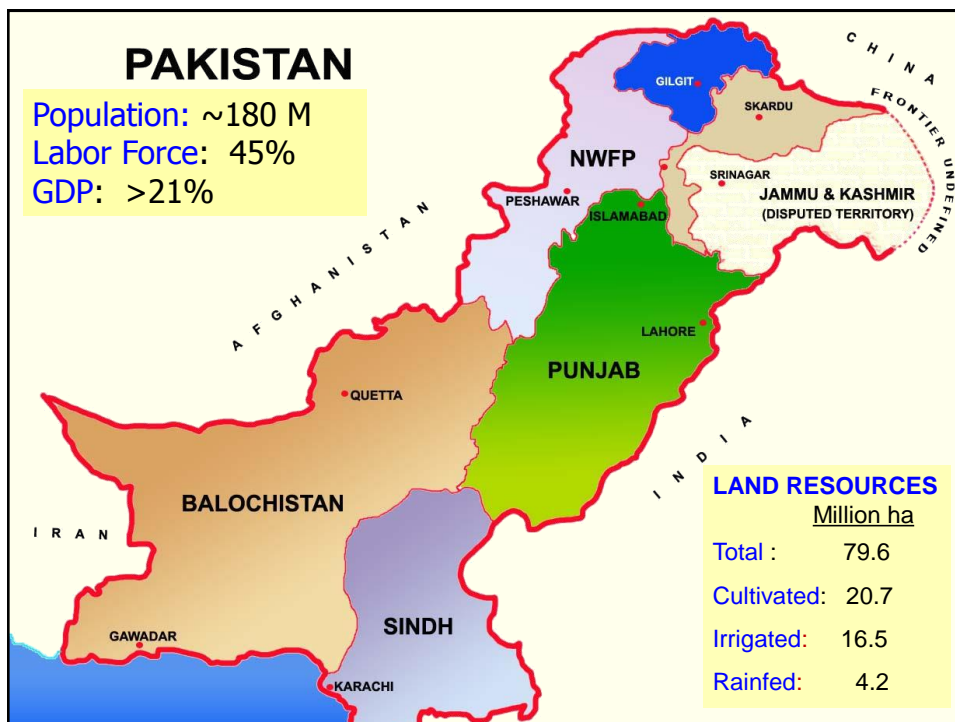


Micronutrients R&D for Balanced Crop Nutrition A Success Story from Pakistan

Abdul Rashid

Pakistan Academy of Sciences
Islamabad, PAKISTAN



Pakistan: Soils & Fertilizer Use

Soil Types:

