Pulses for Food Security, Nutrition and Environment: the Role of Science & Technology to Enhance Productivity and Production of Pulses

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FAO, Rome, 10 November, 2015.

Mahmoud Solh
Director General
ICARDA
Great Challenges of Agriculture

- Growing world population will cause a “serious storm" of food, energy and water shortages by 2050
- Demand for food and energy will jump 70% and 100% and for fresh water by 30%, as the population tops 9 billion
- In the past, only ~12 crops received the major attention of scientific interventions

The Big Challenge: How to expand agriculture output without further constraining natural resources?
Why Pulses

- Improved food security
- Improved livelihood
- Improved nutrition & health
- Sustain natural resources
Pulses offer many nutritional benefits

- Pulses are three times richer in low fat protein as compared to cereals including rice and wheat;
- Pulses have complementary Amino acid profile with cereals;
- Micro-nutrient rich grains (Fe, Zn);
- Good carbohydrates make pulses a great functional food;
- High in dietary fibre.
Pulses - A potential whole food solution

Effect of lentil diet on anemic Sri Lankan Children after 60 Days

<table>
<thead>
<tr>
<th>Indicator</th>
<th>0 days</th>
<th>60 days</th>
<th>% improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>11.1</td>
<td>11.8</td>
<td>6.3</td>
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<tr>
<td>Serum Fe (µg/dL)</td>
<td>51.5</td>
<td>89.8</td>
<td>74.4</td>
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<tr>
<td>Total Fe binding capacity (µg/dL)</td>
<td>405.3</td>
<td>377.6</td>
<td>-6.8</td>
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<tr>
<td>Trans ferritin saturation (%)</td>
<td>12.8</td>
<td>24.3</td>
<td>89.8</td>
</tr>
<tr>
<td>Serum ferritin (ng/mL)</td>
<td>29.5</td>
<td>41.2</td>
<td>39.7</td>
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50g of pulses is a good source of Fe, Zn, and Se

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Lentil</th>
<th>Field pea</th>
<th>Chickpea</th>
<th>Rice</th>
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<tbody>
<tr>
<td>Protein (%)</td>
<td>20 – 27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20 - 23&lt;sup&gt;d&lt;/sup&gt;</td>
<td>19-20</td>
<td>2.9</td>
</tr>
<tr>
<td>Se (µg kg&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>425 – 672&lt;sup&gt;a&lt;/sup&gt;</td>
<td>373-519&lt;sup&gt;d&lt;/sup&gt;</td>
<td>450-850</td>
<td>93</td>
</tr>
<tr>
<td>Fe (mg kg&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>73 – 90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>44-55</td>
<td>50-55</td>
<td>2.4</td>
</tr>
<tr>
<td>Zn (mg kg&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>44 – 54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20-30</td>
<td>20-32</td>
<td>3.7</td>
</tr>
<tr>
<td>Phytic acid (mg g&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>1.8 - 4.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.2 – 8.2</td>
<td>4.9 – 6.1</td>
<td>7.2-11.9</td>
</tr>
</tbody>
</table>

Source; Pallemulле, Thavarajah, Thavarajah et al. unpublished data, 2013
The Balanced Diet: Cereals with Pulses

The complementarities of cereals & food legumes

Food Legumes: High in protein and Lysine, low in sulfur-containing amino acids:

- Faba bean: 20 – 36 %
- Lentil: 20 – 27 %
- Grass pea: 25 – 31 %
- Kabuli Chickpea: 16 – 24 %
- Field Pea: 20 – 23 %

Cereals/Wheat: low in both protein and lysine but high in sulfur-containing amino acids

Combining food legumes and cereals provides a balanced diet: improving nutrition, especially in low-income communities where other sources of protein like animal protein are limited.
In Bangladesh, biofortified lentils developed by NARS and ICARDA are now grown in 145,600 ha, producing 186,000 tons for domestic consumption.
Enhancing Soil Productivity & Health through Biological Nitrogen Fixation

- Chickpea and Faba bean genotypes screened
- Super nodulating lines identified (Egypt)
- TILLING population of FB developed
- Stress tolerant Rhizobium strains identified
- Host-Rhizobium-Environments interaction studied
- Enhancement of soil productivity and soil health.
Pulses are climate smart crops with less water requirement.

