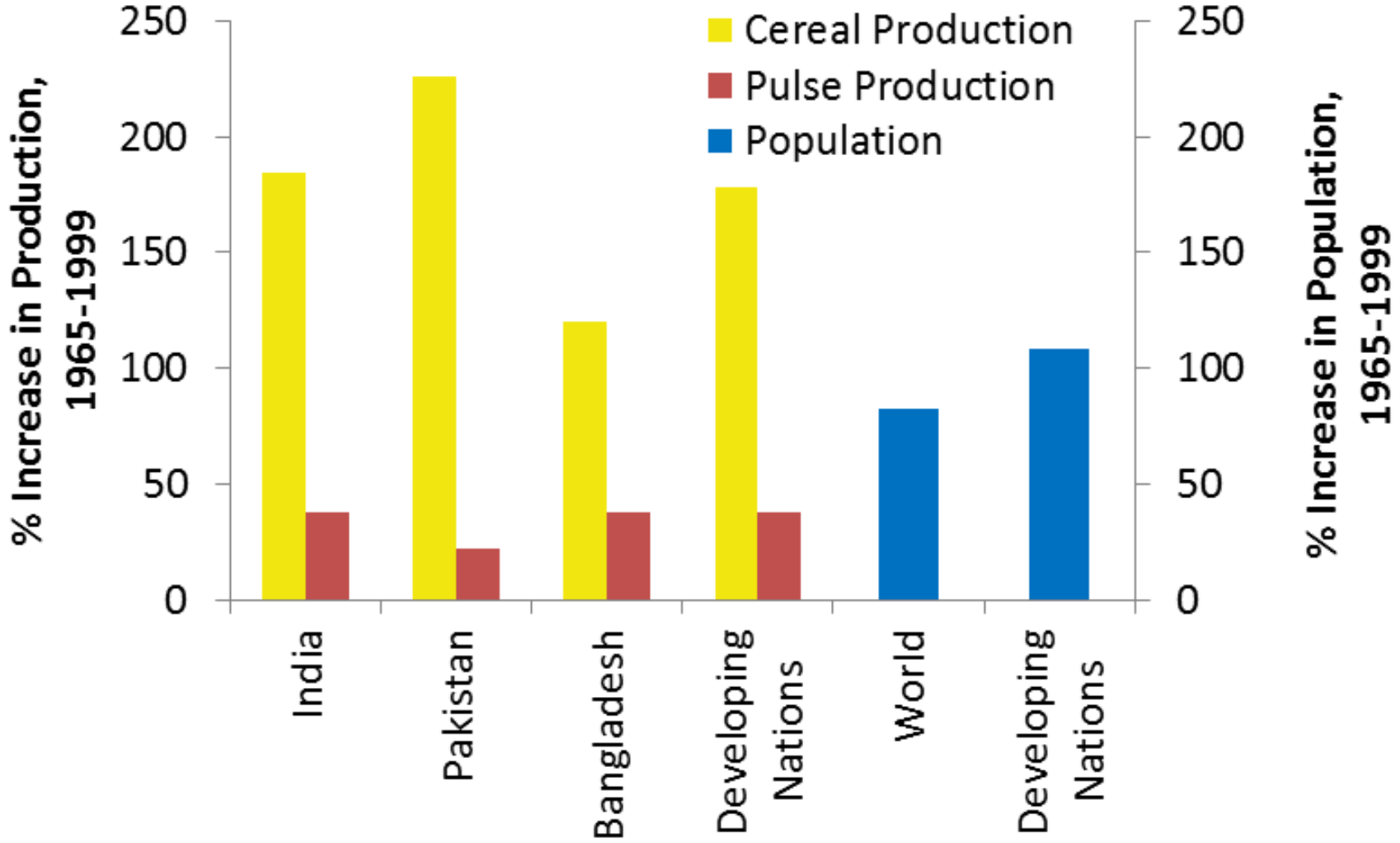
More cereals per capita, less pulses



Bouis, Boy-Gallego & Meenakshi

Micronutrient Malnutrition (% prevalence)

