Pulses contribution to production and dietary diversity to eradicate hunger and malnutrition

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The University of Western Australia

- Established in 1911
- WA’s first and oldest university
- Member of the ‘Group of Eight’
- Links with over 250 top universities

Our Alumni include:
- Nobel Prize winners
- Former Prime Minister
- Numerous State Premiers
- 6 Ambassadors to China
- Ambassador to the USA
## UWA’s International rankings

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARWU – Academic Rankings of World Universities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UWA Overall</td>
<td>91</td>
<td>88</td>
<td>87</td>
</tr>
<tr>
<td>Life and Agricultural Sciences</td>
<td>26</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td><strong>NTU – National Taiwan University Ranking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>40</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>Plant &amp; Animal Science</td>
<td>22</td>
<td>24</td>
<td>18</td>
</tr>
</tbody>
</table>
Outline

• IYP key messages
• What are pulses
• Why pulses?
• Pulse global production, trade and consumption
• Recent success stories
• Health benefits of pulses
• Conclusions
Objectives of the Year

- Promote the value and utilization of pulses throughout the food system
- Raise awareness about the benefits of pulses, including sustainable agriculture and nutrition
- Encourage connections to further global production
- Foster enhanced research
- Advocate for better utilization of pulses in crop rotations
- Address the challenges in the trade of pulses
What are Pulses?

- Represent over sixty species of “grain legumes”
- Dry grain that is typically boiled and eaten
- A traditional crop in agriculture systems and a staple food in diets around the world
Edible Grain Legumes: Pulses

- Adzuki bean- Vigna angularis
- Chickpea- Cicer arietinum
- Broad or Faba bean- Vicia faba
- Cowpea- Vigna unguiculata
- Common Bean- Phaseolus vulgaris
- Lablab- Dolichos lablab
- Lentil- Lens culinaris
- Lima Bean- Phaseolus lunatus
- Mung Bean (green gram)- Vigna radiata
- Field Pea- Pisum sativum
- Pigeon Pea- Cajanus cajan
- Scarlet Runner Bean- Phaseolus coccineus

Source: Irvin Widders
World-wide Origin of Pulses

**Middle East and Mediterranean Region**
Chickpea, faba bean, green pea, lentil

**Americas**
Common bean, lima bean, scarlet runner bean, tepary bean, peanuts

**Africa**
Cowpea (Blackeye pea), lablab, pigeon pea

**Asia**
Adzuki bean, mung bean, black gram, soybean

Source: Irvin Widders
Diverse parts of plant are eaten

Source: Irvin Widders
Diverse Market Classes within each Species

Source: Irvin Widders
Blackeye Pea (Cowpea) types

Source: Irvin Widders
Pulses are grown in climate ranging from tropics to temperate.
Why Pulses?

Improved food security

Improved livelihood

Improved nutrition & health

Sustain natural resources

Source: ICARDA
Legume fixed N or fertilizer N for food production

<table>
<thead>
<tr>
<th>Region</th>
<th>Source &amp; estimated annual N input</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>million ton N/year</td>
</tr>
<tr>
<td>Asia &amp; middle East</td>
<td>19</td>
</tr>
<tr>
<td>Europe</td>
<td>3</td>
</tr>
<tr>
<td>North America</td>
<td>8</td>
</tr>
<tr>
<td>Africa</td>
<td>3</td>
</tr>
<tr>
<td>South America</td>
<td>10</td>
</tr>
<tr>
<td>Australia</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total Global</strong></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>

**value ≈>US$50 billion**

Pulses are climate smart crops with less water requirements

Water efficiency in food production
(measured in gallons per tonne)

- 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

Source: ICARDA
Global pulses production

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (m ha)</th>
<th>Production (m t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-63</td>
<td>68.67</td>
<td>43.85</td>
</tr>
<tr>
<td>1971-73</td>
<td>63.02</td>
<td>42.16</td>
</tr>
<tr>
<td>1981-83</td>
<td>63.64</td>
<td>44.99</td>
</tr>
<tr>
<td>1991-93</td>
<td>68.69</td>
<td>54.24</td>
</tr>
<tr>
<td>2001-03</td>
<td>69.77</td>
<td>57.72</td>
</tr>
<tr>
<td>2011-13</td>
<td>80.32</td>
<td>72.34</td>
</tr>
</tbody>
</table>
Changing regional patterns in pulses production