Water Stress by Country: 2040

Water efficiency in food production (measured in gallons per ton):
- Pulses: 2,500 gallons
- Eggs: 3,200 gallons
- Chicken: 4,500 gallons
- Pork: 5,900 gallons
- Beef: 20,700 gallons

Daal (1kg): 1250 liters
Chicken (1kg): 4325 liters
Mutton (1kg): 5520 liters
Beef (1kg): 13000 liters
Grass Pea: Tolerance to Excessive Drought and Water Logging
**Pulses Production Scenario**

### Global

**Area m ha**

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<tbody>
<tr>
<td>Production</td>
<td>68.67</td>
<td>63.02</td>
<td>63.64</td>
<td>68.69</td>
<td>69.77</td>
<td>80.32</td>
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**Production m t**

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<tr>
<td>Production</td>
<td>43.85</td>
<td>42.16</td>
<td>44.99</td>
<td>54.24</td>
<td>57.72</td>
<td>72.34</td>
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**Yield kg/ha**

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<tr>
<td>Production</td>
<td>640</td>
<td>625</td>
<td>657</td>
<td>663</td>
<td>766</td>
<td>819</td>
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### Asia

**Area**

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<tr>
<td>Asia</td>
<td>39.32</td>
<td>34.07</td>
<td>35.13</td>
<td>34.86</td>
<td>34.38</td>
<td>40.16</td>
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**Production**

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<td>25.18</td>
<td>21.29</td>
<td>23.07</td>
<td>23.14</td>
<td>26.34</td>
<td>32.90</td>
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**Yield**

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Production sufficiency in pulses is a concern in some regions

- Asia accounts for 45% of the global pulses production and remains a major producer, importer, and consumer.
Global pulse trade at present: almost 12 million tons

Pulses deficit regions

North America: +4.9
Europe: +0.2
WANA Region: -1.7
South Asia: -4.5
Oceania: +1.3
Latin America and the Caribbean: -0.5
Sub-Saharan Africa: +0.1

Sources: FAOSTAT (2011)

in Million MT by region (2011)
What Science Can Do to Enhance Productivity and Production of Pulses
Strategy for Enhancing Pulses Production

- Crop genetic improvement & new genetic gains for improved varieties;
- Vertical increase in productivity through sustainable intensification of production systems;
- Closing the yield gaps
- Horizontal expansion
- Reduced post-harvest losses

25-60% yield gaps in pulses
Reasons are many.......
Closing the yield gaps can alone supply 60% of pulses deficit
Farmers participatory research
Winter vs. spring chickpea in West Asia & North Africa

Mature winter crop

Spring sown crop
The Kabuli chickpea, ‘Gokce’, developed by ICARDA and Turkish national scientists, has withstood severe drought in Turkey and produced when most other crops failed in 2007. Gokce is used on about 85% of the chickpea production areas (over 550,000 ha). With a yield advantage of 300 kg/ha over other varieties, and world prices over USD 1000/t, this represents an additional USD 165 million for Turkish farmers, in 2007 alone.
Field visits to pulse farmer involving policy makers

Increase in production 2000/01 - 2009/10:

- Lentils: 3 times
- Faba Bean: 40%
- Chickpea: 60%

Alemaya lentil variety widely adopted in Ethiopia

Increased production and added value products provides employment through food processing in rural areas
Fast-tracking of Iron & Zinc-rich lentil varieties

India: Pusa Vaibhav (Fe 102 ppm)

Bangladesh: Barimasur-4 (Fe 86 ppm; Zn 59 ppm)