Bouis, Boy-Gallego & Meenakshi

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**

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Enhancing the Nutritional Quality of Food Crops with Trace Elements – Welch and Graham

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**

"…it is imperative that fertilizer technology be used to improve the nutritional quality of staple food crops that feed the world's malnourished poor. "

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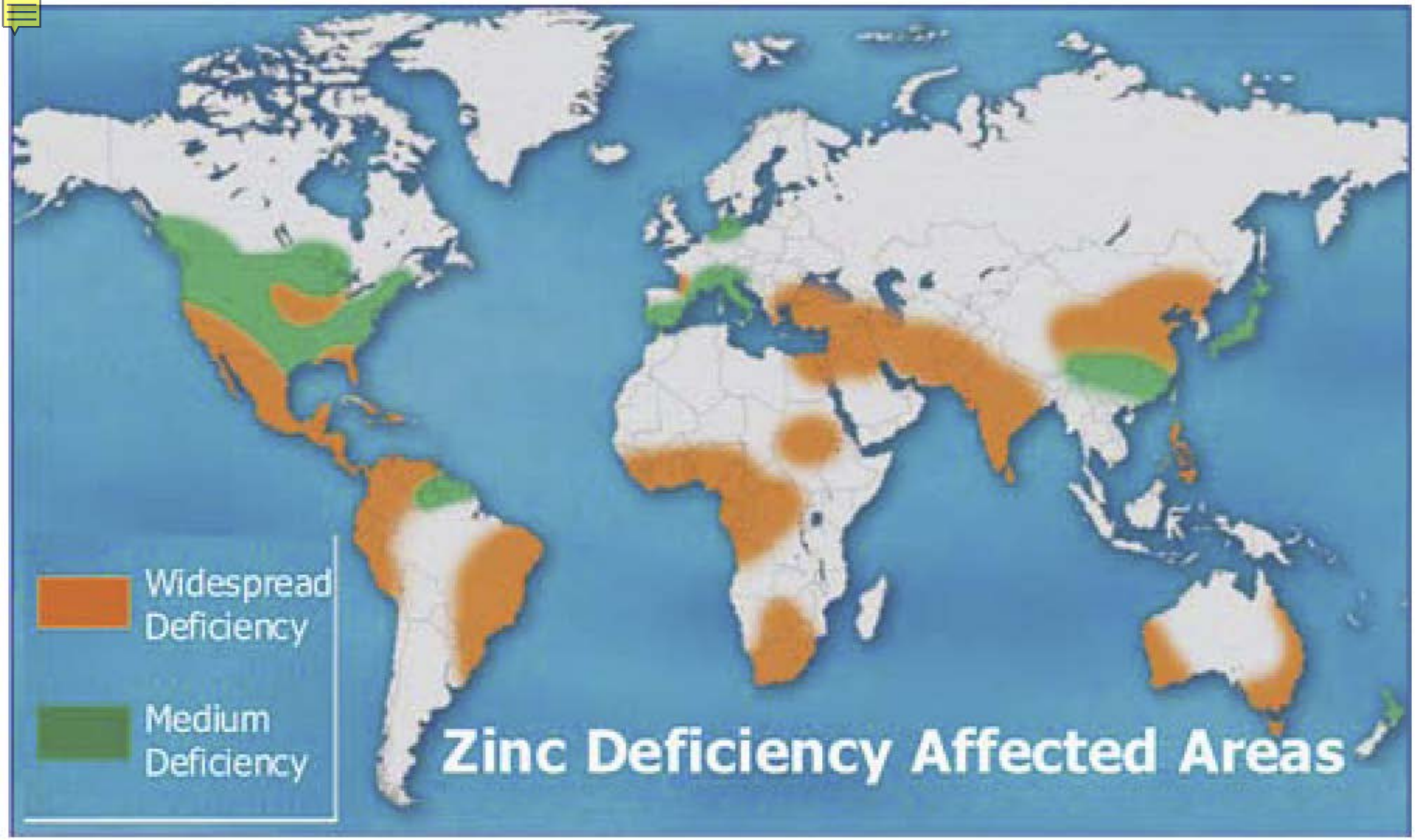