- Asia & Africa share about 70% of all pulses; showing rising trends

- Southeast Asia is emerging fastest growing region in pulses (7.4%)
  - Dry beans, chickpea and pigeon pea are gaining importance

- Africa is also showing fast growing in pulses production (4.6%)
  - Chickpea and pigeon pea in East Africa and cowpea in West Africa

- Among developed regions, North America led by Canada and Australia are showing rising trends (4.1%)
  - Lentils in Canada and chickpea and lentils in Australia
Consumption and utilization of pulses

• Global demand for pulses is increasing
  • Around 70 m t in 2011-13 compared to 42 m t in 1980-81

• But per capita consumption declined (10 kg in 1961 to 6.5 kg in 2011); slow rise in recent years

• Diverse uses for food & feed
  • Developing countries 80% as food
  • Developed countries <40% as food

Source: P.K. Joshi
Consumption of pulses has gone down over the years.

Per capita availability of pulses: 35 g per day.
Yield of pulses versus cereals (kg/ha)

- Global pulse yield is less than 1000 kg/ha; which used to be 550 kg/ha in 1961
- But, global cereals yields increased rapidly
  - 1500 kg/ha in 1961 to 4000 kg/ha in 2013
  - Cereal yields increased significantly both in developed and developing countries
- Pulse yields increased mainly in developed countries until mid 1990s and thereafter stagnated
- In developing countries pulse yields were stagnant throughout and increased marginally only from mid 2005

Source: P.K. Joshi
Yield of all pulses in different countries, 2011-13

- There is large inter-regional and inter-country yield variation

- Average yields of developed countries was > 1.2 t/ha
  - Canada > 2 t/ha; US near 2 t/ha

- Developing countries average yield was <1 t/ha
  - Myanmar and Ethiopia are exception
  - Most of the African and S Asian countries yields are < 500 kg/ha

Source: P.K. Joshi
Growing importance of pulses in many countries - especially more vulnerable population

Share of pulse area in arable land (%)
Global pulse trade: about 12 million tons (2011)

Sources: FAOSTAT (2011)
Mapping of Rice Fallows in South Asia

Rice Fallow (15 million ha in South Asia)
Total Crop Fallows (23 million ha in South Asia*)

Legend:
- Single crop (only rice)
- Double crop (two rice)
- Double crop (one rice; one others)
- Double crop (two others)
- Single vegetation (crops+others)
- Evergreen forest
- Others

Source: Shiv Kumar Agrawal
Production increased from 80,442 ton in 2011 to 167,261 ton in 2015 with an AGR of 10.9% (Magura & Jessore: 25 & 15% AGR)
Yield increased from 930 to 1150 kg/ha

Source: Shiv Kumar Agrawal
Lentil in Rice System in Bangladesh

- Improved varieties (BARI-M4, M5, M6, M7, M8) with disease resistance and rich in Micronutrients developed
  - Stemphylium blight and rust resistance
  - Rich in iron and zinc contents
- Production tech for relay planting
- Large scale demonstration
- Farmers participatory quality seeds

- 85% lentil area under improved varieties
- BARI Masur 4 = 26000 ha

Source: Shiv Kumar Agrawal
Early maturing varieties of Chickpea in India

Source: Shiv Kumar Agrawal
Impact of short duration Chickpea Varieties in Andhra Pradesh, India

- Improved chickpea varieties (JG11) developed through ICRISAT-NARS partnerships covers 98% of chickpea area in Andhra Pradesh
- >six-fold increase in area under chickpea and doubling of yield
- Benefits from the adoption of chickpea cultivars estimated at $358.9 million.
- Introduction of new cultivars reduced the unit cost of production by 22% ($144 per ton).
- 28% return on research investment

Source: Shiv Kumar Agrawal
Early Chickpea Varieties in Myanmar

- 7 varieties released from ICRISAT germplasm
- 96% chickpea area under 5 varieties (43% Yezin3, 20% Yezin4, 16% Yezin6, 16% Yezin8 and 1% Yezin11)
- Compound AGR of 5.6% for yield during past 15 years
- Production increased 5-fold (117,000 to 581,000 tons), 3.3-fold increase in area and 2.2-fold increase in yield
- Myanmar - annual export of 47,500 tons (US$ 24 million)

Source: Shiv Kumar Agrawal
Nepal – Exporter of Lentil in South Asia

- 10 varieties released
- ~60% (124,578 ha) area under improved varieties
- 124,952 tons production
- $61.92 m additional annual income
- >3x export value at present than in 2001

