Biofortification: How to Reach 1 Billion Consumers with Micronutrient-Dense Crops

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Founding Director and Interim CEO, HarvestPlus
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Dietary Diversity

Why are Mineral and Vitamin Deficiencies Such A Significant Public Health Problem?
Percent Changes in Cereal and Pulse Production and in Population Between 1965 and 1999

The graph shows the percent changes in cereal and pulse production and in population between 1965 and 1999 for different countries and regions. The countries and regions include India, Pakistan, Bangladesh, Developing, India, Pakistan, Bangladesh, Developing, World, and Developing. The graph indicates a significant increase in cereal production and population, with a smaller increase in pulse production.
Price Indices By Food Group for India, 1970-2016, Deflated by Non-Food Price Index

<table>
<thead>
<tr>
<th>Cereals</th>
<th>Price Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>Maximum During Time Period</td>
</tr>
<tr>
<td>160</td>
<td>Minimum During Time Period</td>
</tr>
</tbody>
</table>

Three-Year Averages

Source: Personal Communication, JV Meenakshi, Delhi School of Economics
Price Indices By Food Group for India, 1970-2016, Deflated by Non-Food Price Index

Price Indices

Three-Year Averages

Source: Personal Communication, JV Meenakshi, Delhi School of Economics
A Primary Role of Agriculture Is To Provide Nutrients for Healthy Populations

Supply of Nutrients From Agriculture

Present

Supply Gap

Supplementation And Fortification

Unreached Populations

Supplementation And Fortification

Unreached Populations

Future

Supplementation And Fortification

Unreached Populations

Agriculture
<table>
<thead>
<tr>
<th>Food Group</th>
<th>Lower Income</th>
<th>Middle Income</th>
<th>Higher Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Staples</td>
<td>1816</td>
<td>1848</td>
<td>1876</td>
</tr>
<tr>
<td>Non-Staple Plant Food</td>
<td>339</td>
<td>427</td>
<td>474</td>
</tr>
<tr>
<td>Fish and Animal Foods</td>
<td>47</td>
<td>59</td>
<td>92</td>
</tr>
<tr>
<td>All Food Groups</td>
<td>2201</td>
<td>2334</td>
<td>2442</td>
</tr>
</tbody>
</table>
Biofortified Crops - Reaching over 30 Million

Rice
Wheat
Maize
Pearl Millet
Millet
Sorghum
Cassava
Orange
Sweetpotato
Potato
Banana
Plantain
Lentil
Beans
Cowpea
Over 340 Biofortified Varieties Released

- Biofortified crops released in 30+ countries. Testing underway.
Cost-effective: Central, One Time Investment
8 BILLION
VITAMIN A CAPSULES

Government of Canada
Gouvernement du Canada

Thanks to a donation programme financed by the Government of Canada and implemented through the Micronutrient Initiative, UNICEF has received more than 8 billion capsules since 1998, which, when combined with programme financing, have been critical to maintaining strong Vitamin A supplementation programmes.

4 MILLION

The Micronutrient Initiative estimates that more than 4 million deaths have been averted during this time.

Cost Per Vitamin A Capsule  $US 0.50-1.25  World Bank (2007)
Biofortification is Climate-Smart

• Biofortified crops piggyback on crop varieties that are bred for desirable attributes which include resistance to climate change effects such as tolerance to heat, drought, flooding.

Examples:

Heat and drought tolerant iron beans

Drought tolerant vitamin A maize

Flood/Submergence tolerant zinc rice
• **Rising CO₂ levels will likely cause plants to lose nutritional value**
  
  - Under rising CO₂ levels, many food crops have iron and zinc contents that are reduced by 3-17% compared with current conditions
  
  - Elevated CO₂ could cause an additional 175 million people to be zinc deficient
  
  - 1.4 billion women of childbearing age and children under 5 live in countries with greater than 20% of anemia prevalence and would lose >4% of dietary iron

Risk of inadequate nutrient intake from elevated atmospheric CO2 concentrations of 550 ppm. (Smith and Myers 2018)
Nutrition Contribution

- Biofortified crops, as consumed, provide \textit{an extra} 40\% of estimated average requirement each day – substituting one-for-one the biofortified variety for the existing non-biofortified variety.
Human Nutrition Efficacy Trials

Fourteen Efficacy Trials either completed or in process

– High iron crops ✓+
  • Meta-analysis completed for beans and pearl millet

– High vitamin A crops ✓
  • Multiple efficacy trials completed for sweetpotato, maize, and cassava

– High zinc crops
  • Bioavailability studies positive, one efficacy trial completed, others in data analysis stage
Efficacy trials with vitamin A, iron, and zinc biofortified crops have also shown improved functional outcomes:

- Improved cognitive function (iron)
- Better work performance (iron)
- Reduced morbidity (zinc and provitamin A)
- Better sight adaptation to darkness (provitamin A)
## Ten Bean Varieties Released in Rwanda