Figure 2: Global distribution of Zn-deficiency affected regions (Alloway, 2007)

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Urea coated with Zn increases yield and grain Zn

Fertilizer	Rice		Wheat	
	Grain yield, t/ha	Grain Zn, mg/kg	Grain yield, t/ha	Grain Zn, mg/kg
Prilled urea	3.99	30	3.72	40
Urea + 1% ZnO	4.46	36	4.14	46
Urea + 1% $ZnSO_4$	4.67	39	4.25	49
Urea + 2% ZnO	4.95	43	4.39	49
Urea + 2% $ZnSO_4$	5.15	48	4.53	51

"urea fertilizers coated with $ZnSO_4$ always produced better results than urea coated with ZnO" - *Lyons and Cakmak, Chapter 4*

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Selenium-Enhanced Foods in Cancer Prevention – Combs

- Selenoproteins – Se essential to the antioxidant enzyme glutathione peroxidase (GPX)
- 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
- Epidemiological studies have found Se status to be inversely associated with cancer risk. While relatively few clinical trials have been conducted, all but one have shown cancer risk reduction due to Se.

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Functional Quality of Fruits and Vegetables

- Jifon, Lester, Stewart, Crosby & Leskovar

- 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

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Concentration of isoflavones in soybean seeds in response to applied K fertilizer (two sites, three years, 1998-2000).

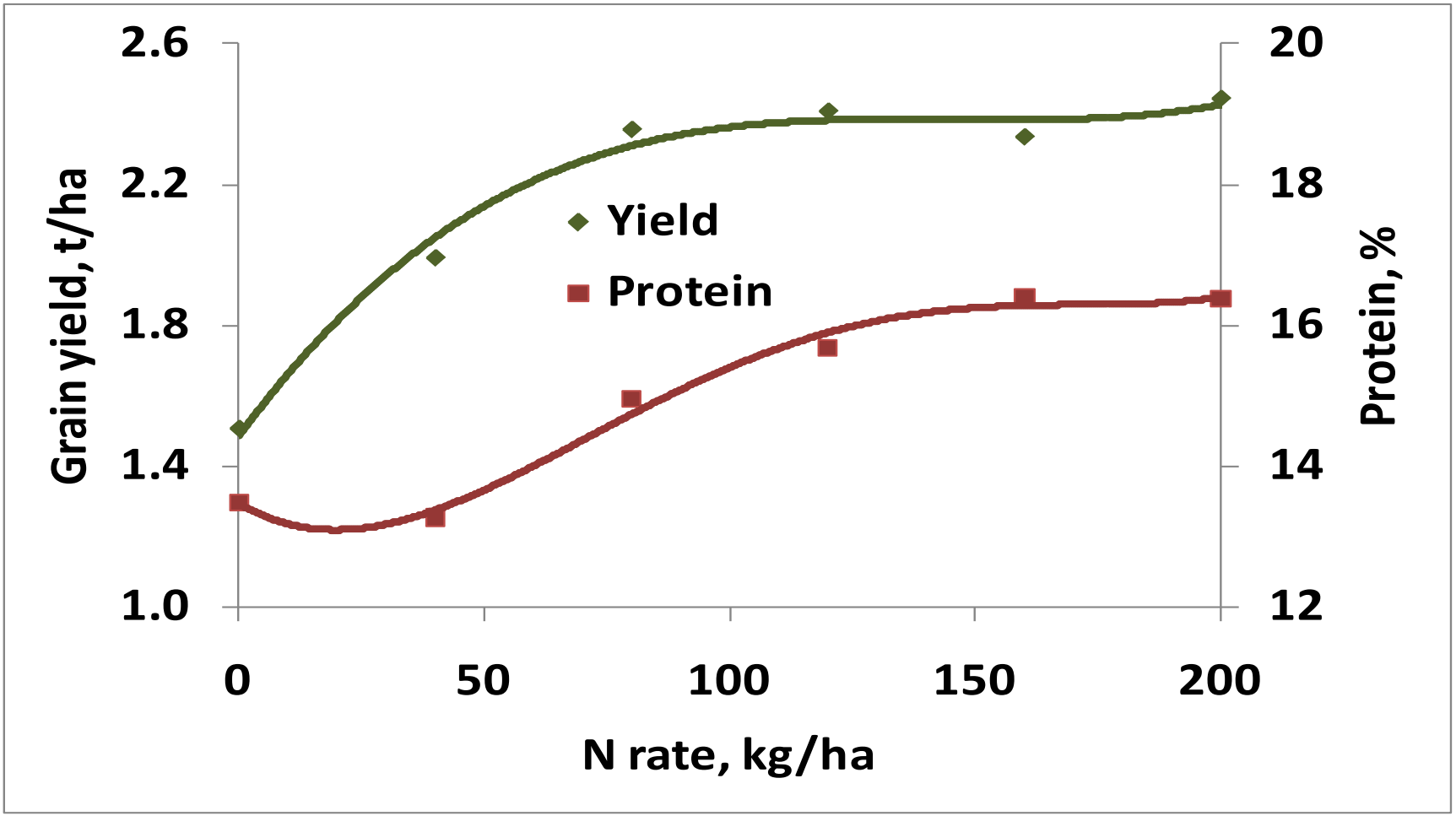
K_2O application	Genistein	Daidzein	Glycitein	Total[1]
Spring banded	938	967	146	2,051
None	831	854	130	1,851
Increase due to K, %	13	13	12	13

