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

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The University of Western Australia (UWA)

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

	2013	2014	2015
ARWU – Academic Rankings of World Universities			
• UWA Overall	91	88	87
• Life and Agricultural Sciences	26	24	25
NTU – National Taiwan University Ranking			
• Agriculture	40	34	30
• Plant & Animal Science	22	24	18

Outline

- IYP key messages

- What are pulses

- Why pulses?

- Pulse global production, trade and consumption

- Recent success stories

- Health benefits of pulses

- Conclusions

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2016 INTERNATIONAL YEAR OF PULSES

nutritious seeds for a sustainable future

Food and Agriculture Organization of the United Nations

fao.org/pulses-2016 | pulses-2016@fao.org | #IYP2016

Objectives of the Year

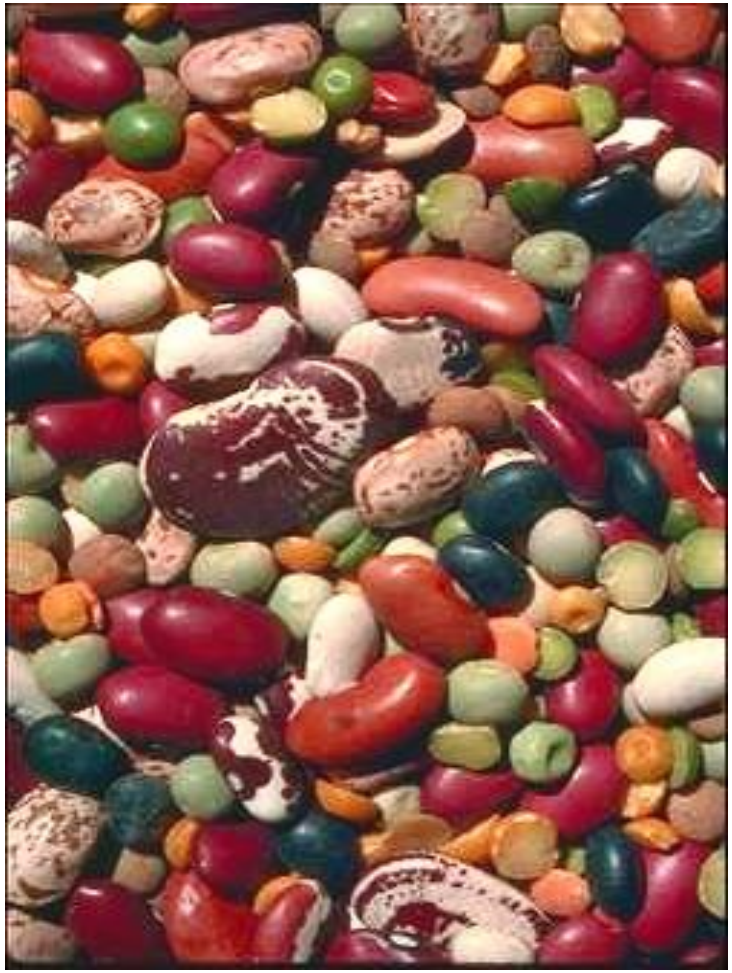
- Promote the value and utilization of pulses throughout the food system
- Raise awareness about the benefits of pulses, including sustainable agriculture and nutrition
- Encourage connections to further global production
- Foster enhanced research
- Advocate for better utilization of pulses in crop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

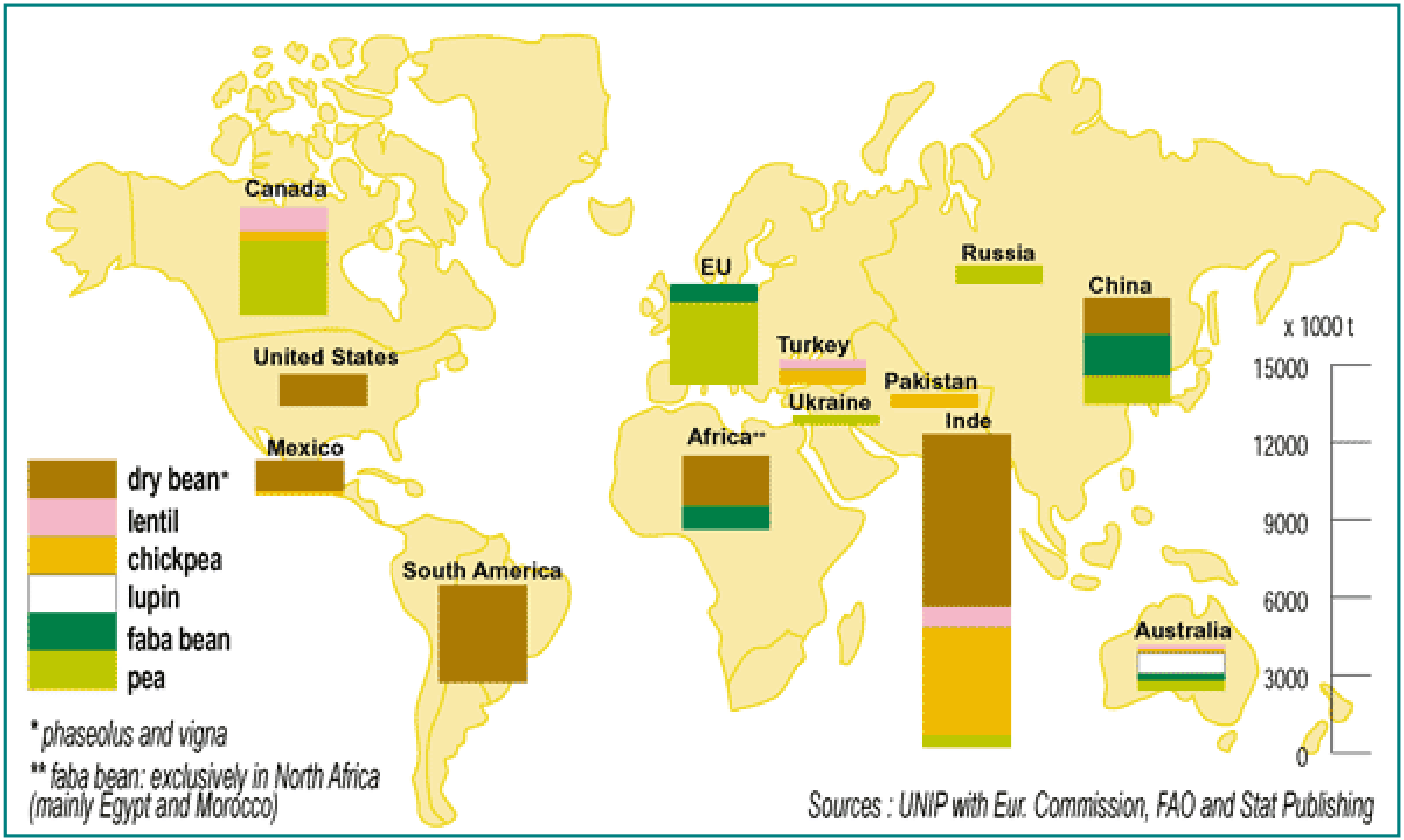
Diverse Market Classes within each Species

Source: Irvin Widders

Blackeye Pea (Cowpea) types

Source: Irvin Widders

Pulses are grown in climate ranging from tropics to temperate



Why Pulses?

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Source: ICARDA

Legume fixed N or fertilizer N for food production

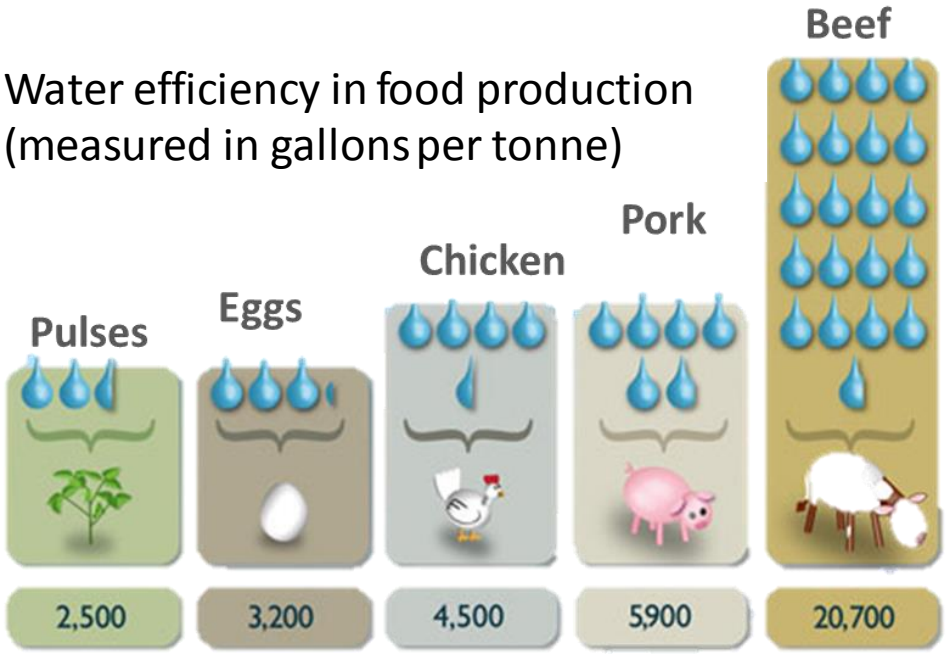
Region	Source & estimated annual N input million ton N/year	
		
Asia & middle East	19	47
Europe	3	14
North America	8	14
Africa	3	5
South America	10	6
Australia	4	1
Total Global	47	87

value ≈>US$50 billion

Source: Herridge *et al* (2008) *Plant & Soil* 311:1-18
Peoples *et al* (2009) *Nitrogen Fixation in Crop Production: Agronomy Monograph 52*, pp.349-385

Pulses are climate smart crops with less water requirements

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



Daal (1kg) **1250 liters**

Chicken (1kg) **4325 liters**

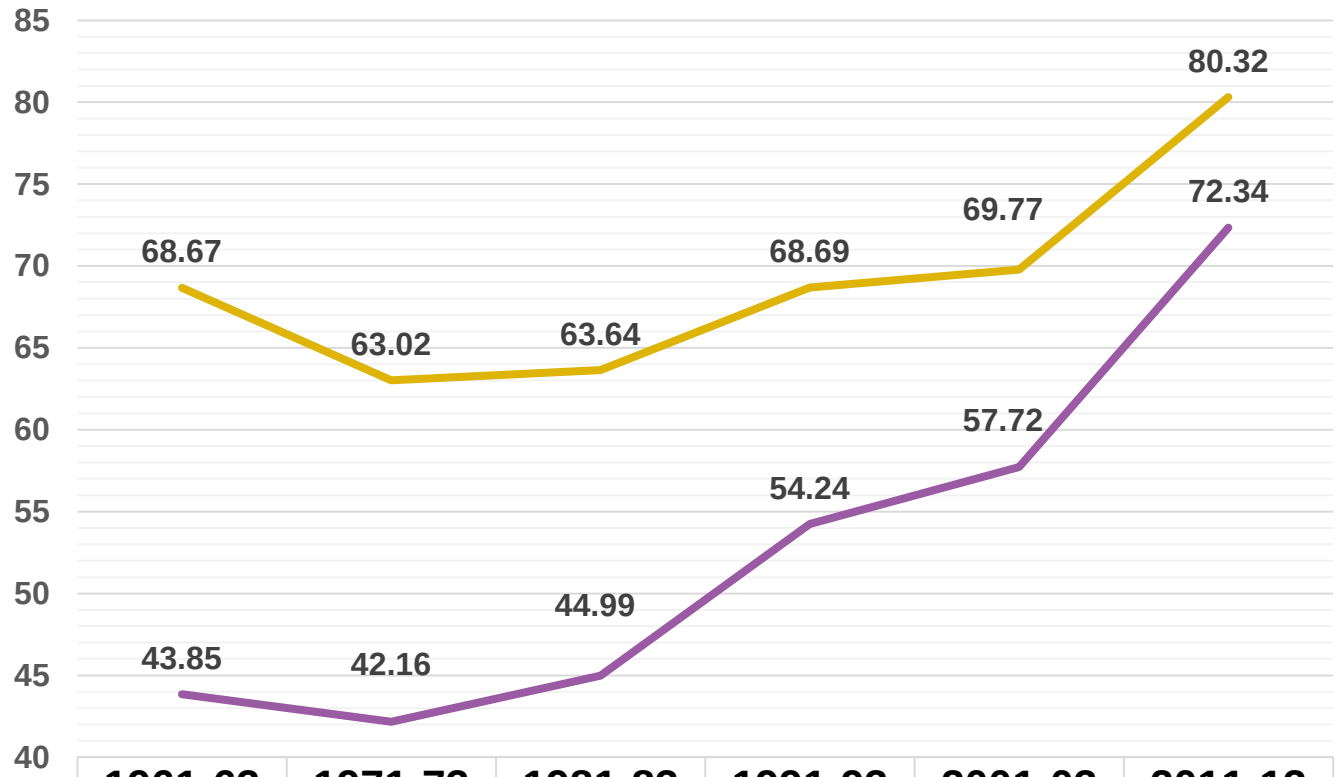
Mutton (1kg) **5520 liters**

Beef (1kg) **13000 liters**

Source: ICARDA

Global pulses production

Area **m ha**
Prod **m t**



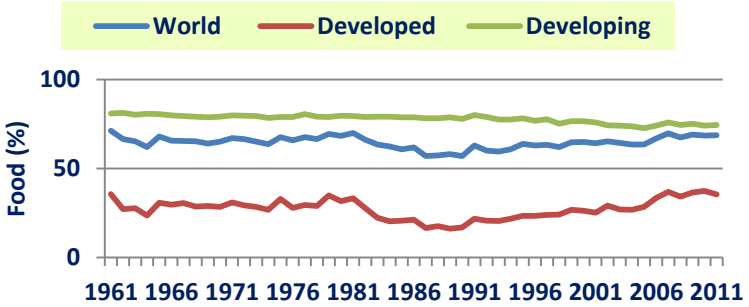
	1961-63	1971-73	1981-83	1991-93	2001-03	2011-13
Area	68.67	63.02	63.64	68.69	69.77	80.32
Production	43.85	42.16	44.99	54.24	57.72	72.34