Source: Shiv Kumar Agrawal
Pigeon pea Production ('000 t) trends

Source: Ganga Rao
## Pigeon pea growth trends in Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>In ‘000 t</th>
<th>% increase</th>
<th>Production</th>
<th>Area</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
<td>2014</td>
<td>Production</td>
<td>Area</td>
<td>Yield</td>
</tr>
<tr>
<td>Tanzania</td>
<td>87.1</td>
<td>249.3</td>
<td>186</td>
<td>106</td>
<td>39</td>
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<tr>
<td>Mozambique</td>
<td>31.6</td>
<td>120.9</td>
<td>282</td>
<td>261</td>
<td>6</td>
</tr>
<tr>
<td>Malawi</td>
<td>105.8</td>
<td>301.0</td>
<td>184</td>
<td>69</td>
<td>68</td>
</tr>
<tr>
<td>Kenya</td>
<td>73.46</td>
<td>274.5</td>
<td>274</td>
<td>68</td>
<td>122</td>
</tr>
<tr>
<td>Uganda</td>
<td>80.0</td>
<td>93.6</td>
<td>17</td>
<td>28</td>
<td>-8</td>
</tr>
<tr>
<td>Africa</td>
<td>380.6</td>
<td>1047.3</td>
<td>175</td>
<td>96</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: Ganga Rao
## Pigeon pea Exports from Africa (000’ t)

India imports about 570,000 t annually

50% from Myanmar and 50% from Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>5 year range</th>
<th>2016 (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>75-90</td>
<td>70</td>
</tr>
<tr>
<td>Mozambique</td>
<td>55-75</td>
<td>75</td>
</tr>
<tr>
<td>Malawi</td>
<td>60-90</td>
<td>70</td>
</tr>
<tr>
<td>Kenya</td>
<td>15-20</td>
<td>18</td>
</tr>
<tr>
<td>Uganda</td>
<td>8-14</td>
<td>12</td>
</tr>
<tr>
<td>Sudan</td>
<td>40-50</td>
<td>45</td>
</tr>
<tr>
<td>Africa</td>
<td>253-339</td>
<td>290</td>
</tr>
</tbody>
</table>

Source: Ganga Rao
Pigeon pea Drivers of Success

• High yielding, wilt resistant MD varieties
• SI through ICM with women participation
• Regional and international export and participation of large traders
• Innovative seed systems in partnership with local farmers, NGOs and Government
• Value addition and then export to regional and international markets
• Very strong participation of partners, donors (BMGF, USAID, Irish Aid etc.,) Governments initiatives -Kilimo Kwanza, Input subsidy

Source: Ganga Rao
Climatic regions suitable for pulses in Australia

Knights and Siddique, 2003
Global trade in pulses 2013
Australia’s share shown in %
Top exporting country/region shown

Source: FAOSTAT.org

Beans, dry = Mungbean and coloured beans. Not soybean
Chickpea – the No. 1 Pulse in Australia

Ascochyta blight

0.6 MHa

Australia
Chick peas
Area harvested

M = Million, K = Thousand
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.
Region-wise self-sufficiency in pulses

- At aggregate level, Developed countries have surplus while deficit in developing countries
  - Northern America and Australia has very surplus, while Asia has high deficit
- Self-sufficiency is increasing in developed countries and further declining in developing countries
- West and South Asia are highly deficit in pulses
  - Self-sufficiency is declining fast over the years
Improve pulse value chain and correct price policy in India

• Unorganized, fragmented and inefficient
• High transaction costs and high losses; leading to rise in prices

Source: P.K.Joshi
Why are Pulses Important?

1. A nutrient-rich food that enhances dietary quality.
2. Promote gut health and function for improved human health
3. Legume crops fix atmospheric nitrogen (N) for improved sustainability of cropping systems.
4. Provide farmers with diverse crop options to mitigate risk to climate change
5. Ensure food and nutritional security for a growing global population
Pulses lower risks of Chronic Diseases

- Type 2 diabetes
- Cardiovascular disease
- Gastro-intestinal disease
- Colon cancer

**Bottom line** - Pulses lower risks of chronic diseases frequently associated with obesity.
Importance of the Gut (Intestinal Track)

- The interface of humans with their environment
- An estimated 70% of one’s immune system is located in the gut.
- Foods influence the gut micro-biome (bacterial flora)
- Inflammation of the gut leads to poor nutrition and health