- Aridisol
- Entisol
- Inceptisol
- Alfisol
- Mollisol
- Vertisol

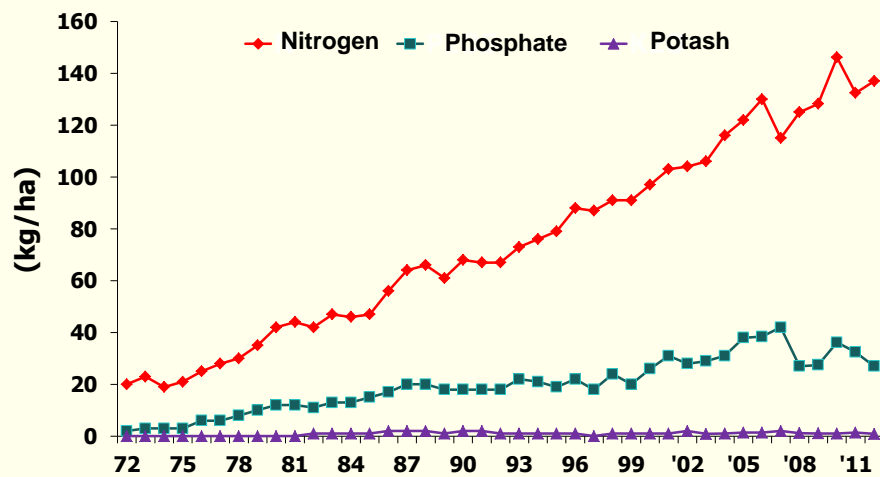
Alluvial, Alkaline, Calcareous, Low OM

Fertilizer Use: Historical Perspective

N	P	K	Zn	Fe	B
1950s	1960	1966	1970s	1980s	1990s

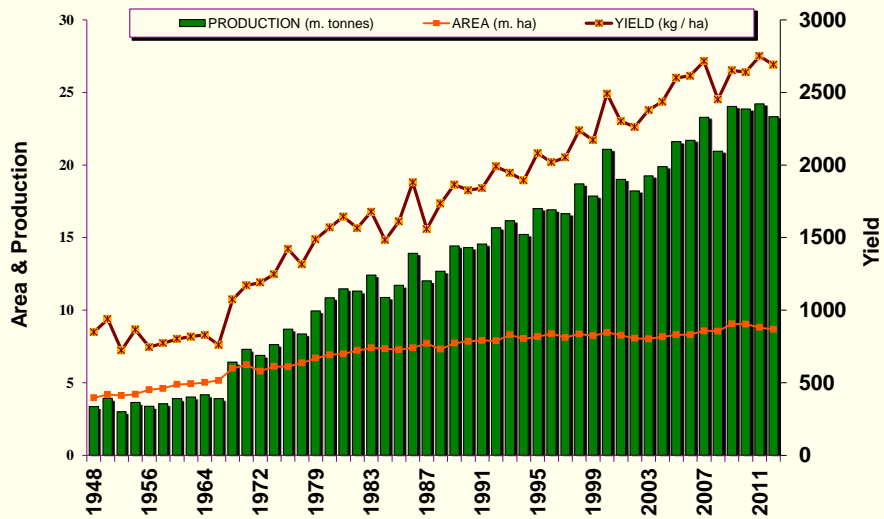
Source : Rafiq (1996); NFDC

Fertilizer Nutrient Use (per ha)

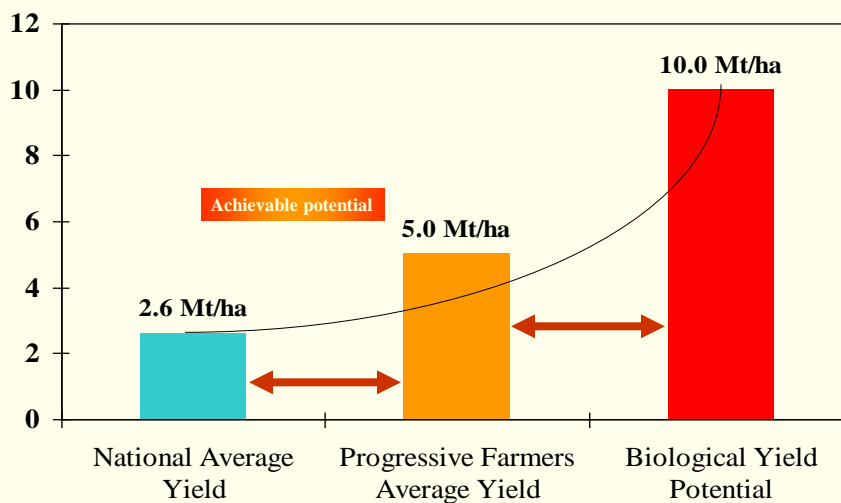


Source: NFDC

Wheat: Production and Yield

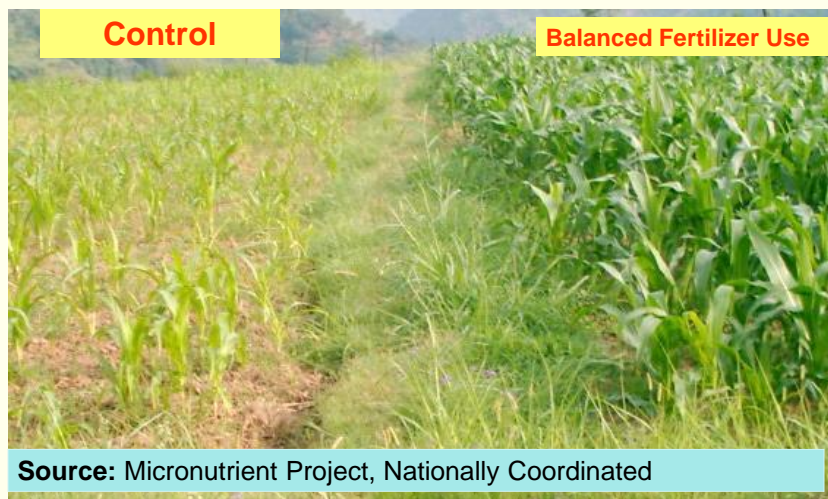


Wheat: Yield Gap & Crop Nutrition



Source: Pakistan Agricultural Research Council

Balanced Nutrient Management *including Micronutrients*



MICRONUTRIENTS

Zinc (Zn), Boron (B), Iron (Fe), Copper (Cu),
Manganese (Mn), Molybdenum (Mo),
Chloride (Cl), Nickel (Ni)