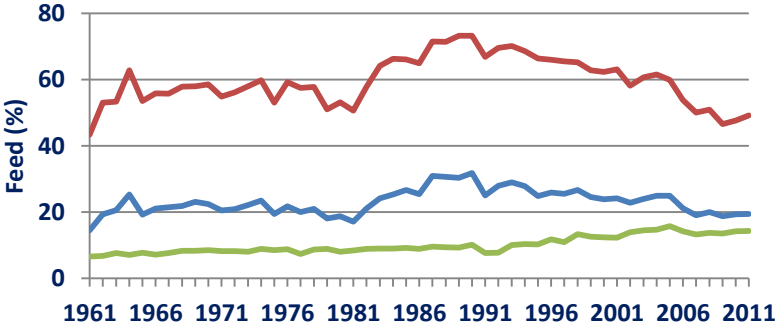
Changing regional patterns in pulses production

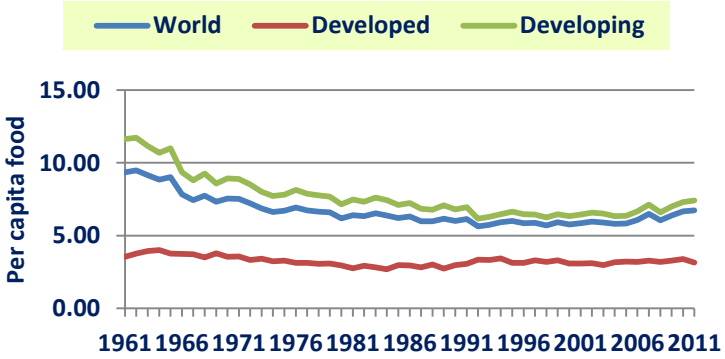
- Asia & Africa share about 70% of all pulses; showing rising trends
- Southeast Asia is emerging fastest growing region in pulses (7.4%)
  - **Dry beans, chickpea and pigeon pea are gaining importance**
- Africa is also showing fast growing in pulses production (4.6%)
  - **Chickpea and pigeon pea in 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**

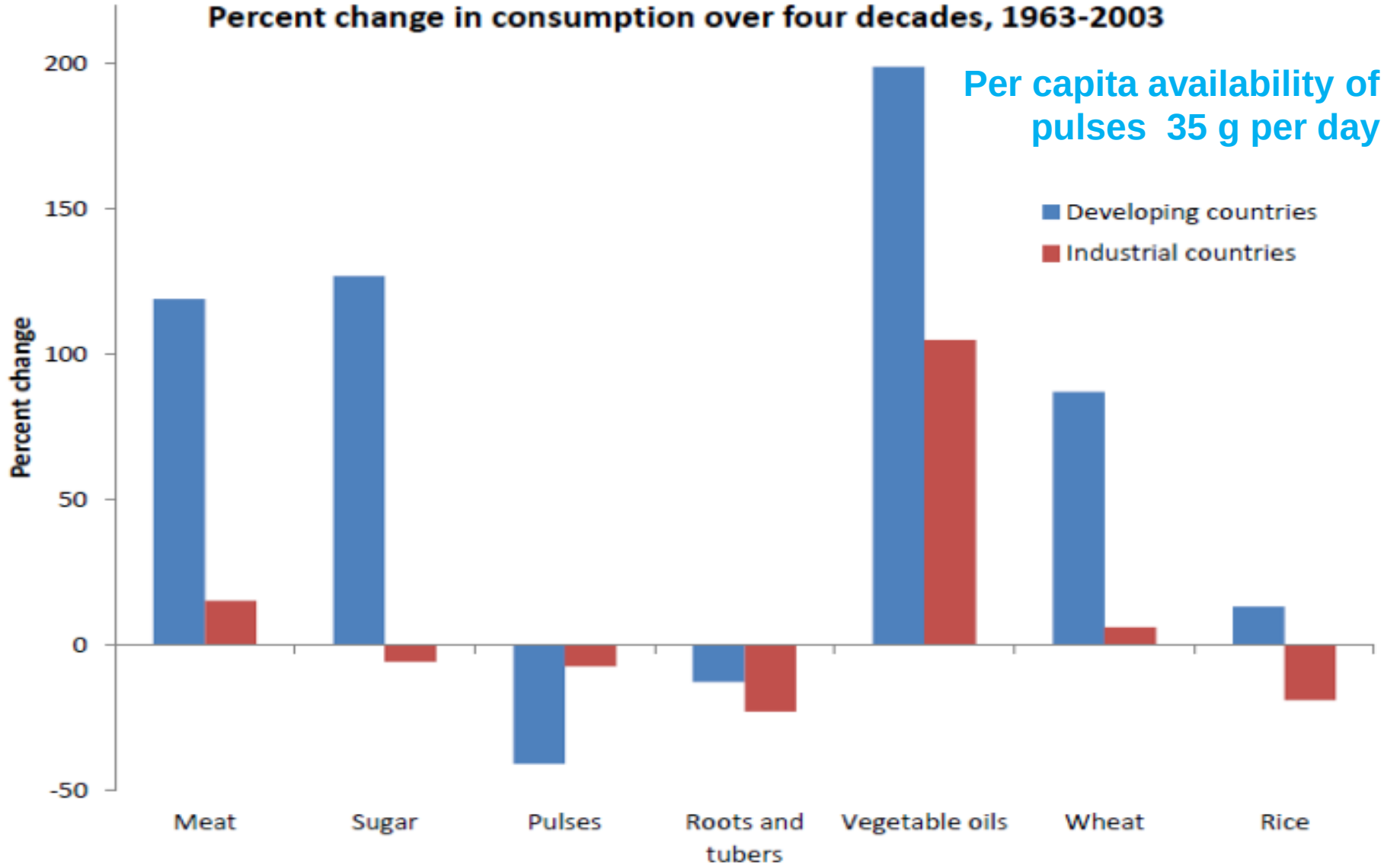




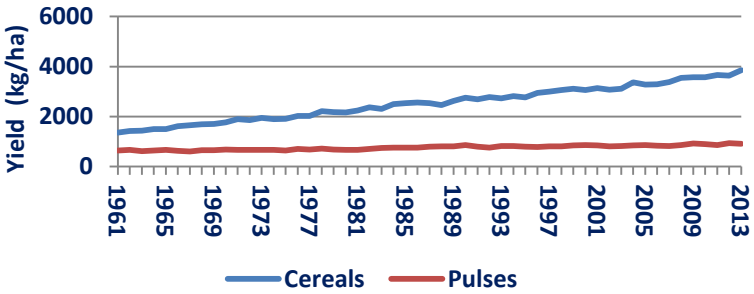


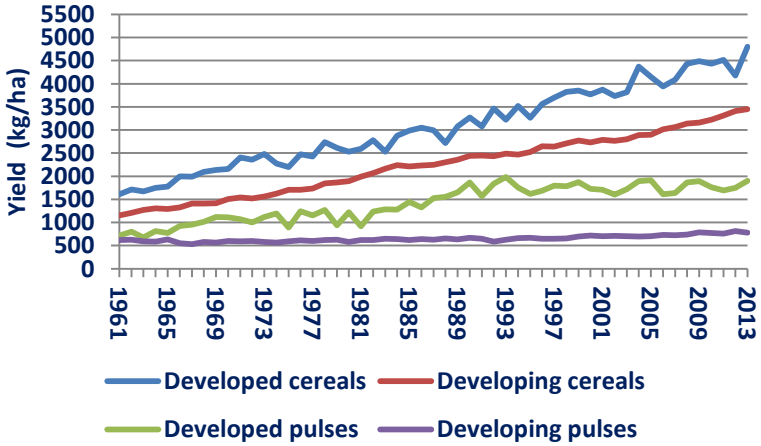
Source: P.K. Joshi

Consumption of pulses has gone down over the years



Yield of pulses versus cereals (kg/ha)

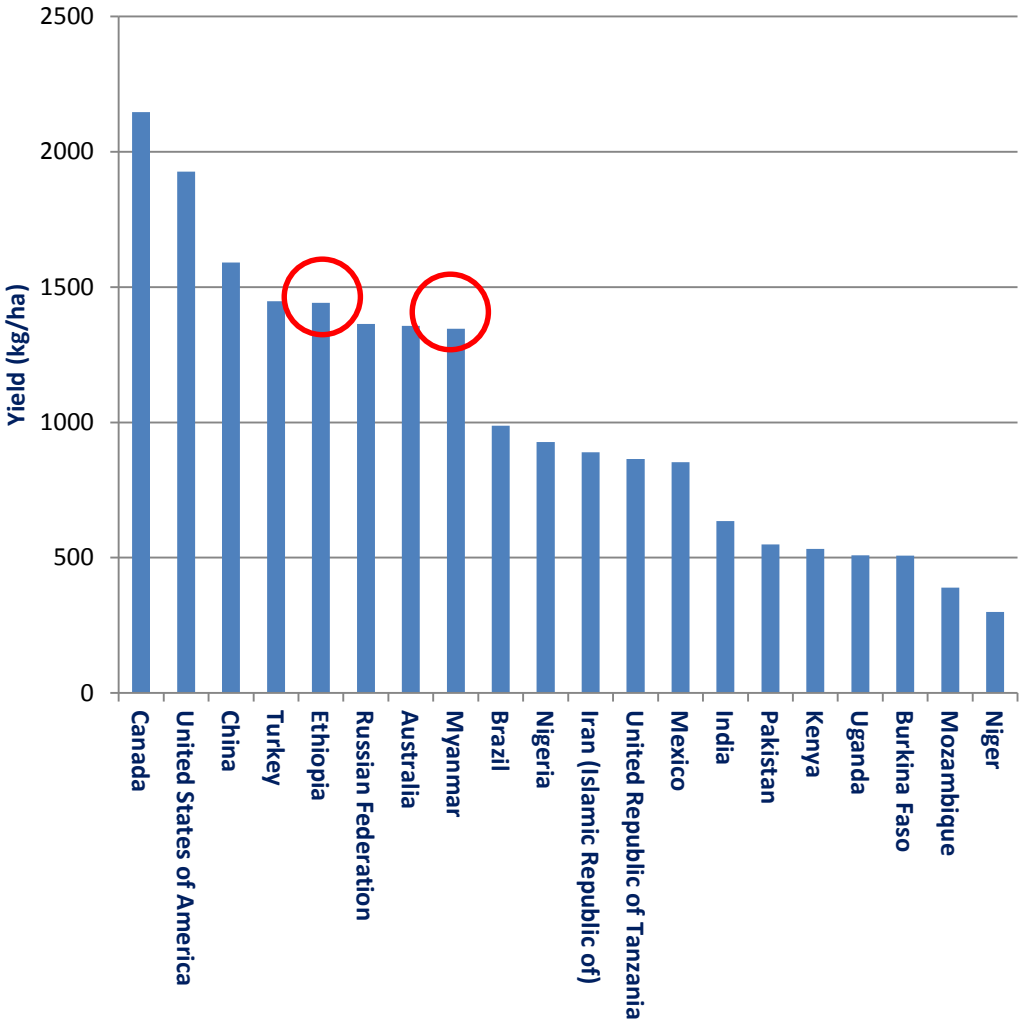




- **Global pulse yield is less than 1000 kg/ha; which used to be 550 kg/ha in 1961**
- **But, global cereals yields increased rapidly**
  - **1500 kg/ha in 1961 to 4000 kg/ha in 2013**
  - **Cereal yields increased significantly both in developed and developing countries**
- **Pulse yields increased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

Source: P.K.Joshi

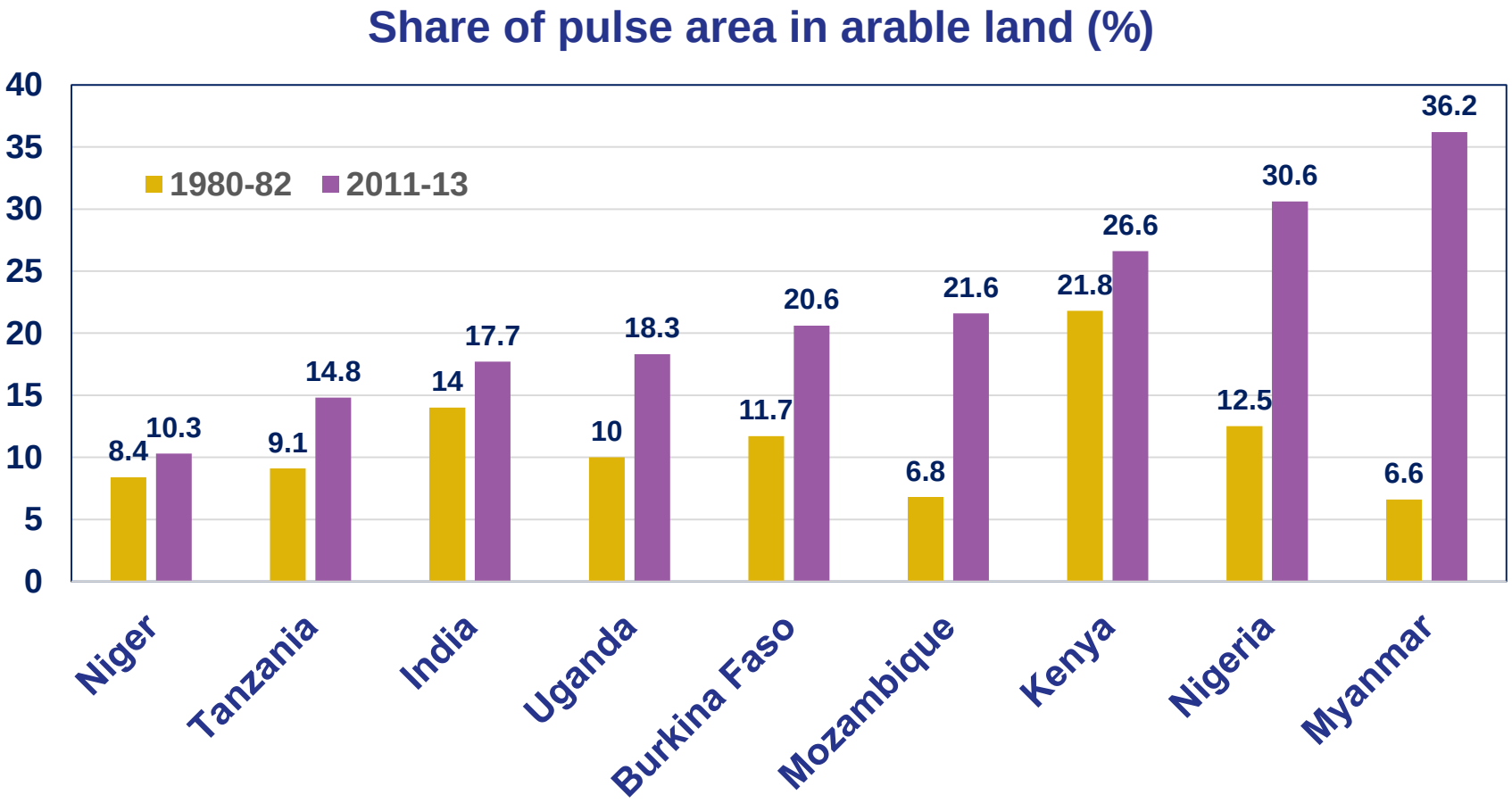
Yield of all pulses in different countries, 2011-13