[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.

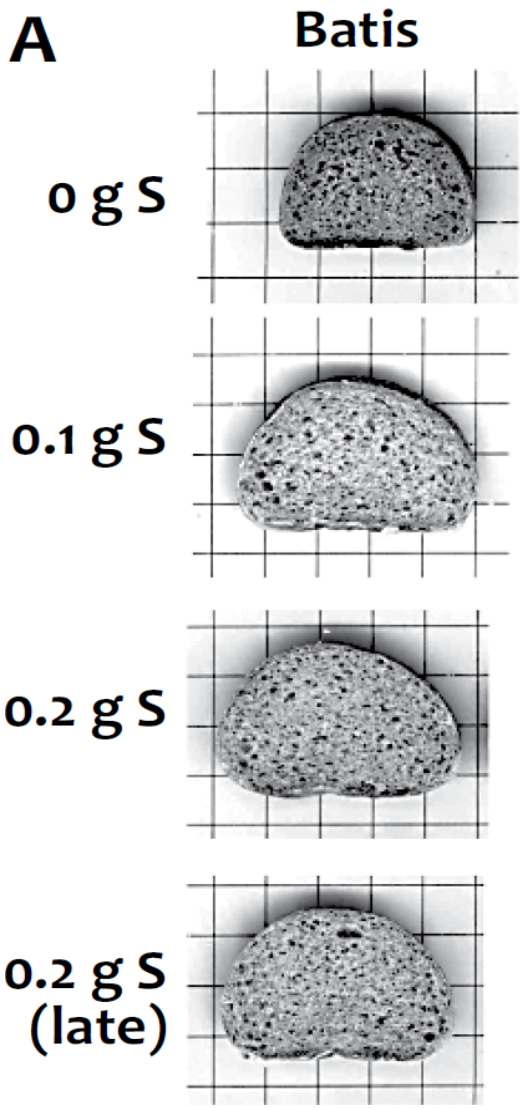
Protein, Oil, Carbohydrate

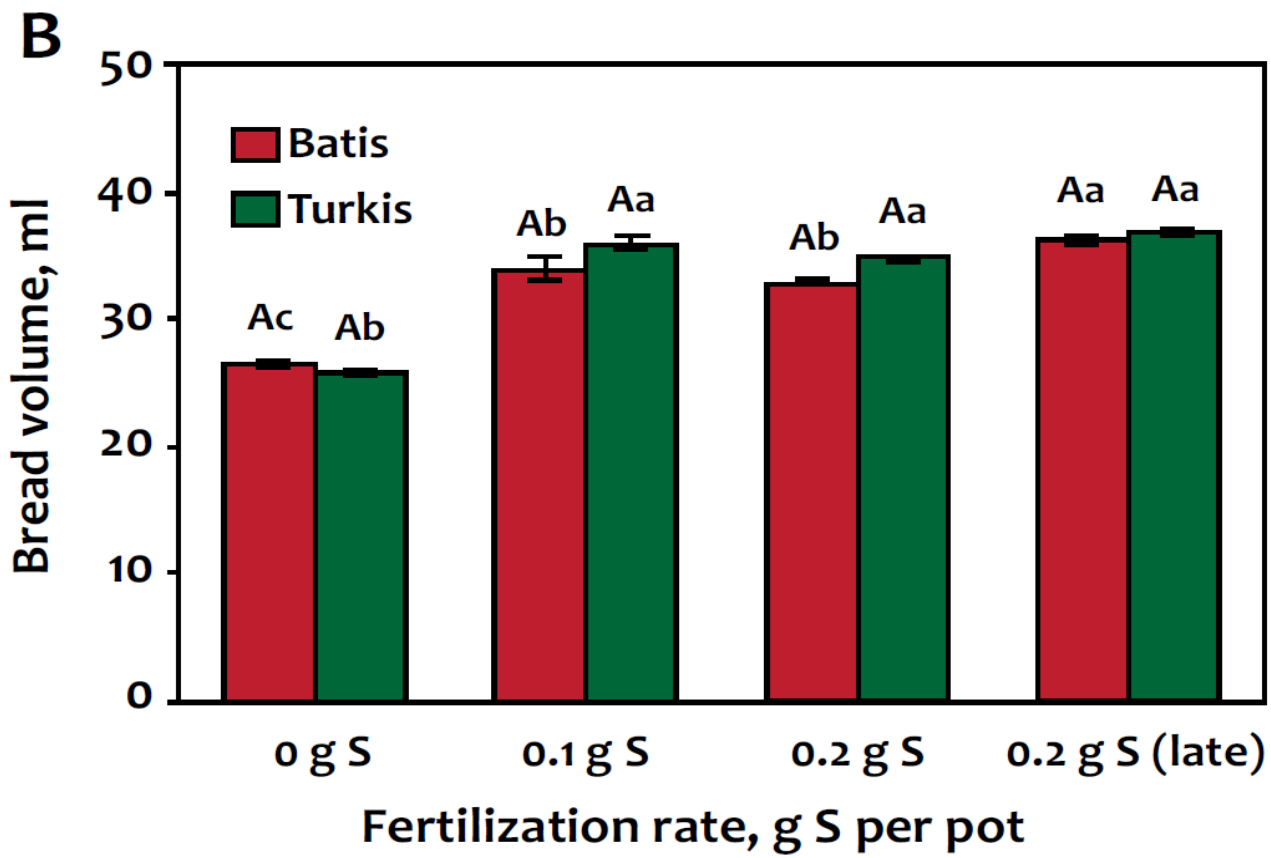
Grant & Bruulsema



Katepwa hard red spring wheat (Grant, unpublished)

Sulphur and Wheat Bread-making Quality





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

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Plant diseases, mycotoxins & food safety - Huber

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 + ?