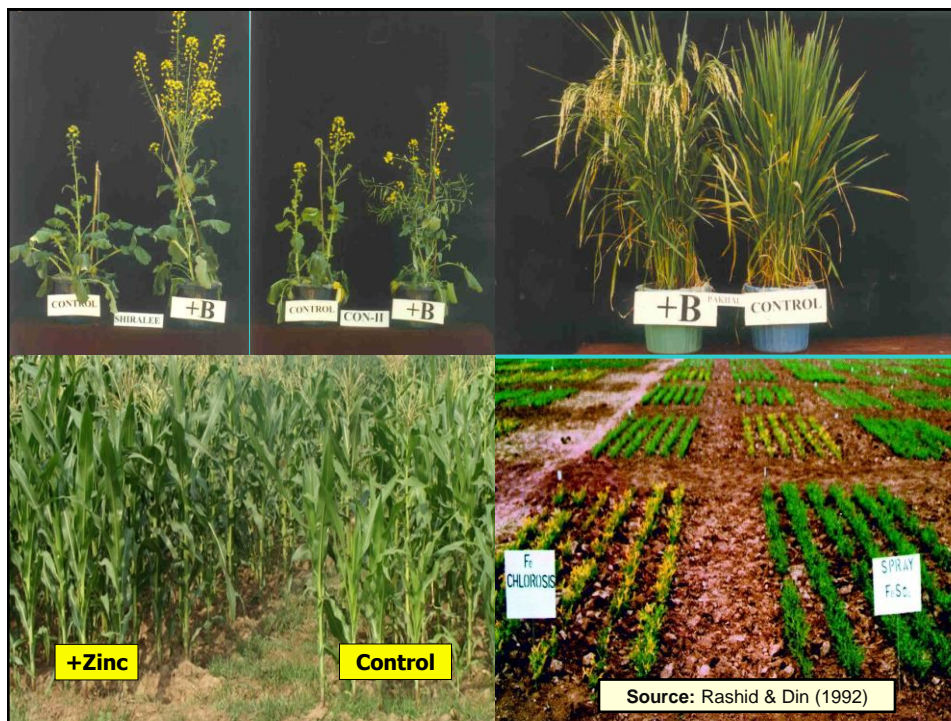
- “Small but Mighty” – TFI
- **Crop Deficiency:** Low Yields,
Poor Quality Produce
- **Humans & Animals:** Growth, Reproduction
- **Deficient - Pakistani Soils:** **Zn, B, Fe**

Micronutrients: R&D Strategy

- 1) Deficiency Diagnosis: Cropping Systems-based
- 2) Crop Responses: Greenhouse, Farmers' Fields
- 3) Res. Info. Dissemination: Journals, Conferences,
Books, Brochures
- 4) Micronutrient Use Technologies: Cost-effective;
Practically Feasible
- 5) Field Demonstrations: Industry & Extension
- 6) Recommendations: Agric. Extension
- 8) Fertilizer Availability: Industry

Deficiency Diagnosis

- Soil & Plant Sampling – Farmers' Fields
 - Lab Analyses
 - Data Interpretation
- Micronutrient Deficiencies: Nature, Extent, Severity, e.g., Cotton: Zn, 41%; B, 55%
- Spatial Variability Mapping: Geostatistics;
Contour Mapping