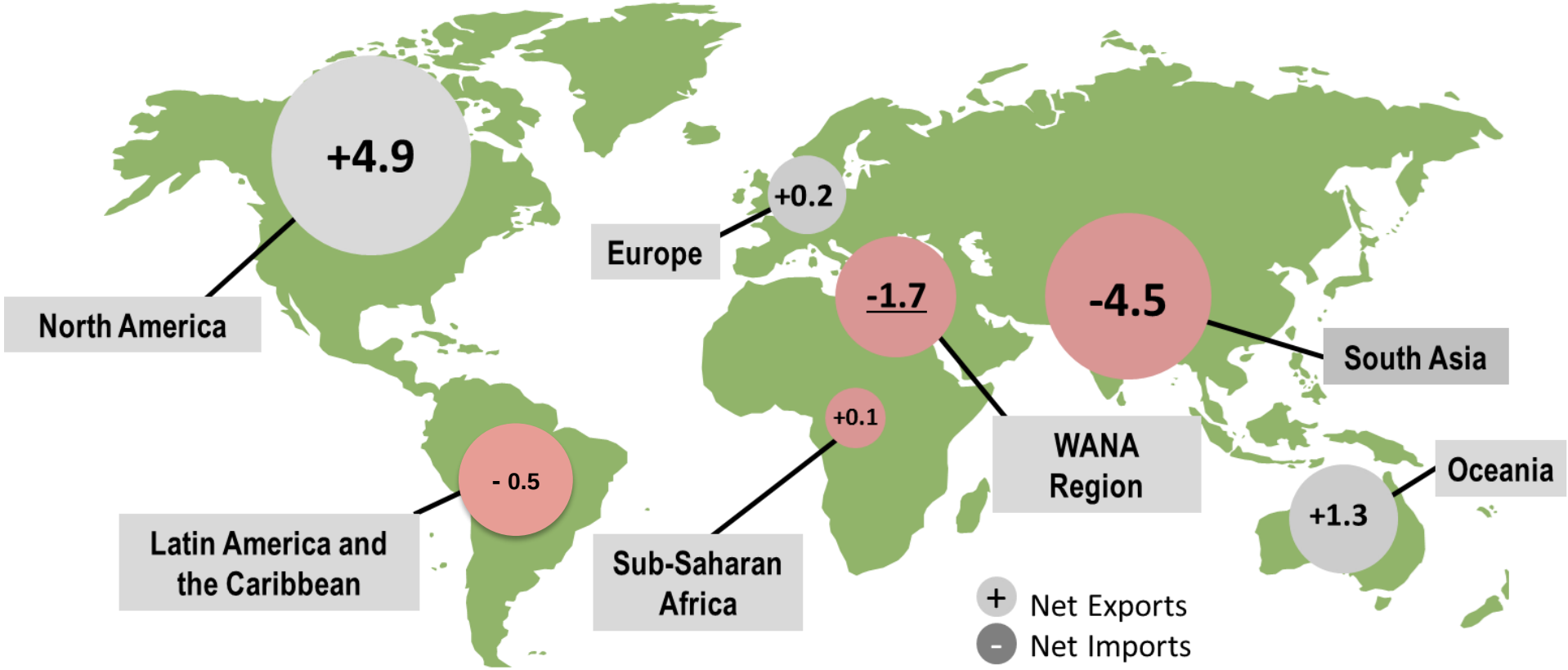
- There is large inter-regional and inter-country yield variation
- Average yields of developed countries was > 1.2 t/ha
  - **Canada > 2 t/ha; US near 2 t/ha**
- Developing countries average yield was <1 t/ha
  - **Myanmar and Ethiopia are exception**
  - **Most of the African and S Asian countries yields are < 500 kg/ha**

Source: P.K. Joshi

Growing importance of pulses in many countries - especially more vulnerable population



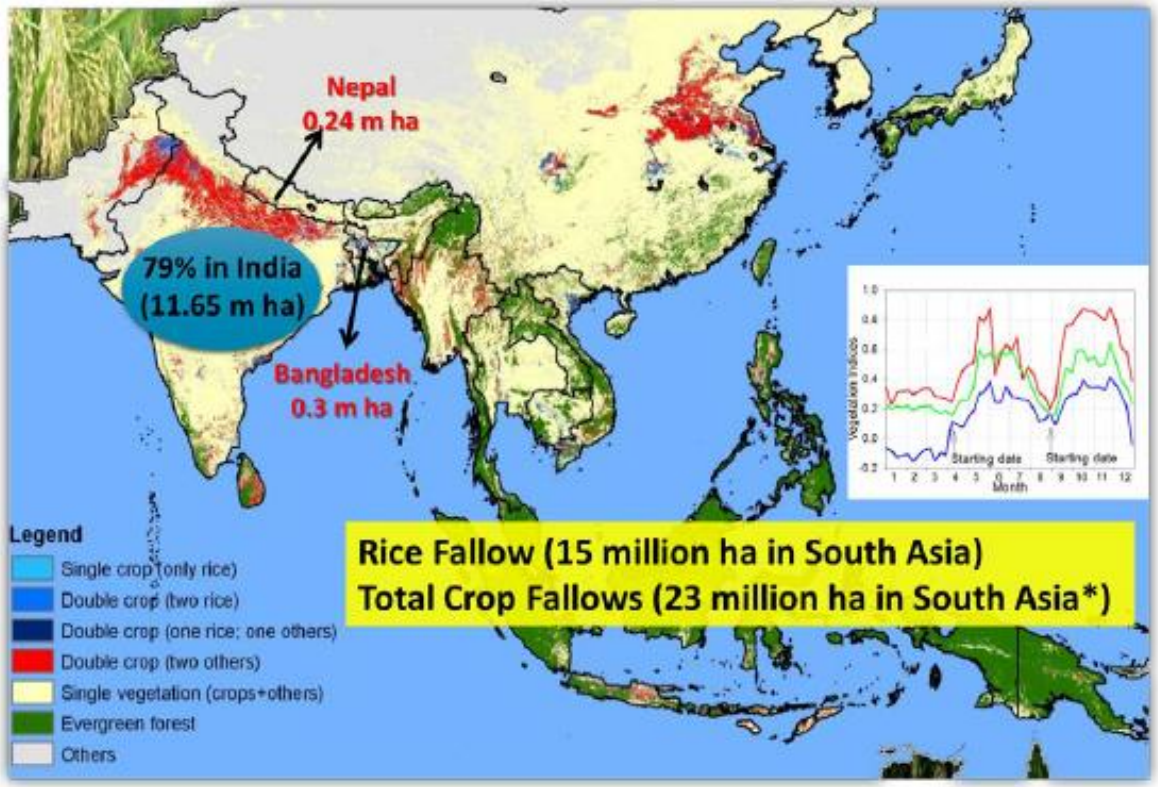
Global pulse trade : about 12 million tons (2011)

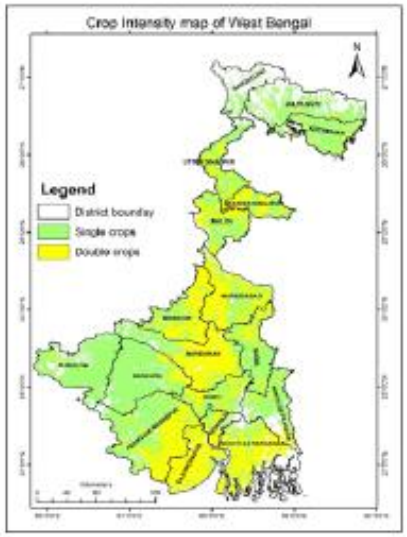


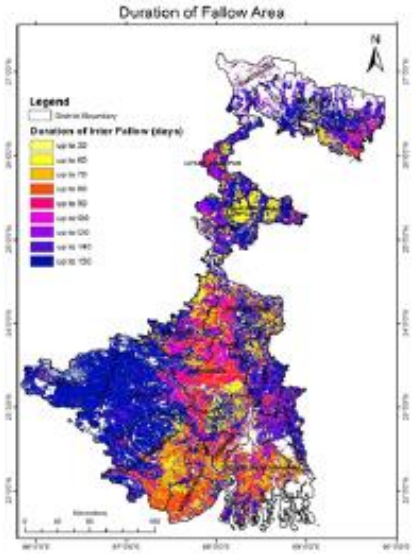
Sources: FAOSTAT (2011)

Source: ICARDA

Mapping of Rice Fallows in South Asia





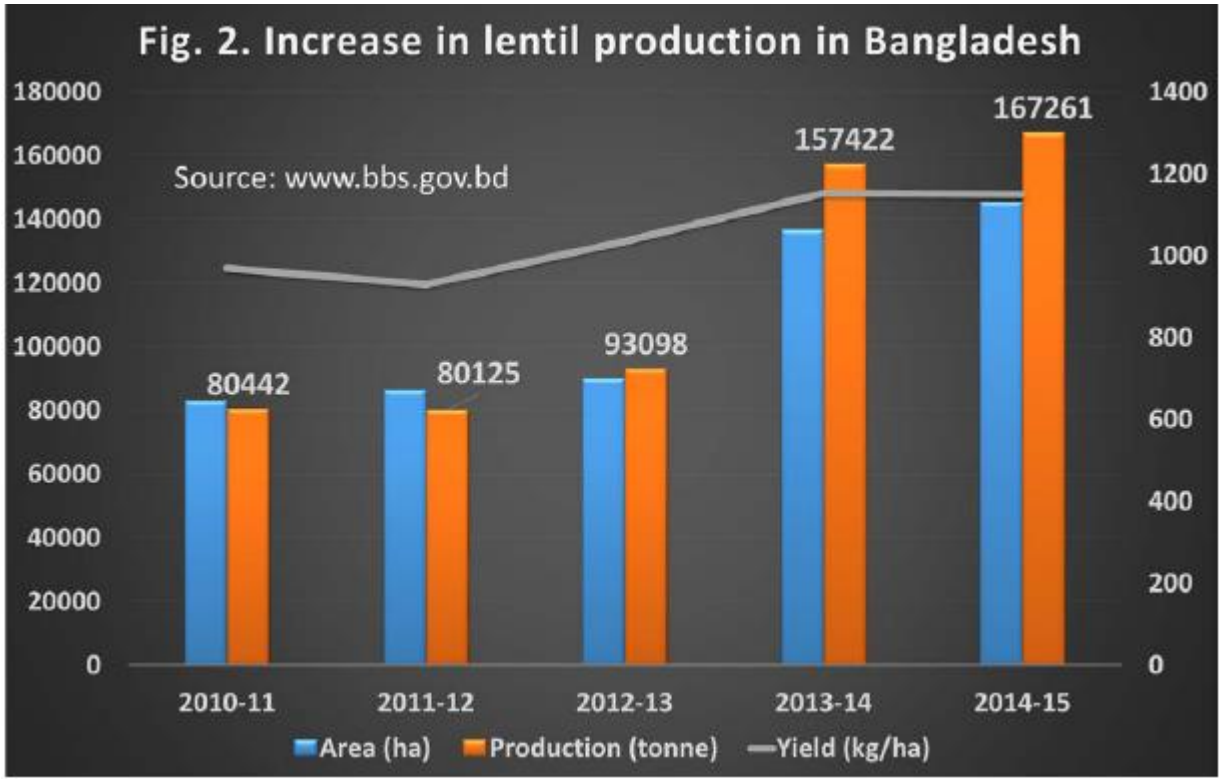


Source: Shiv Kumar Agrawal

Lentil in Rice System in Bangladesh

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)

