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

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Islamabad, PAKISTAN

PAKISTAN

Population: ~180 M
Labor Force: 45%
GDP: >21%

LAND RESOURCES
Million ha
Total: 79.6
Cultivated: 20.7
Irrigated: 16.5
Rainfed: 4.2
Pakistan: Soils & Fertilizer Use

**Soil Types:**
- Aridisol
- Alfisol
- Entisol
- Mollisol
- Inceptisol
- Vertisol

**Alluvial, Alkaline, Calcareous, Low OM**

**Fertilizer Use: Historical Perspective**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Zn</th>
<th>Fe</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>1960</td>
<td>1966</td>
<td><strong>1970s</strong></td>
<td>1980s</td>
<td>1990s</td>
<td></td>
</tr>
</tbody>
</table>

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

**Source:** Micronutrient Project, Nationally Coordinated
### 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

<table>
<thead>
<tr>
<th>Technology</th>
<th>Paddy Yield (t ha)</th>
<th>Zn Dose (kg ha)</th>
<th>VCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field broadcast</td>
<td>3.75</td>
<td>5.0</td>
<td>10:1</td>
</tr>
<tr>
<td>Nursery beds</td>
<td>3.85</td>
<td>0.8</td>
<td>24:1</td>
</tr>
</tbody>
</table>
**Boron Nutrition of Cotton**

- Less Boll Shedding
- More Boll Weight

**Boron Nutrition of Rice**

- Super Basmati
- IR - 6
## Economics of Micronutrient Use

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

* + 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

<table>
<thead>
<tr>
<th>Field Crops</th>
<th>Vegetables</th>
<th>Fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Beans</td>
<td>Apple</td>
</tr>
<tr>
<td>Clovers</td>
<td>Cabbage</td>
<td>Apricot</td>
</tr>
<tr>
<td>Cotton</td>
<td>Carrot</td>
<td>Citrus</td>
</tr>
<tr>
<td>Maize</td>
<td>Cauliflower</td>
<td>Grapes</td>
</tr>
<tr>
<td>Mustard</td>
<td>Lettuce</td>
<td>Peach</td>
</tr>
<tr>
<td>Peanut</td>
<td>Onion</td>
<td>Pear</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>Potato</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>Radish</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>Spinach</td>
<td></td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>Sweet Potato</td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td>Tomato</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>Turnip</td>
<td></td>
</tr>
<tr>
<td>Tobacco</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
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### Micronutrient Use Recommendations

#### ZINC

**Crops & Vegetables**
- Soil application
- 2-3 Foliar Sprays
- 2-5 kg Zn ha\(^{-1}\)
- 0.1% Zn solution

**Fruits**
- 2-3 Foliar Sprays
- 0.1% Zn solution

#### BORON

**Crops & Vegetables**
- Soil application
- 2-3 Foliar Sprays
- 0.75 - 1.0 kg B ha\(^{-1}\)
- 0.1% B solution

#### IRON

**Crops & Fruits**
- 3-4 Foliar Sprays
- 0.5% Ferrous Sulfate
- 1% *Sequestrene*

**Source:** Rashid (2006)
Soil Zn Deficiency  →  Low Yields & Zn-Poor Crop Produce

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

<table>
<thead>
<tr>
<th><strong>PAKISTAN:</strong> National Nutrition Survey (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children</strong> (&lt; 5 Yr)</td>
</tr>
<tr>
<td><strong>Women:</strong> Pregnant</td>
</tr>
<tr>
<td><strong>Non-pregnant</strong></td>
</tr>
<tr>
<td>39%</td>
</tr>
<tr>
<td>53%</td>
</tr>
<tr>
<td>44%</td>
</tr>
</tbody>
</table>

Poor Growth & Development:
Stunted Physical & Mental Growth, Skin lesions, Diarrhea, …


Wheat Response to Zinc

Fig. 4: Difference in spike length and number by zinced fertilizer

Location: Basharat Farm-Sheikhura, Pakistan
**Wheat Grain Zn Concentration**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain Zn (mg kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>39</td>
</tr>
<tr>
<td>Soil Zn</td>
<td>47</td>
</tr>
<tr>
<td>Foliar Zn</td>
<td>52</td>
</tr>
<tr>
<td>Soil + Foliar Zn</td>
<td>52</td>
</tr>
</tbody>
</table>

**Boron Deficiency in Soils and Crops of Pakistan: Diagnosis and Management**

Abdul Rashid

Pakistan Agricultural Research Council
Islamabad
2006
Technology Transfer: A Challenging Issue
Farmers’ Field Days

GRATITUDE

- My Family
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- Fertilizer Industry: Engro, Fauji Fertilizer Co.