ZINC Deficiency in Rice

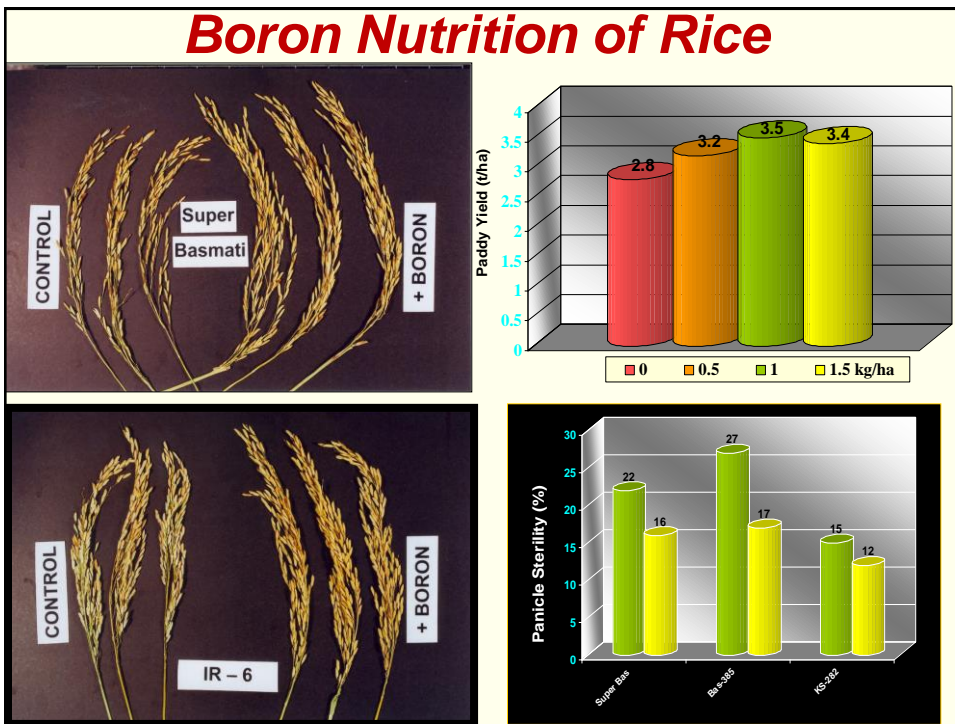
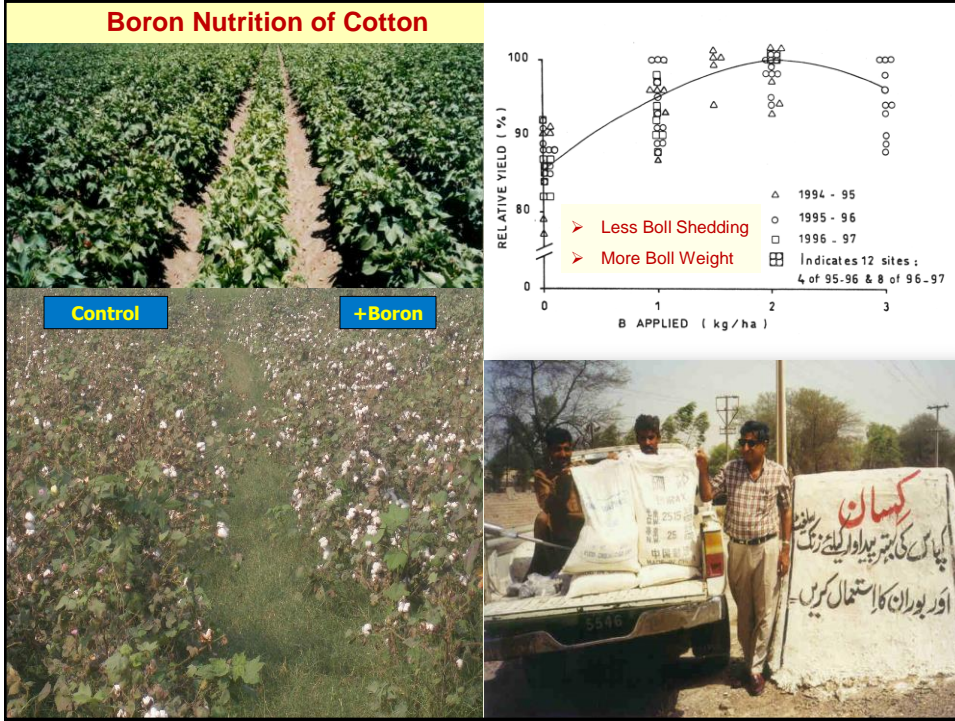
➤ **Hadda 'disease'** : Bronzing
IRRI Scientists: Yashida & Tanaka (1969)

- Zn Deficiency: 80% of 2 M ha Rice Area
- Yield Increases with Zn: 8 – 35%



Zinc-enriched Nursery

Technology	Paddy Yield (t ha)	Zn Dose (kg ha)	VCR
Field broadcast	3.75	5.0	10:1
Nursery beds	3.85	0.8	24:1



Economics of Micronutrient Use

Crop	Yield Increase	Value-Cost Ratio*
ZINC		
Wheat	13 %	7:1
Rice	11 %	10:1
BORON		
Cotton		
Soil	14 %	15:1
Foliar	12 %	30:1
Rice		
<i>Basmati</i>	15-25 %	32:1
IR-6	30 %	28:1

* + Beneficial Residual Effect; Current Crop uptake, < 2%

Micronutrient Use: Additional Benefits

Example: RICE: Boron Fertilizer Use

➤ Produce Quality Improvement

- Increased Milling Return
- More Head-rice
- More Elongation upon Cooking
- Less Bursting upon Cooking