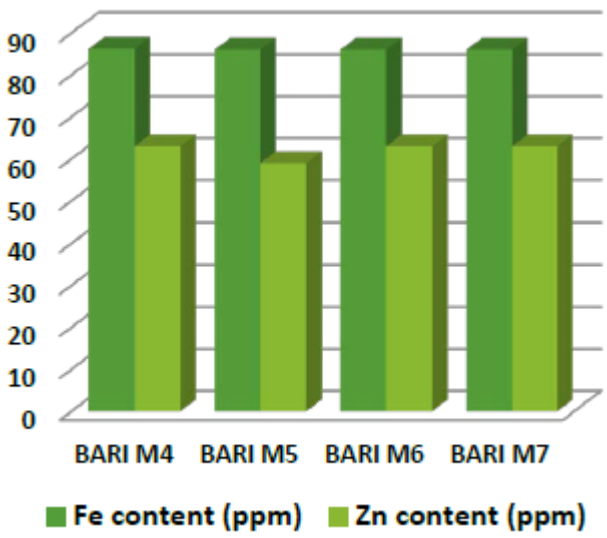
Yield increased from 930 to 1150 kg/ha



Source: Shiv Kumar Agrawal

Lentil in Rice System in Bangladesh

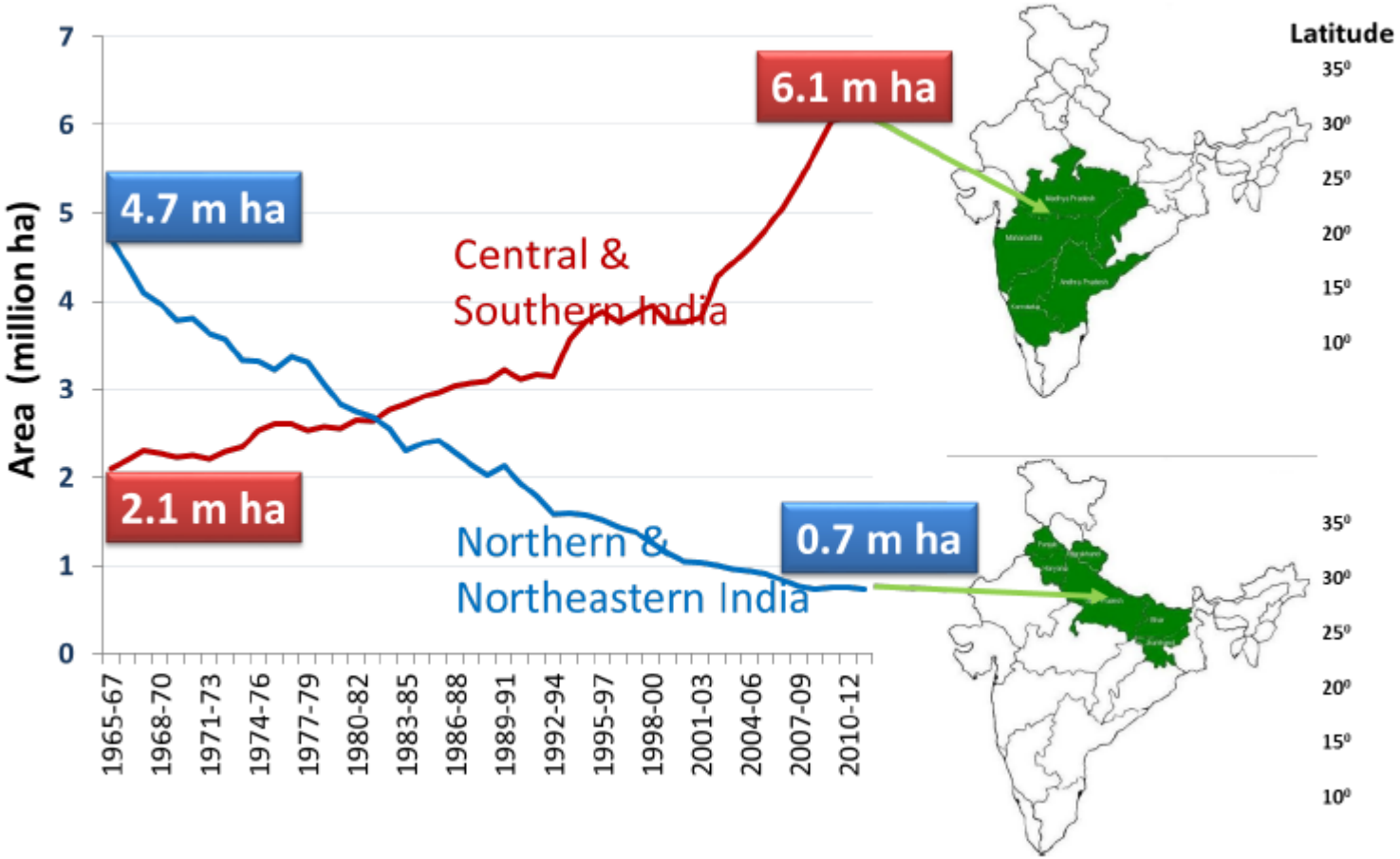
- Improved varieties (BARI-M4, M5, M6, M7, M8) with disease resistance and rich in Micronutrients developed
  - Stemphylium blight and rust resistance
  - Rich in iron and zinc contents
- Production tech for relay planting
- Large scale demonstration
- Farmers participatory quality seeds



- **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

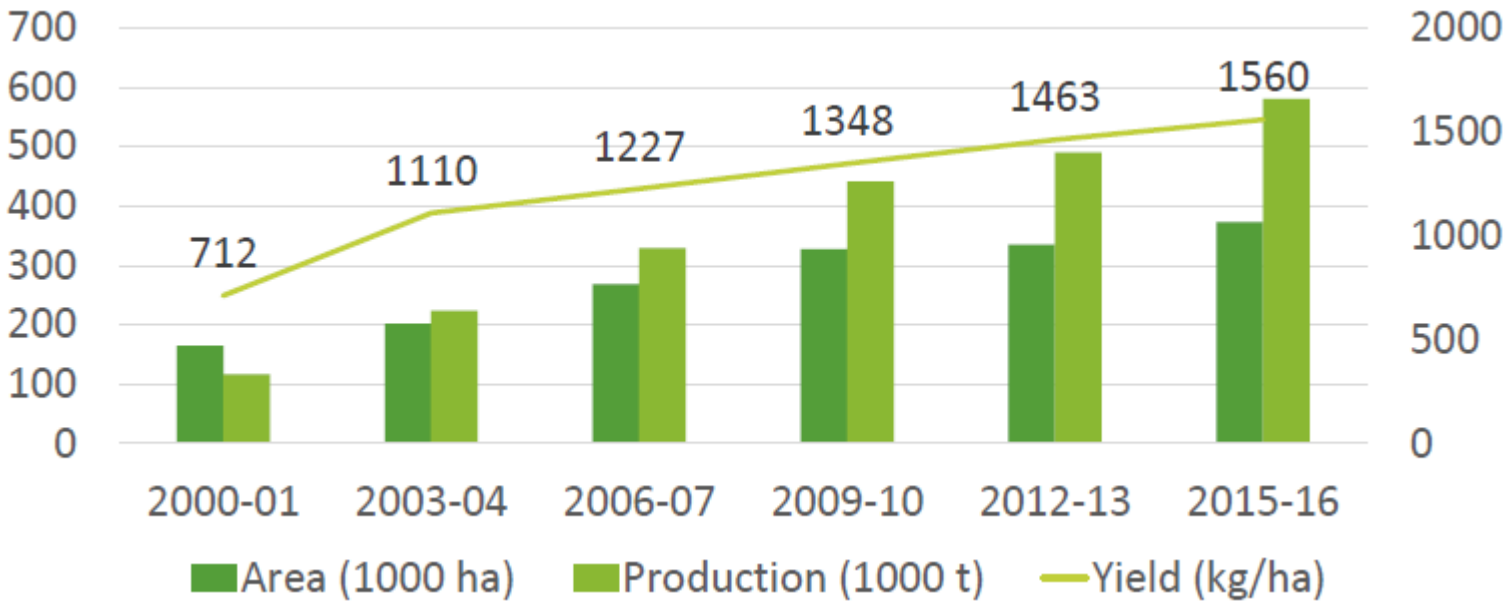
Impact of short duration Chickpea Varieties in Andhra Pradesh, India

- 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

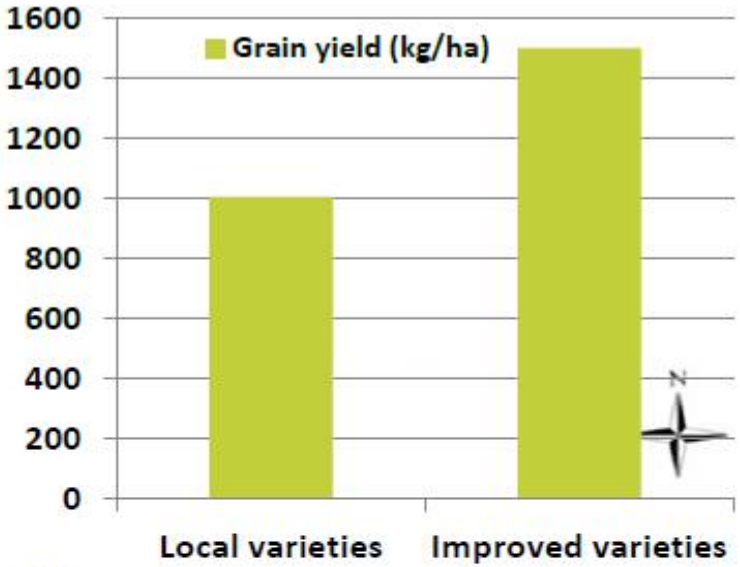
- 7 varieties released from ICRISAT germplasm
- 96% chickpea area under 5 varieties (43% Yezin3, 20% Yezin4, 16% Yezin6, 16% Yezin8 and 1% Yezin11)
- Compound AGR of 5.6% for yield during past 15 years
- Production increased 5-fold (117,000 to 581,000 tons), 3.3-fold increase in area and 2.2-fold increase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

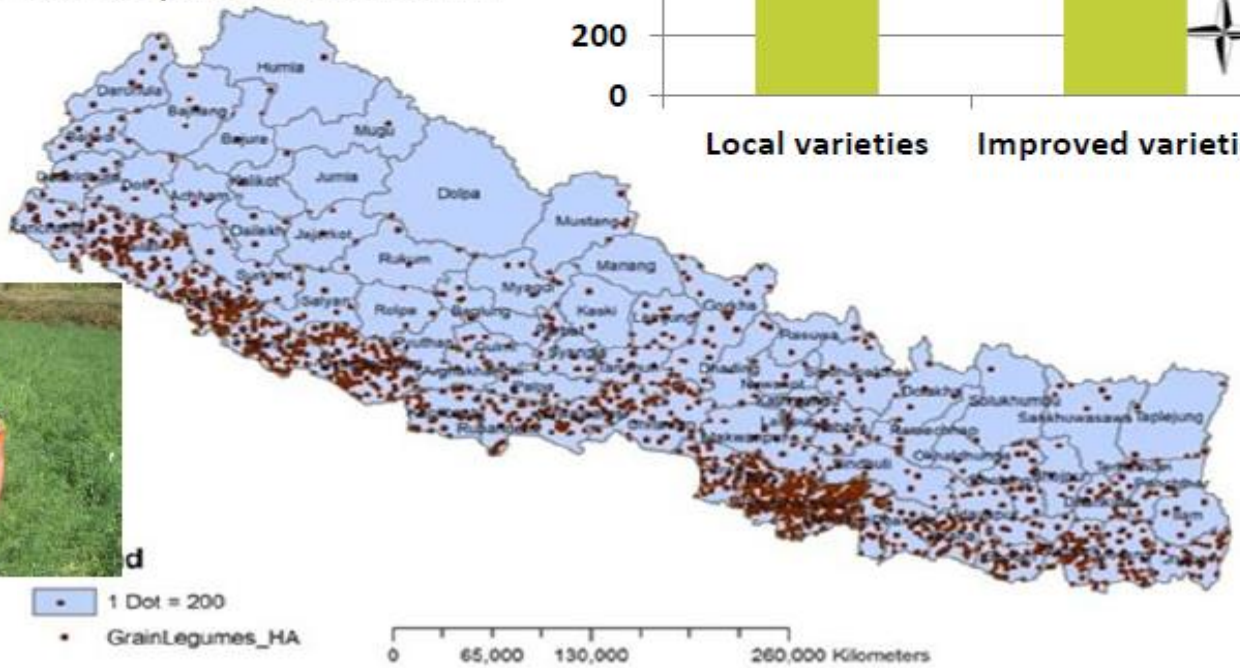


Source: Shiv Kumar Agrawal

Nepal – Exporter of Lentil in South Asia

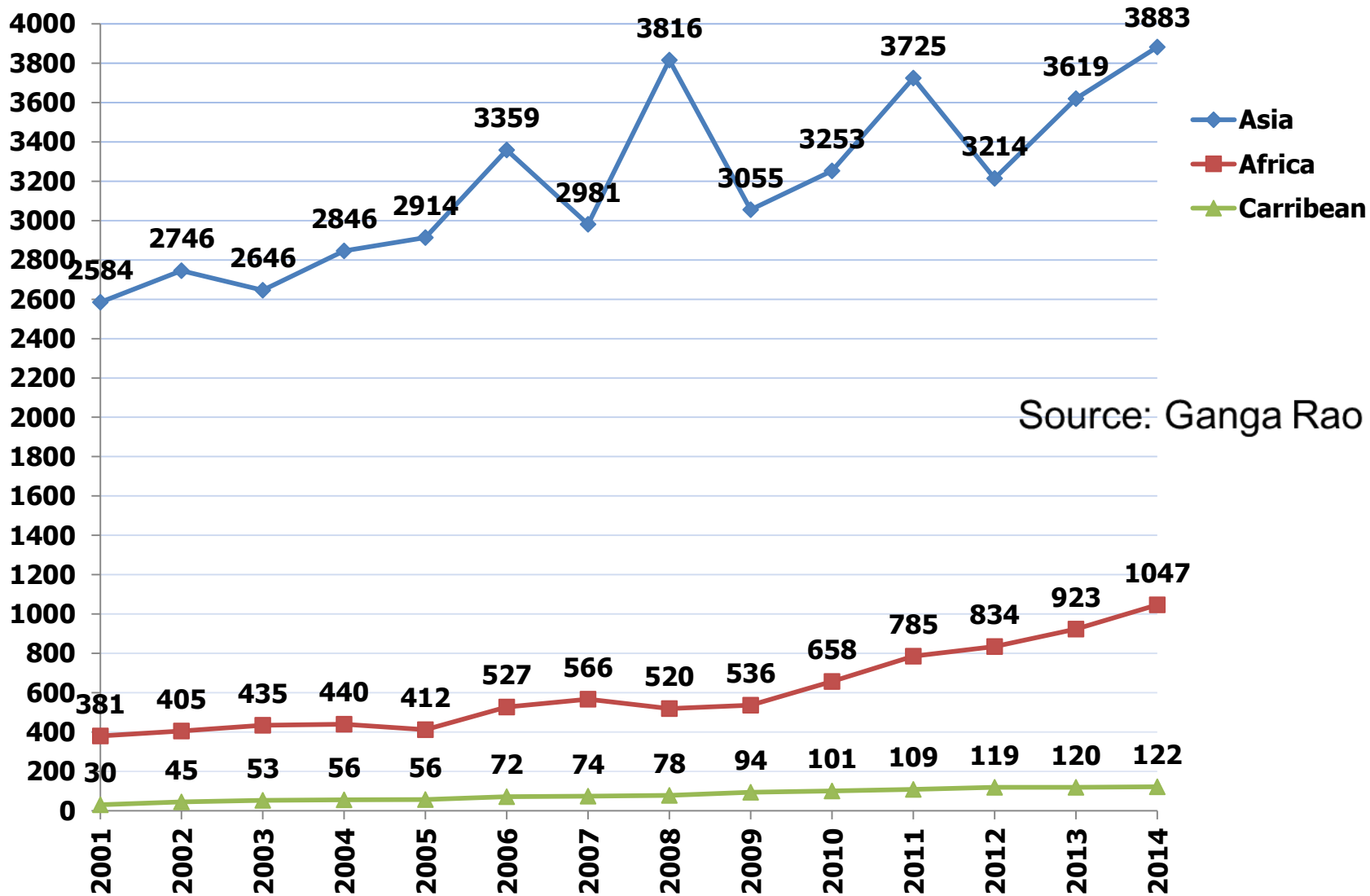
- 10 varieties released
- ~60% (124,578 ha) area under improved varieties
- 124,952 tons production
- 61.92 m $ additional annual income
- > 3x export value at present than in 2001