Source: Irvin Widders
Scientific Evidence for Pulse Improvements to Gut Health

- Unique oligo-sacharides (raphinose sugars) improve bacterial ecology in the gut (probiotic effect - promote beneficial bacteria)
- Complex carbohydrates (dietary fiber) improve digestion
- Non-digestible portion of pulses have anti-inflammatory properties
- Pulse-based foods produce short-chain fatty acids that inhibit colon cancer cell growth

Source: Irvin Widders
Lupins

- L. angustifolius
- L. luteus
- L. albus
- L. mutabilis
- L. cosentinii
- L. atlanticus
- L. pilosis
- L. polyphyllus

Source: Jonathan Hodgson
Why are we interested in lupin for health?

• Lupin flour is a novel food ingredient with a unique macronutrient composition
  – 45% protein, 30% dietary fibre, negligible available carbohydrate

• Increased intake of plant proteins and dietary fibre may benefit obesity via effects on appetite and improve risk factors for heart disease

• Lupin flour can be substituted for wheat/corn/rice flour in baked foods to increase protein and fibre, and reduce refined carbohydrate content

Source: Jonathan Hodgson
Health benefits of lupin

1. Appetite and body weight and body fatness (Obesity)

2. Blood pressure (Heart disease)

3. Glucose and insulin (Diabetes)

Source: Jonathan Hodgson

Source: Jonathan Hodgson

Source: Jonathan Hodgson
Effects of replacement of refined carbohydrate with lupin flour in bread


Source: Jonathan Hodgson
1. Lupin can reduce hunger and appetite acutely

2. These effects do not translate into significant benefits on weight reduction in longer-term trials

3. Incorporation of lupin flour into the diet at the expense of refined carbohydrate can reduce blood pressure

4. Lupin-enriched foods may assist in the management of blood glucose in diabetes

5. Lupin-enriched foods may improve insulin sensitivity longer-term

Source: Jonathan Hodgson
Opportunity and Necessity Drive Innovation

Research on Pulses needed to:

- Increase productivity
- Improve climate resilience
- Understand the health and nutritional benefits
- Add value through ingredients and food processing
Global investment in pulse R,D&E is too low compared with cereal crops: (US $ 175 million per annum in 13 pulse crops)

Neglecting legumes has compromised human health and sustainable food production

Christine H. Foyer¹,²*, Hon-Ming Lam³, Henry T. Nguyen⁴, Kadambot H. M. Siddique⁵, Rajeev Varshney⁶, Timothy D. Colmer²,⁵, Wallace Cowling⁵, Helen Bramley⁷, Trevor A. Mori⁸, Jonathan M. Hodgson⁸, James W. Cooper¹, Anthony J. Miller⁹, Karl Kunert¹⁰, Juan Vorster¹⁰, Christopher Cullis¹¹, Jocelyn A. Ozga¹², Mark L. Wahlqvist¹³,¹⁴, Yan Liang¹⁵, Huixia Shou¹⁶, Kai Shi¹⁷, Jingquan Yu¹⁷, Nandor Fodor¹, Brent N. Kaiser¹⁸, Fuk-Ling Wong³, Babu Valliyodan⁵ and Michael J. Considine²,⁵,¹⁹
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
Pulses contribute to **Food and Nutritional Security** for a growing global population.

Source: Irvin Widders
Pulse Consumption in Selected Countries

Per capita per day consumption of pulses in grams

- Bangladesh
- Cambodia
- India
- Myanmar
- Nepal
- Pakistan
- Sri Lanka
- Vietnam

2011 - 2012 - 2013
Strategies for Enhancing Pulse Production

- Crop genetic improvement and 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

Source: ICARDA
Conclusions and way forward

- IYP2016 is timely because pulses are important for food & nutritional security, environmental benefits, and mitigation of climate change
- Demand for pulses is growing but supply constraints will lead to rise in prices and increase trade
- Pulses production and trade scenario in changing
  - New countries producing pulses and exporting to deficit countries
- Global level
  - Increase funding for pulse R, D & E
  - Incentives for improved technologies to public and private sector
  - Effective trade
- National level
  - Bridge yield gaps to increase domestic production
  - Improve pulse value chains to benefit producers and consumers
  - Attract private sector in pulses production, processing and marketing
  - Promote innovative institutions for scale