1. Managing nutrition influences diseases and their control
2. Knowledge Gap: nutritional control of the plant diseases most relevant to food safety

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Plant Diseases – Huber

- Strategies to reduce disease through nutrition:
  1. **Nutrient-efficient cultivars –** Mn uptake ability in cereals
  2. **Balanced nutrition:** optimum levels
  3. **Form & Source:** NH_4 versus NO_3, KCl versus K_2SO_4
  4. **Timing:** apply N during conditions favoring plant growth
  5. **Integration:** tillage, crop rotation, soil microbes

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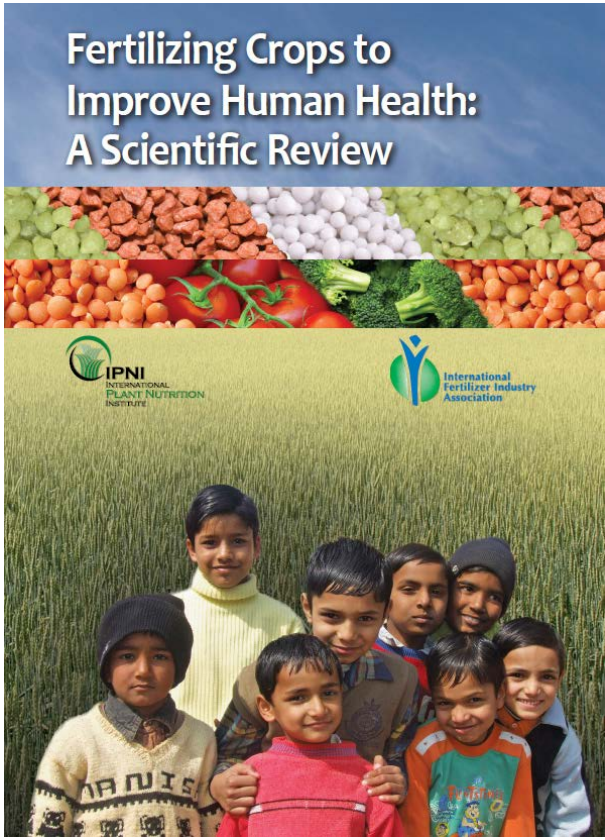
Benefits to the industry

1. Compilation of benefits for public awareness.
2. Foundation to build on for further research.
3. Builds relationships with research scientists.

Continuing efforts:

1. Encourage evaluation of impacts on human health in research supporting 4R Nutrient Stewardship.
2. Include human health impacts in messaging related to food and nutrition security.



4R nutrient stewardship

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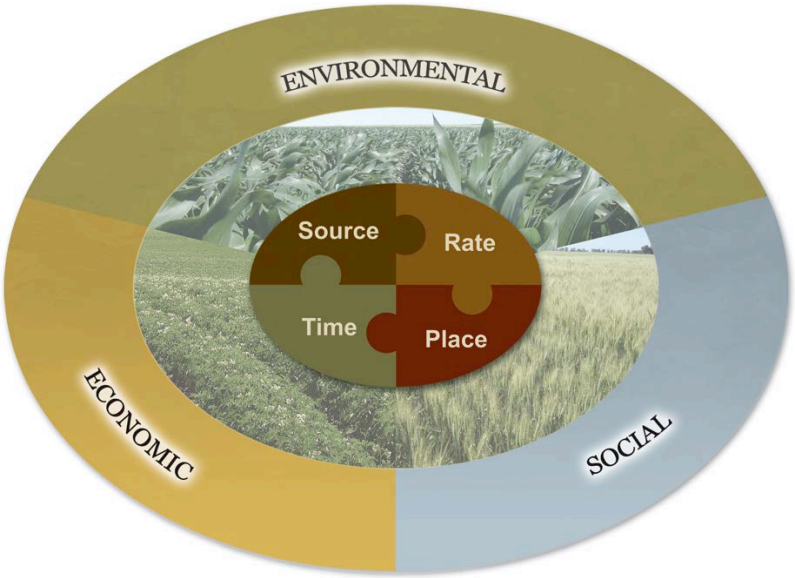
Summary

- Fertilizer contributes immensely to the health and well being of humanity.
  - Quantity & Quality
  - Protein, minerals, vitamins and nutraceuticals
- Research supporting 4R Nutrient Stewardship has great potential to improve human health.