Source: Shiv Kumar Agrawal

Pigeon pea Production ('000 t) trends



Pigeon pea growth trends in Africa

Country	In '000 t		% increase		
	2001	2014	Production	Area	Yield
Tanzania	87.1	249.3	186	106	39
Mozambique	31.6	120.9	282	261	6
Malawi	105.8	301.0	184	69	68
Kenya	73.46	274.5	274	68	122
Uganda	80.0	93.6	17	28	-8
Africa	380.6	1047.3	175	96	40

Source: Ganga Rao

Pigeon pea Exports from Africa (000' t)

India imports about 570, 000 t annually

50% from Myanmar and 50% from Africa

Country	5 year range	2016 (expected)
Tanzania	75-90	70
Mozambique	55-75	75
Malawi	60-90	70
Kenya	15-20	18
Uganda	8-14	12
Sudan	40-50	45
Africa	253-339	290

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

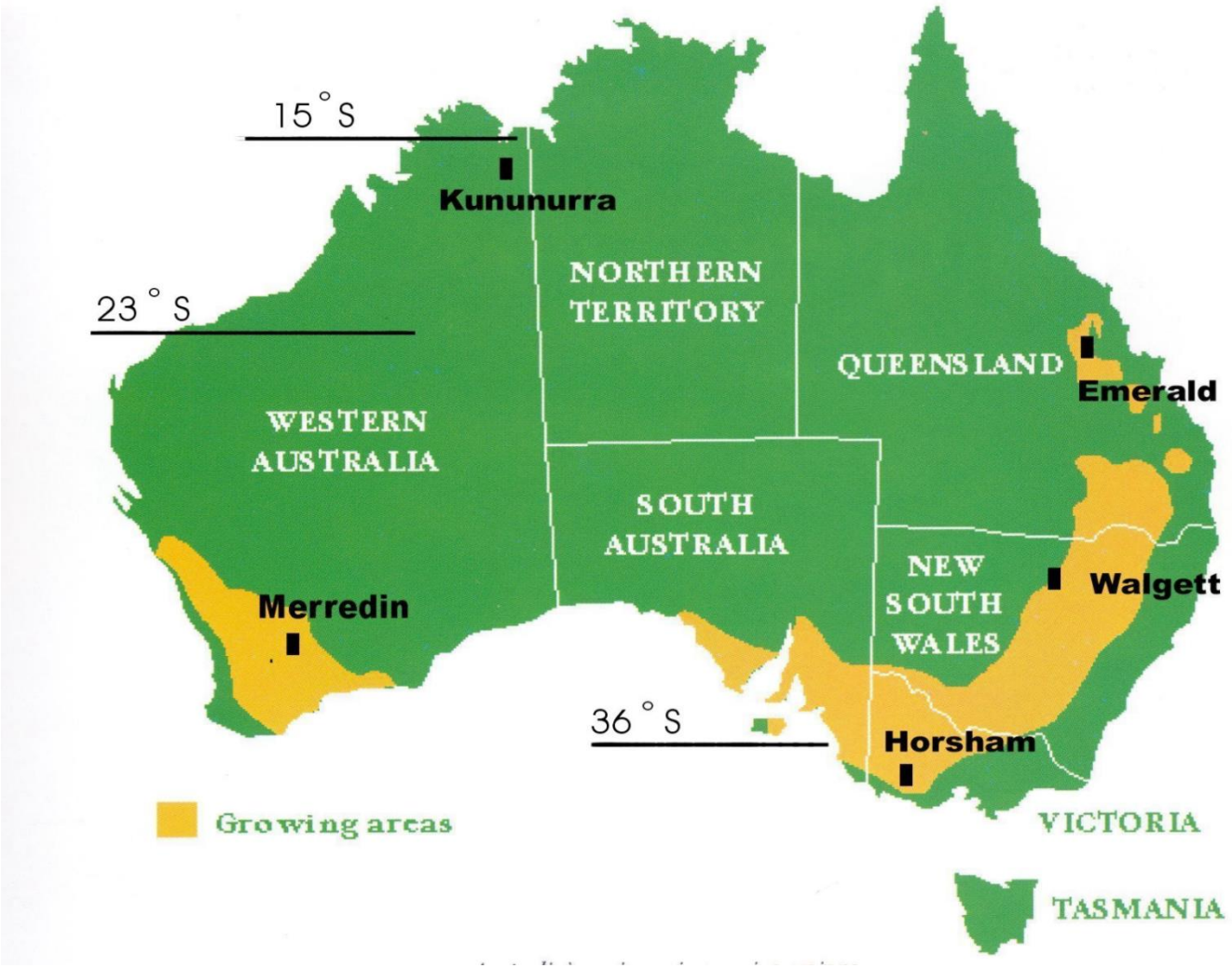
Mrs. E.Mollel of Kikatiti, Tanzania

In front of her old house of 1988

In front of her new improved house

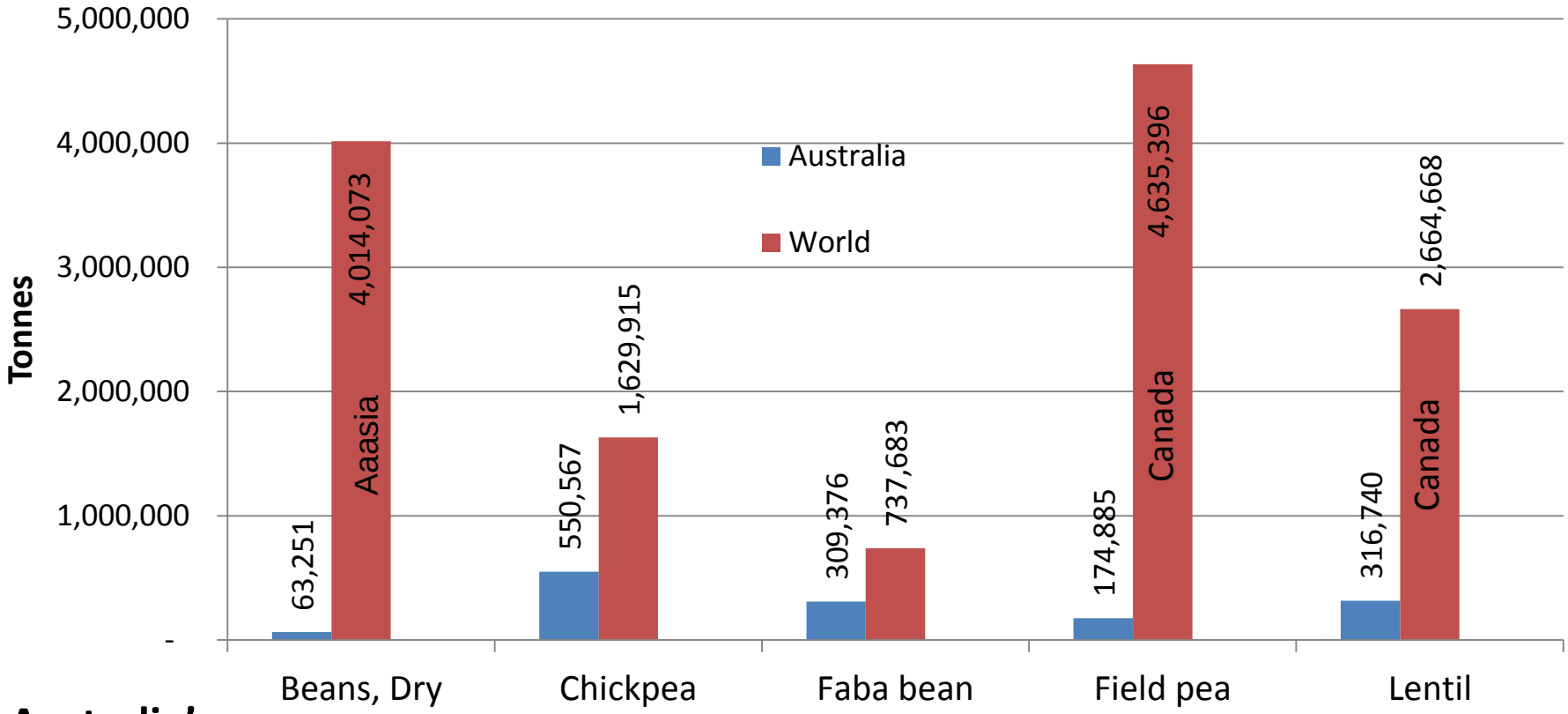
Source: Ganga Rao

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



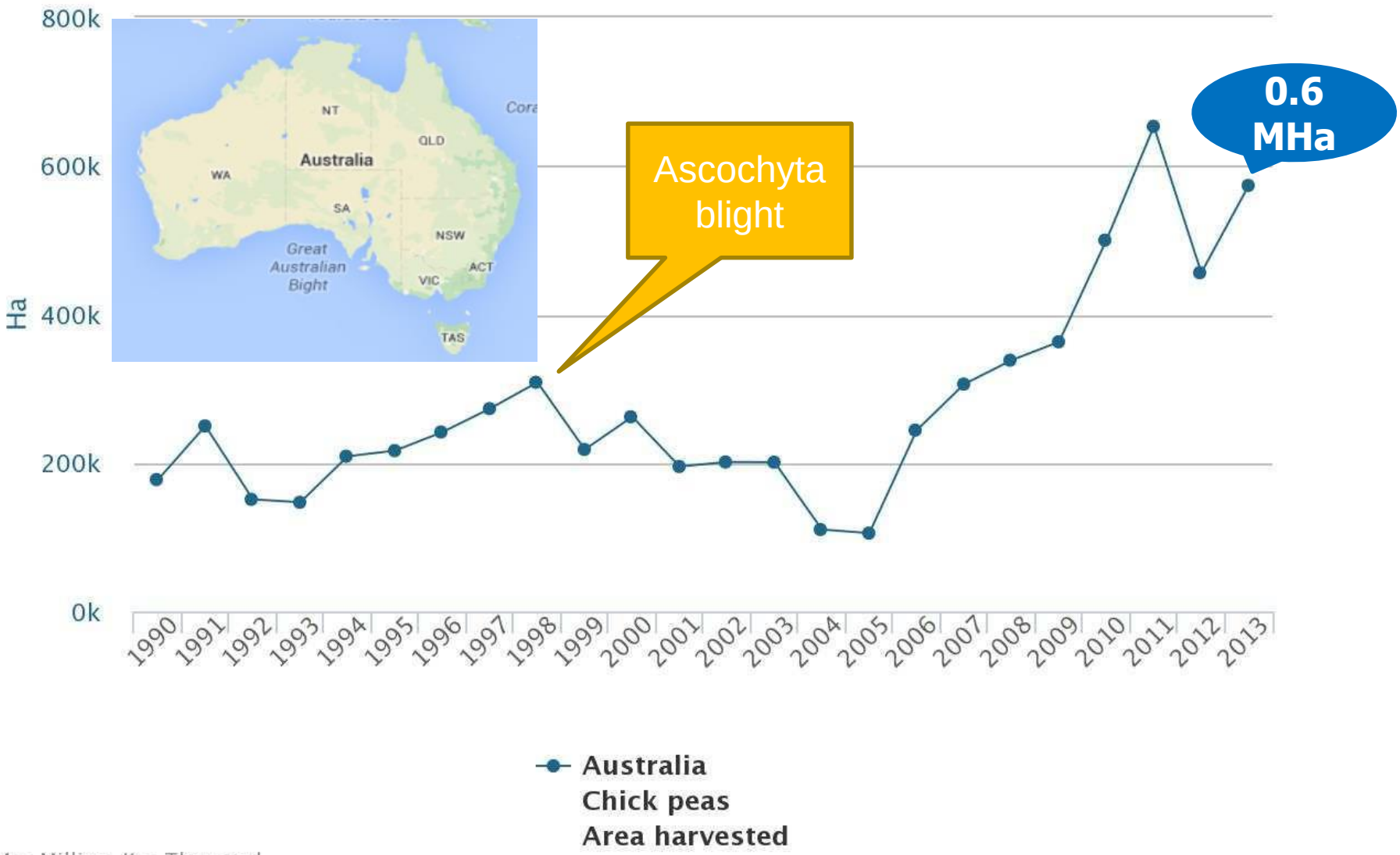