### Agronomic Properties of Iron Bean

<table>
<thead>
<tr>
<th>Names</th>
<th>Pictures</th>
<th>Type</th>
<th>Yield Potential</th>
<th>Adaptation</th>
<th>Iron Content</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWV 3316</td>
<td><img src="image1.png" alt="Picture" /></td>
<td>Climber</td>
<td>4 t/ha</td>
<td>High altitude</td>
<td>91.6 ppm</td>
<td>110 Days</td>
</tr>
<tr>
<td>RWV 3006</td>
<td><img src="image2.png" alt="Picture" /></td>
<td>Climber</td>
<td>3.8 t/ha</td>
<td>High altitude</td>
<td>91.7 ppm</td>
<td>110 Days</td>
</tr>
<tr>
<td>MAC 44</td>
<td><img src="image3.png" alt="Picture" /></td>
<td>Climber</td>
<td>3.5 t/ha</td>
<td>Mid to low altitude</td>
<td>78 ppm</td>
<td>87 Days</td>
</tr>
<tr>
<td>RWR 2245</td>
<td><img src="image4.png" alt="Picture" /></td>
<td>Bush</td>
<td>2.5 t/ha</td>
<td>Mid to low altitude</td>
<td>75 ppm</td>
<td>87 Days</td>
</tr>
<tr>
<td>RWR 2154</td>
<td><img src="image5.png" alt="Picture" /></td>
<td>Bush</td>
<td>2.5 t/ha</td>
<td>Mid to low altitude</td>
<td>75 ppm</td>
<td>87 Days</td>
</tr>
<tr>
<td>RWV 3129</td>
<td><img src="image6.png" alt="Picture" /></td>
<td>Climber</td>
<td>3.5 t/ha</td>
<td>Mid to high altitude</td>
<td>81 ppm</td>
<td>110 Days</td>
</tr>
<tr>
<td>Cab2</td>
<td><img src="image7.png" alt="Picture" /></td>
<td>Climber</td>
<td>3 t/ha</td>
<td>High altitude</td>
<td>94.8 ppm</td>
<td>115 Days</td>
</tr>
<tr>
<td>RWV 3317</td>
<td><img src="image8.png" alt="Picture" /></td>
<td>Climber</td>
<td>4 t/ha</td>
<td>High altitude</td>
<td>74 ppm</td>
<td>110 Days</td>
</tr>
<tr>
<td>RWV 2687</td>
<td><img src="image9.png" alt="Picture" /></td>
<td>Climber</td>
<td>3.5 t/ha</td>
<td>Mid to high altitude</td>
<td>93.7 ppm</td>
<td>106 Days</td>
</tr>
<tr>
<td>MAC 42</td>
<td><img src="image10.png" alt="Picture" /></td>
<td>Climber</td>
<td>3.5 t/ha</td>
<td>Mid to high altitude</td>
<td>91 ppm</td>
<td>81 Days</td>
</tr>
</tbody>
</table>
Rwanda: Location of Combined Activities in 2014
### Results Of Nationally Representative Farm Survey

**Rwanda 2015 Season B Bean Production**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Farmers Planting Iron Beans At Least Once</td>
<td>30%</td>
</tr>
<tr>
<td>Iron Beans As Percentage of Total Bean Production</td>
<td>16%</td>
</tr>
<tr>
<td>Yield Advantage of Climbing Iron Beans</td>
<td>+22%</td>
</tr>
<tr>
<td>Yield Advantage of Bush Iron Beans</td>
<td>+17%</td>
</tr>
<tr>
<td>Added Value of Production of Climbing Iron Beans</td>
<td>+$78/hectare</td>
</tr>
<tr>
<td>Added Value of Production of Bush Iron Beans</td>
<td>+$57/hectare</td>
</tr>
<tr>
<td>Iron Beans in Rwanda ($million)</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Observed 2010-2018</strong></td>
<td></td>
</tr>
<tr>
<td>Extra Bean Production</td>
<td>$19.8</td>
</tr>
<tr>
<td>Reduced Iron Deficiency (4,939 DALYs Saved)</td>
<td>$4.9</td>
</tr>
<tr>
<td><strong>Simulated Pessimistic 2010-2025 (no change in 2018 production)</strong></td>
<td></td>
</tr>
<tr>
<td>Extra Bean Production</td>
<td>$61.6</td>
</tr>
<tr>
<td>Reduced Iron Deficiency (16,151 DALYs Saved)</td>
<td>$16.2</td>
</tr>
<tr>
<td><strong>Simulated Optimistic 2010-2025 (2025 production increases to 40%)</strong></td>
<td></td>
</tr>
<tr>
<td>Bean Production</td>
<td>$83.8</td>
</tr>
<tr>
<td>Reduced Iron Deficiency (22,280 DALYs Saved)</td>
<td>$22.3</td>
</tr>
</tbody>
</table>
HarvestPlus in Bangladesh

GO - 5
NGO - 25
PS - 2 associations
(300 seed companies)
Additional Crop in Cropping Pattern

Before

Aman
Sharna
(155 days)

Fallow
(70 Days)

Boro
BRRI dhan28
(140 days)

Now

Aman
BRRI dhan62
(100 days)

Mustard/ lentil/
vegetables
(125-130 days)

Boro
BRRI dhan64/
BRRI dhan28
(135-140 days)
Harvest Plus and Partners are Catalyzing Robust Supply Chains

1. Upstream Research
   - Research Institutes, CGIAR, NARS

2. Crop Development
   - Seed Producers

3. Seed Multiplication
   - Seed Producers

4. Seed Systems & Transfer to Farmers
   - Farmers and seed firms, Dealers, distributors

5. Crop Production & Post-Harvest Handling

6. Food processing & Value Creation
   - Food manufacturers

7. Retail & Consumption
   - Retailers and consumers
Vitamin A Sweetpotato Puree - No refrigeration

Preservation free OFSP puree
Vitamin A Maize Marketing in Zambia
Vitamin A Cassava Marketing in Nigeria
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Mainstreaming Through Key Stakeholders

- Public agricultural research (CGIAR, NARS)
- Seed Companies (SeedCo in Africa)
- Food Companies (exploratory)
- International financial institutions (World Bank, IFAD)
- Multi-lateral agencies (World Food Program, Codex)
- National governments (Brazil, China, India)
- International NGOs (World Vision, GAIN)