Nepal: Shekhar (Fe 78 ppm; Zn 68 ppm)

Ethiopia: Alemaya (Fe 98, Zn 64 ppm)

ICARDAGovernmental Research Organization for Development through Agricultural Biotechnology
Lentil cultivars with high concentration of Fe & Zn are in ‘fast-tracking’ seed dissemination

- Ethiopia: Alemaya
- Bangladesh: Barimasur-4, Barimasur-5 and Barimasur-6, Barimasur-7, Binamasur-7
- India: Pusa Vaibhav
- Nepal: Sisir, Shital, Shekhar, Khajurah-1, Khajurah-2
- Syria: Idlib-2, Idlib-3 and Idlib-4
- Turkey: Myveci-2001
- Portugal: Beleza
Climate resilient varieties of faba bean

- **Heat tolerant faba bean varieties in Sudan**
- **Production increased from ~40,000 t in 1995 to 150,000 t at present.**
  - Area increased by 50,000 ha
  - Productivity increased by 600 kg/ha
- **Misr3 - orobanche tolerant and Nubaria2 and Nubaria3 - drought tolerant varieties helped improved the self sufficiency level of faba bean in Egypt**
Insect Resistant Chickpea

**Leaf miner**
- 6 segregating population and FIGS set evaluated at Kemis Zemamra station in Morocco
- 200 single plants with good resistance and pods/plant.

**Pod borer**
- FIGS (375) evaluated in Annaceur (off season)
- 34 lines with 1-5% damage

Damage by Helicoverpa pod borer in chickpea

Evaluation of breeding lines for resistance to Leaf miner
Extra Early Varieties

Replacing fallow in rice fallow in South Asia

Lowland Areas in Ethiopia
Pulses offer scope for diversification of cereal based systems

- Intensification of cereal based CS by inclusion of pulses as catch crop
- Diversification of cereal based CS by replacement
- Introduction in Rice-fallows in South Asia
- New niches such as winter planting
- Market opportunities for rural income
Early Lentil Demonstration Replacing Fallow in Fallow Rice Rotation in Bangladesh & India
Enhancing profitability of pulses production

- Reducing cost of cultivation

- Value addition and linking farmers to market
Steep rise in food prices in India over 30 years

Pulses are becoming cash crops
Consumption of pulses has gone down over the years.

Per capita availability of pulses is 35 g per day.
How to raise awareness about pulse benefit?

- Inclusion pulses benefits in school curriculum among children;
- Innovations in pulse products and ready to eat products;
- Messages by celebrities and eminent personalities about the benefits of pulses in electronic media and print;
- National, regional and global events involving participation of general public and celebrities;
- Short documentary films on benefits on pulses.
Conclusions & Recommendation

- **Pulses for Food Security**
  - Pulses contribute to global food and nutritional security both directly & indirectly through high protein content.
  - Major source of micro nutrients
  - Important source of dietary fibre;
  - The protein content of legumes is not as affected by e\([CO_2]\) as cereals & grasses –

- **Pulses for Environmental Benefits and Mitigation of Climate Change**
  - Pulse production enhance soil N content and soil productivity and health;
  - Production of pulses has lower greenhouse gas emissions than crops that require N-fertilization;
  - Lower fossil energy costs than crops that needs N-fertilization;
Pulses for Environmental Benefits and Mitigation of Climate Change (cont’d)

- The inclusion of legumes in farming systems appears to accelerate soil C sequestration promote soil health since it breaks the disease and insect cycles in soil created by the prevailed cereal mono-culture.

Considering the nutritional and environmental benefits of pulses, it is essential that pulses consumption is well encouraged;

It is important to bridge the gap between production and consumption at both national and global levels;

There is an urgent need to invest more in science and technology to enhancing pulses productivity, production and reduce production cost.

The IYP is an excellent opportunity to promote the consumption of pulses & more investment in science and Technology to enhance pulses productivity and production for global food and nutrition security and healthy soils.
Thank you