Australia's share

Beans, Dry	Chickpea	Faba bean	Field pea	Lentil
2%	**34%**	**42%**	**4%**	**12%**

Source: FAOSTAT.org

Beans, dry = Mungbean and coloured beans. Not soybean

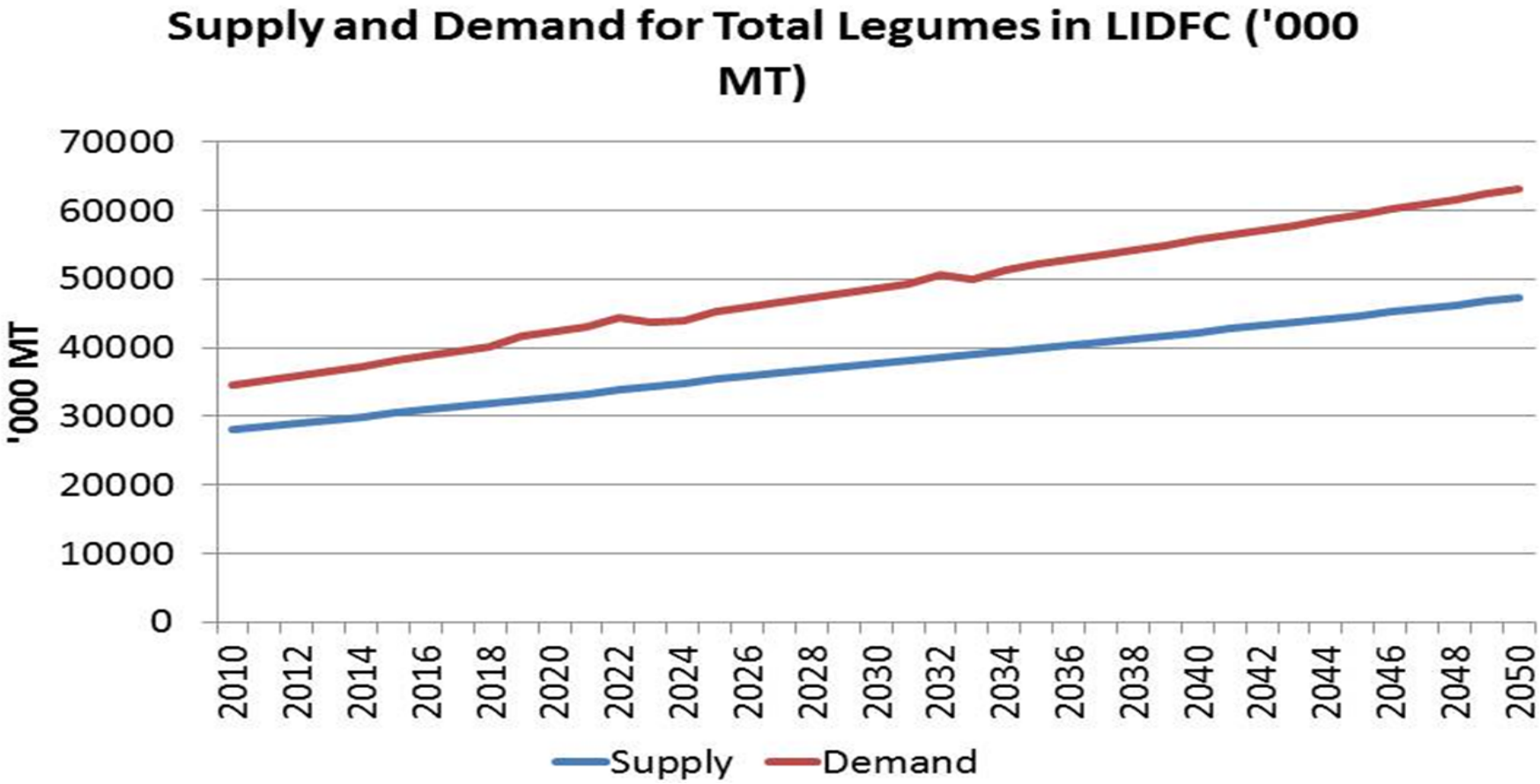
Chickpea– the No. 1 Pulse in Australia



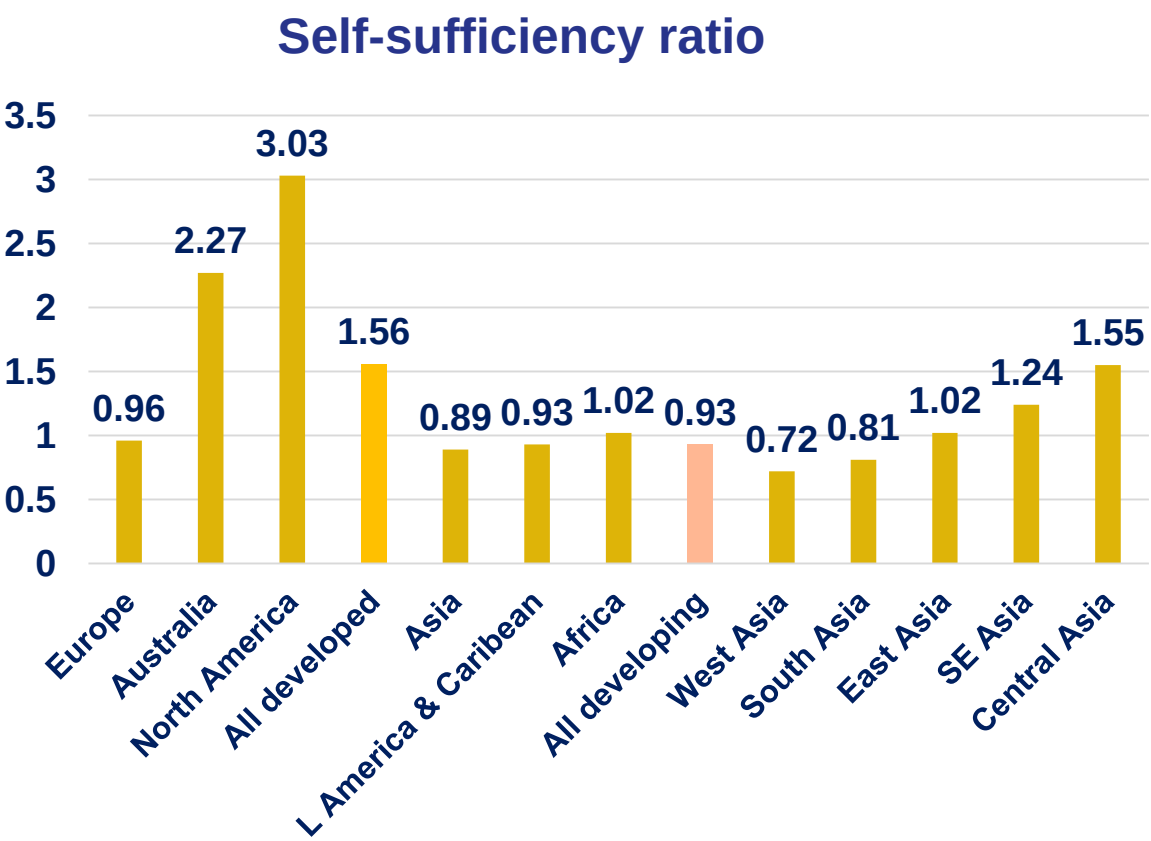
M = Million, K = Thousand

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**

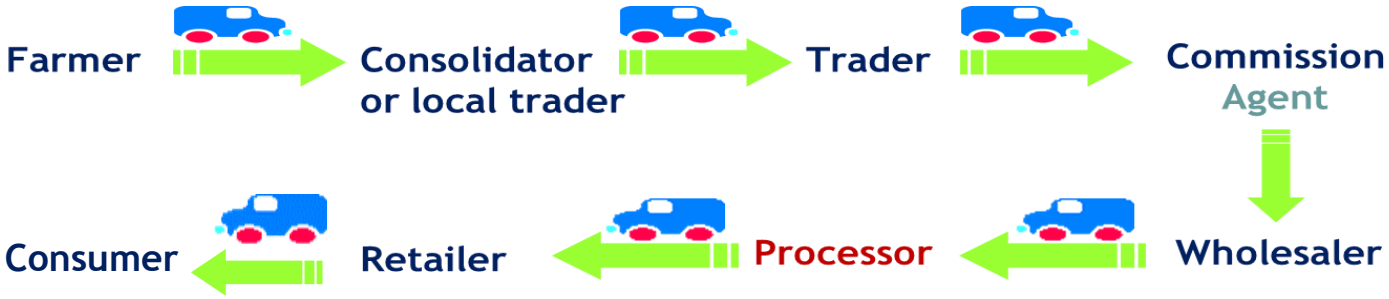


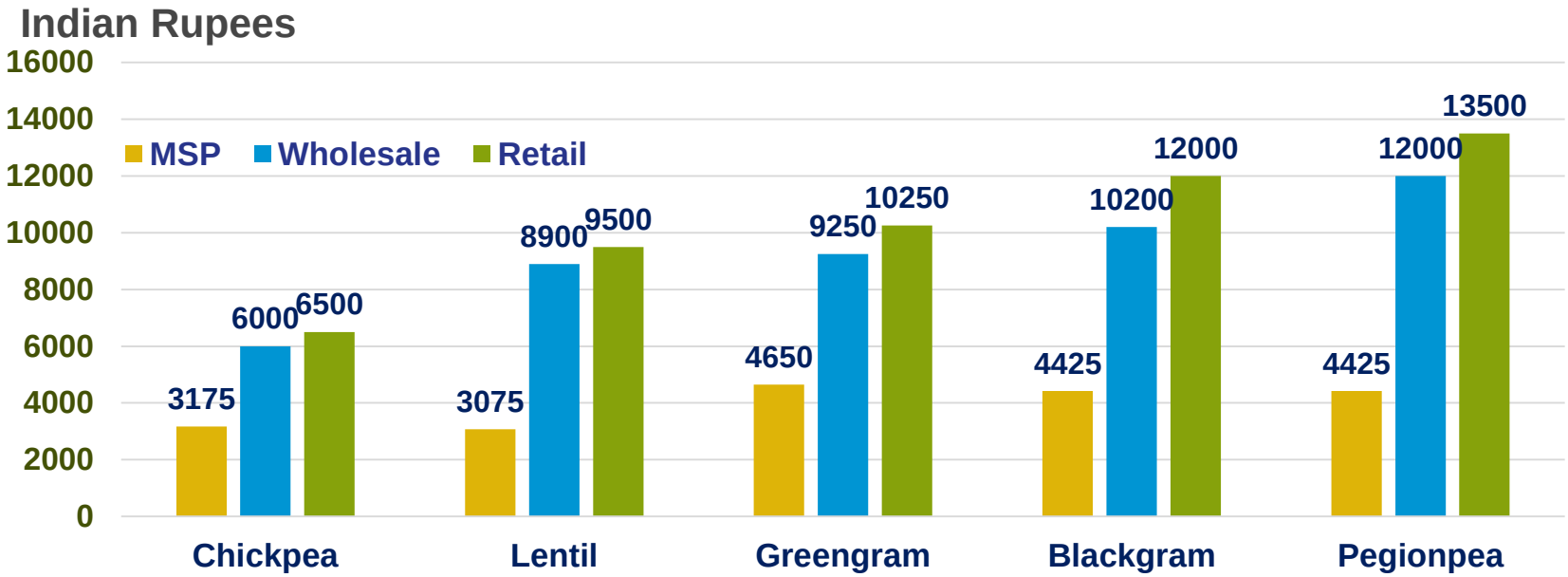
Region-wise self-sufficiency in pulses



- 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?

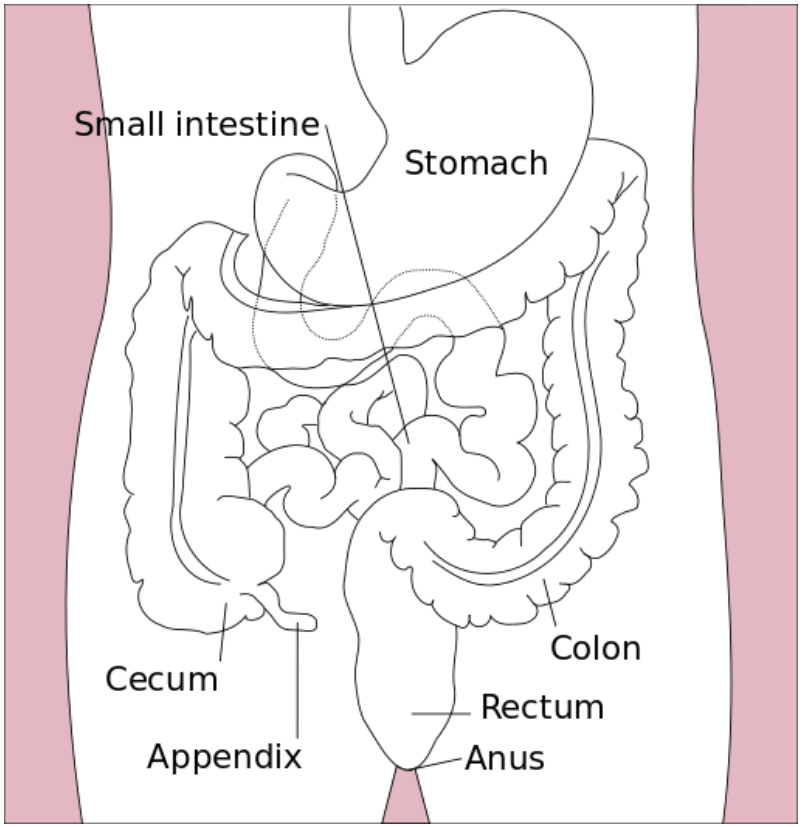
1. A nutrient-rich food that enhances **dietary quality.**
2. Promote gut health and function for improved **human health**
3. Legume crops fix atmospheric nitrogen (N) for improved **sustainability** of cropping systems.
4. Provide farmers with diverse crop options to mitigate risk to ***climate change***
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.