➤ Residual Effect on wheat: Rice B uptake < 2%

Pakistan: Crops Requiring Micronutrient Fertilizer

Field Crops	Vegetables	Fruits
Alfalfa	Beans	Apple
Clovers	Cabbage	Apricot
Cotton	Carrot	Citrus
Maize	Cauliflower	Grapes
Mustard	Lettuce	Peach
Peanut	Onion	Pear
Rapeseed	Potato	Plum
Rice	Radish	
Sorghum	Spinach	
Sugarbeet	Sweet Potato	
Sugarcane	Tomato	
Sunflower	Turnip	
Tobacco		
Wheat		

Micronutrient Use Recommendations

ZINC

Crops & Vegetables	Soil application	2-5 kg Zn ha ⁻¹
Fruits	2-3 Foliar Sprays	0.1% Zn solution

BORON

Crops & Vegetables	Soil application	0.75 -1.0 kg B ha ⁻¹
	2-3 Foliar Sprays	0.1% B solution

IRON

Crops & Fruits	3-4 Foliar Sprays	0.5% Ferrous Sulfate 1% Sequestrene
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Source: Rashid (2006)

Soil Zn Deficiency \longrightarrow Low Yields & Zn-Poor Crop Produce

**Zinc Malnutrition: Globally, 1 Billion People
especially Developing Countries***

PAKISTAN: National Nutrition Survey (2011)

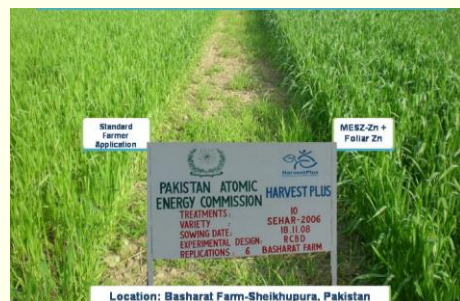
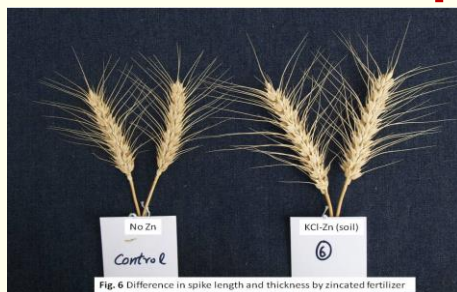
Children (< 5 Yr)	39%
Women: Pregnant	53%
Non-pregnant	44%

Poor Growth & Development:

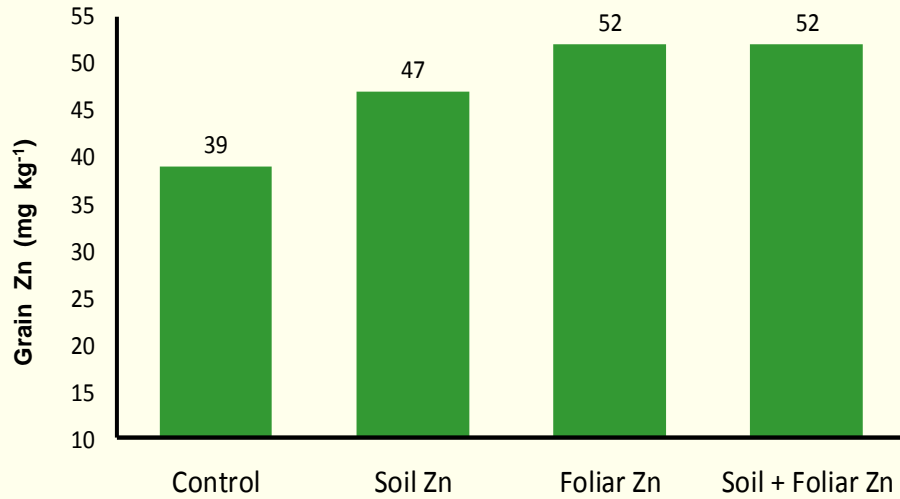
Stunted Physical & Mental Growth, Skin lesions, Diarrhea, ...

* Biesalski, H.K. **Hidden Hunger**. Springer (2013)

Wheat Response to Zinc



Wheat Grain Zn Concentration



Boron Deficiency in Soils and Crops of Pakistan Diagnosis and Management

Abdul Rashid



Pakistan Agricultural Research Council
Islamabad
2006



22

Technology Transfer: A Challenging Issue Farmers' Field Days



GRATITUDE

- My Family
- East-West Center, Hawaii, USA
- PhD Supervisor at Univ. of Hawaii:

Prof. Robert L. Fox


- Pakistan Agricultural Research Council
- My Colleagues: PARC & Elsewhere
- Numerous Farmers
- Fertilizer Industry: Engro, Fauji Fertilizer Co.