4 nutrient stewardship

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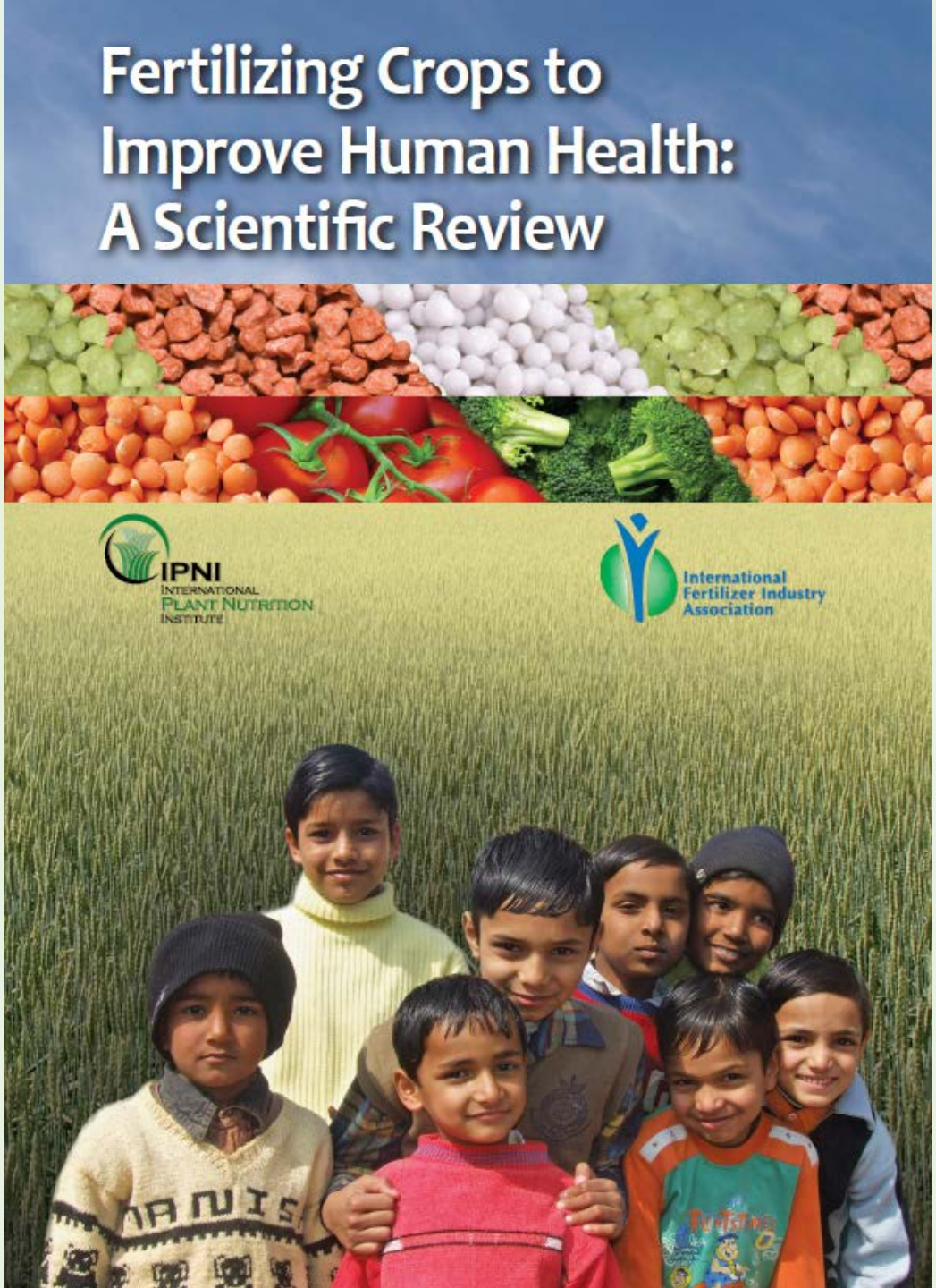

Thank You

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