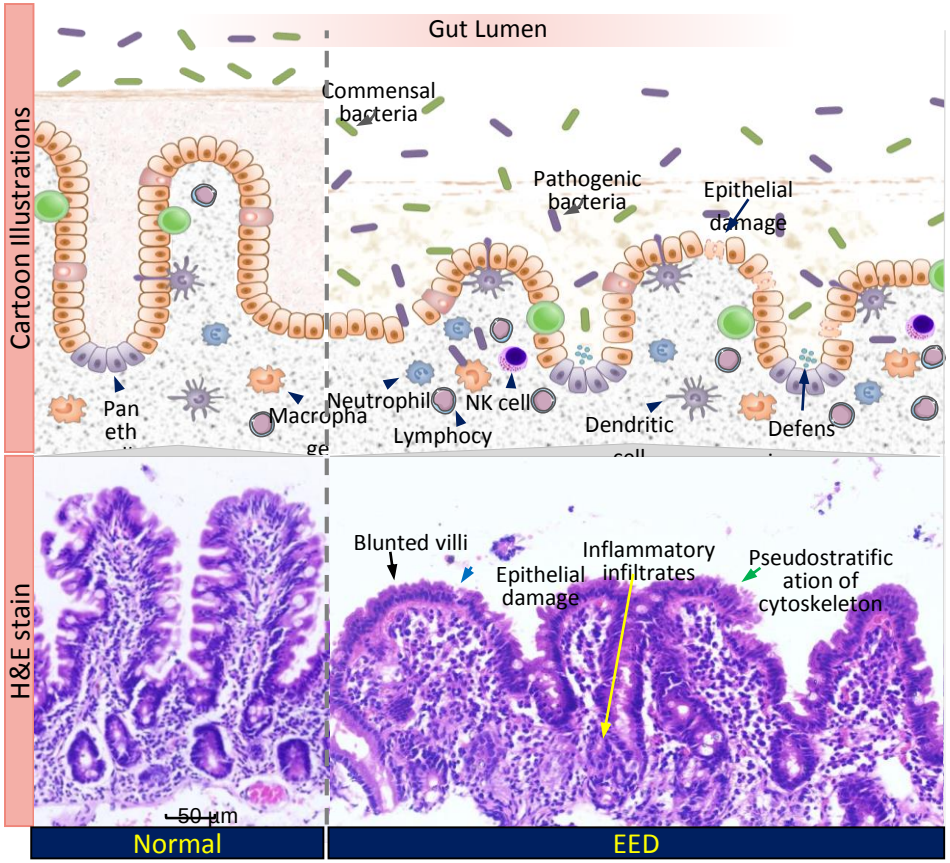
Importance of the Gut (Intestinal Track)



- 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

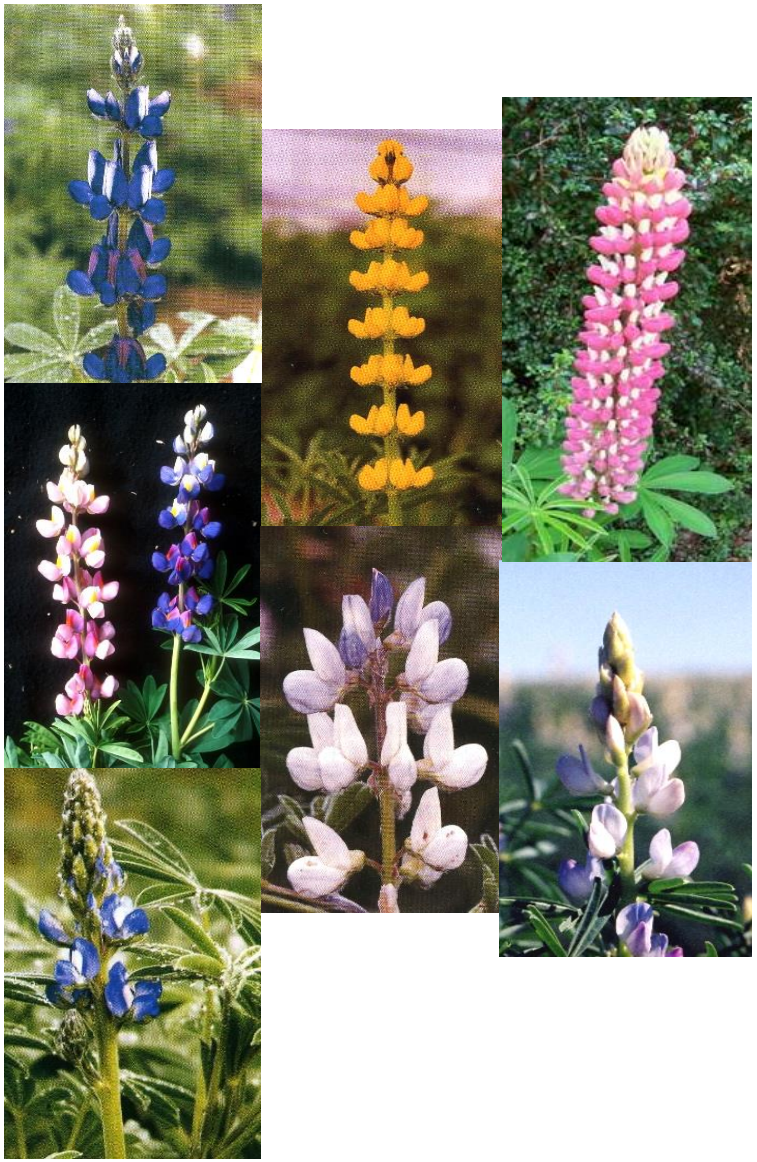


- Unique oligo-sacharides (raphinose sugars) improve bacterial ecology in the gut (probiotic effect- promote beneficial bacteria)
- Complex carbohydrates (dietary fiber) improve digestion
- Non-digestible portion of pulses have anti-inflammatory properties
- Pulse-based foods produce short-chain fatty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

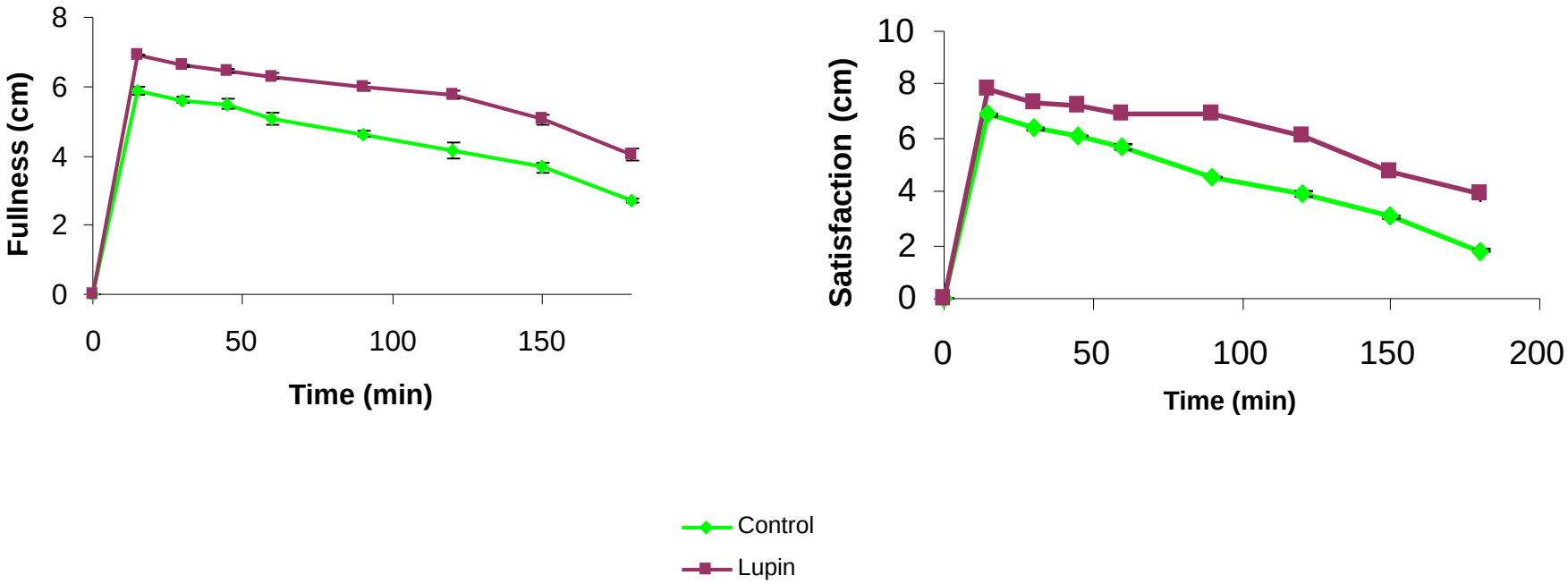
Source: Jonathan Hodgson

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

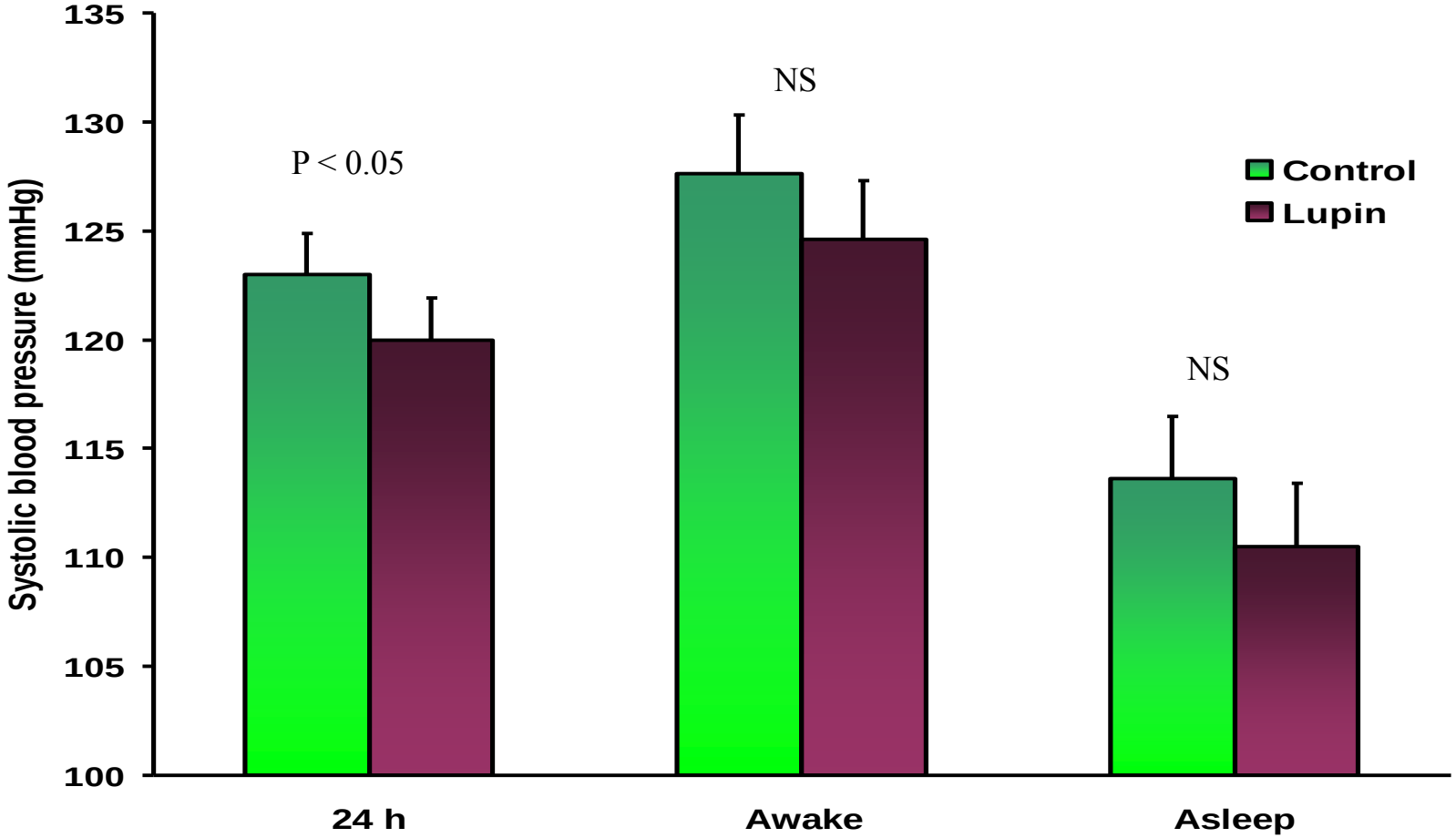
Appetite



Lee YP, Mori TA, Sipsas S, Barden A, Puddey IB, Burke V, Hall RS, Hodgson JM. Lupin-enriched bread increases satiety and reduces energy intake acutely. Am J Clin Nutr 2006; 84:975-980

Source: Jonathan Hodgson

Blood pressure

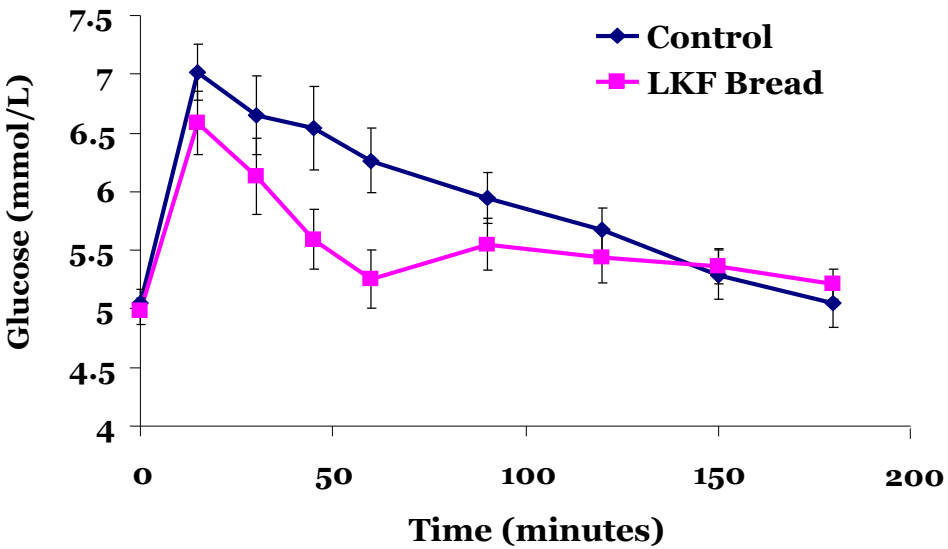


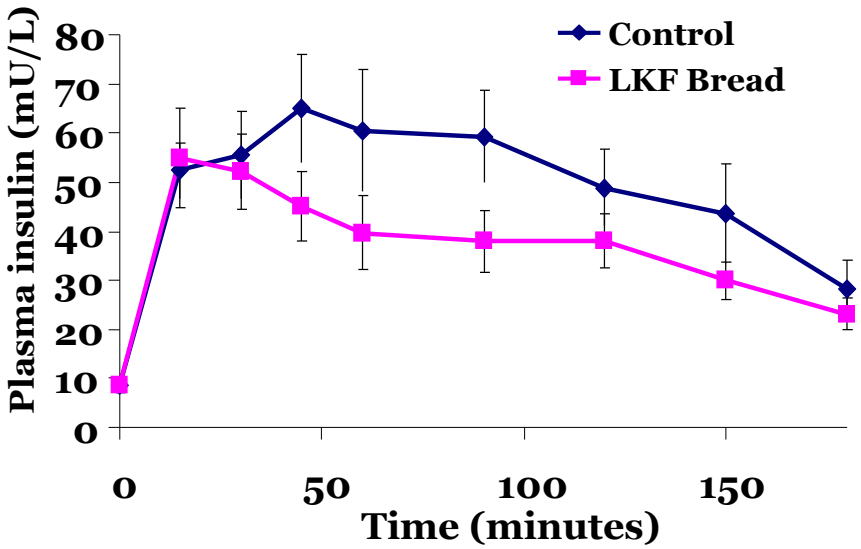
Lee YP, Mori TA, Puddey IB, Sipsas S, Ackland TR, Beilin LJ, Hodgson JM. The effects of lupin kernel flour-enriched bread on blood pressure: a controlled intervention study. Am J Clin Nutr 2009; 89: 766-82

Source: Jonathan Hodgson

Glucose and insulin (Diabetes)

Effects of replacement of refined carbohydrate with lupin flour in bread





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Source: Jonathan Hodgson

Summary- lupin & health

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)

THE UNIVERSITY OF WESTERN AUSTRALIA

nature plants

PERSPECTIVE

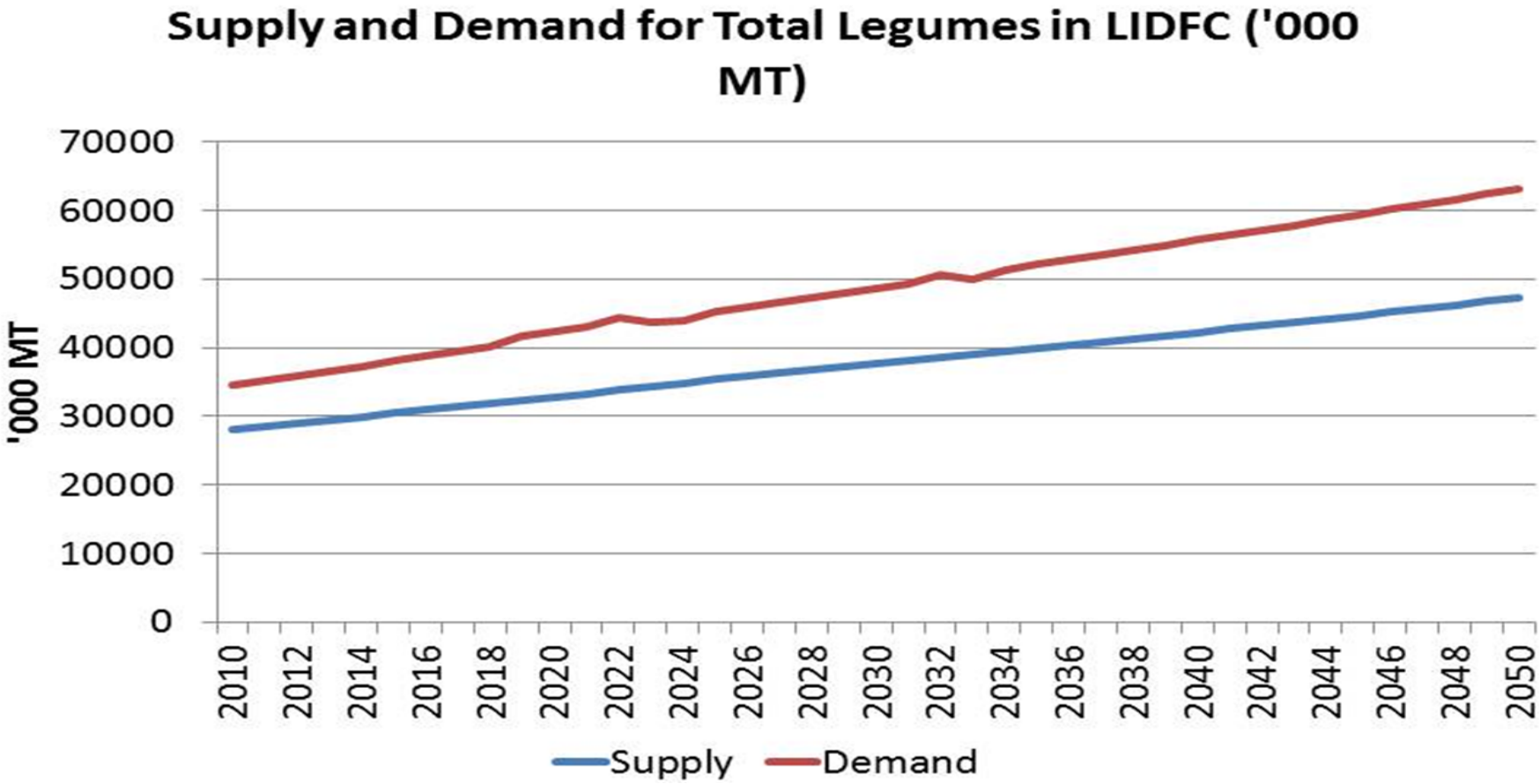
PUBLISHED: 2 AUGUST 2016 | ARTICLE NUMBER: 16112 | DOI: 10.1038/NPLANTS.2016.112

Neglecting legumes has compromised human health and sustainable food production

Christine H. Foyer[1,2*], Hon-Ming Lam[3], Henry T. Nguyen[4], Kadambot H. M. Siddique[5], Rajeev Varshney[6], Timothy D. Colmer[2,5], Wallace Cowling[5], Helen Bramley[7], Trevor A. Mori[8], Jonathan M. Hodgson[8], James W. Cooper[1], Anthony J. Miller[9], Karl Kunert[10], Juan Vorster[10], Christopher Cullis[11], Jocelyn A. Ozga[12], Mark L. Wahlqvist[13,14], Yan Liang[15], Huixia Shou[16], Kai Shi[17], Jingquan Yu[17], Nandor Fodor[1], Brent N. Kaiser[18], Fuk-Ling Wong[3], Babu Valliyodan[5] and Michael J. Considine[2,5,19]

Production sufficiency in pulses is a concern in some regions

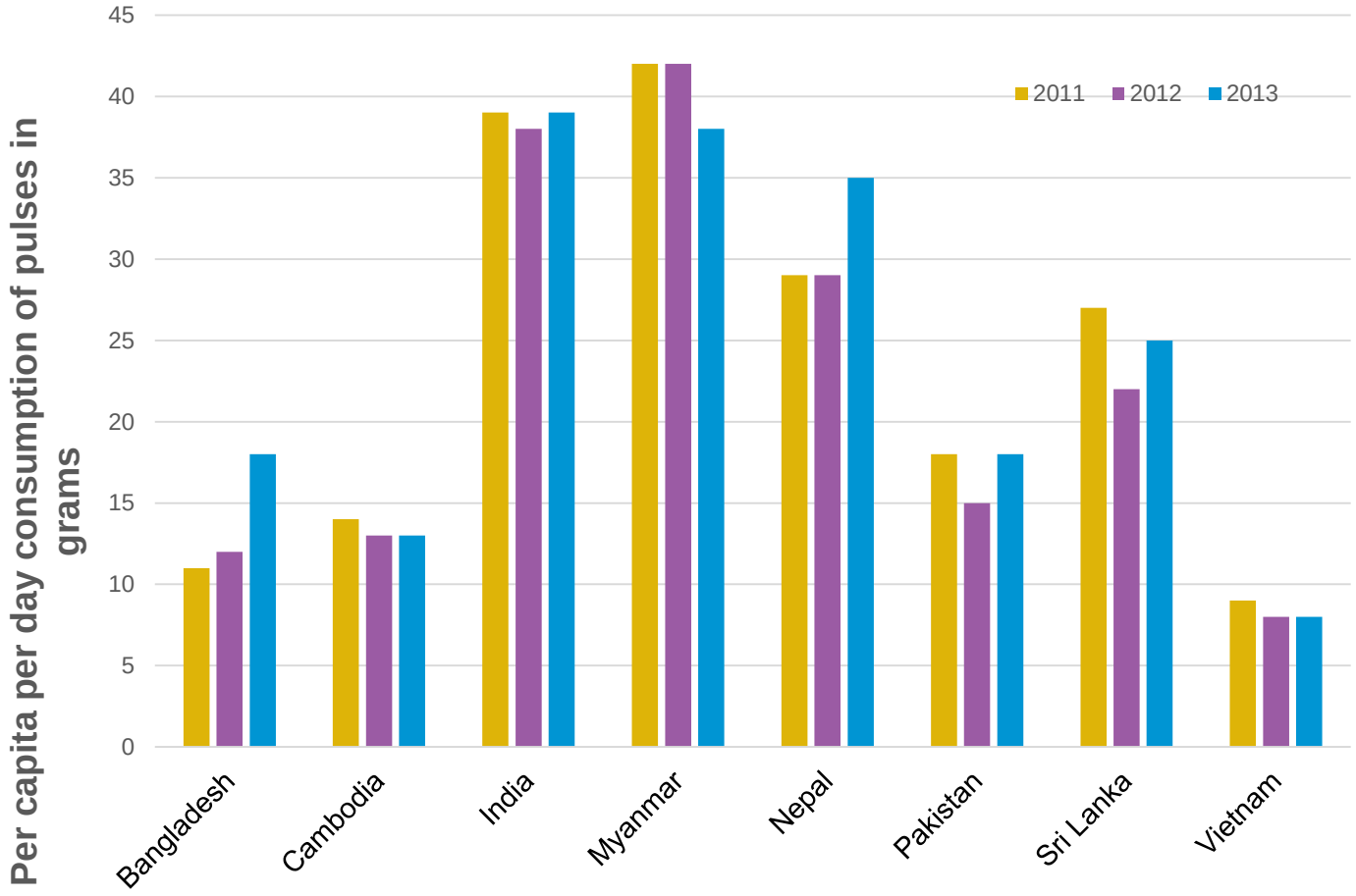
- **Asia accounts for 45% of the global pulses production and remains a major producer, importer and consumer**



Pulses contribute to **Food and Nutritional Security** for a growing global population.

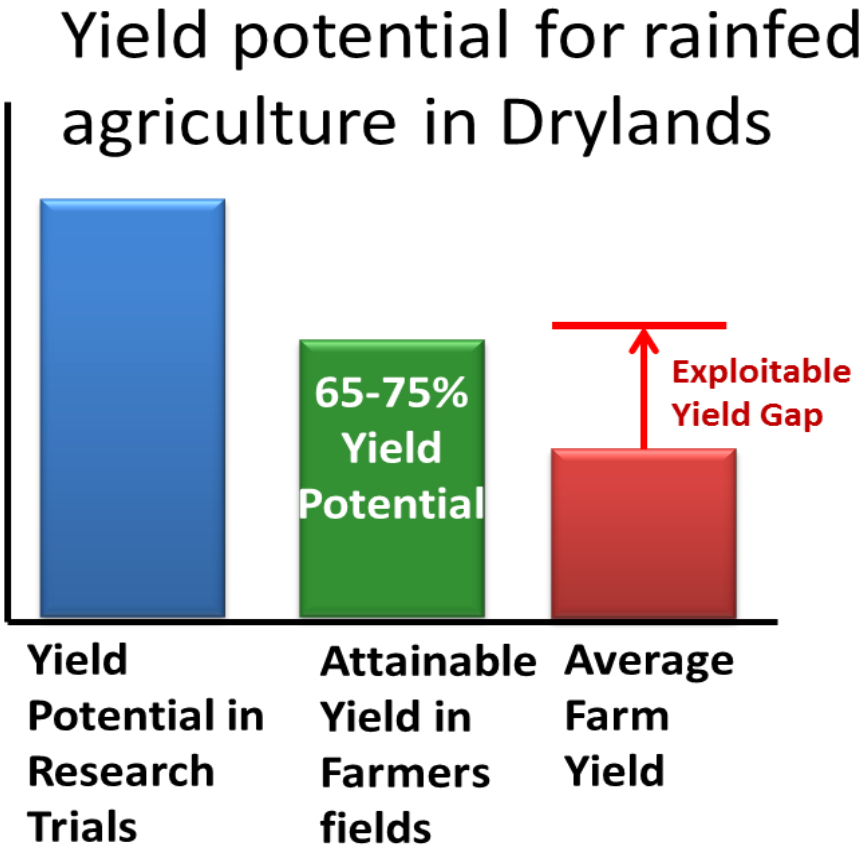
Source: Irvin Widders

Pulse Consumption in Selected Countries



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