

# Golden Rice & biofortification: purpose & progress

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Fundación Cassará

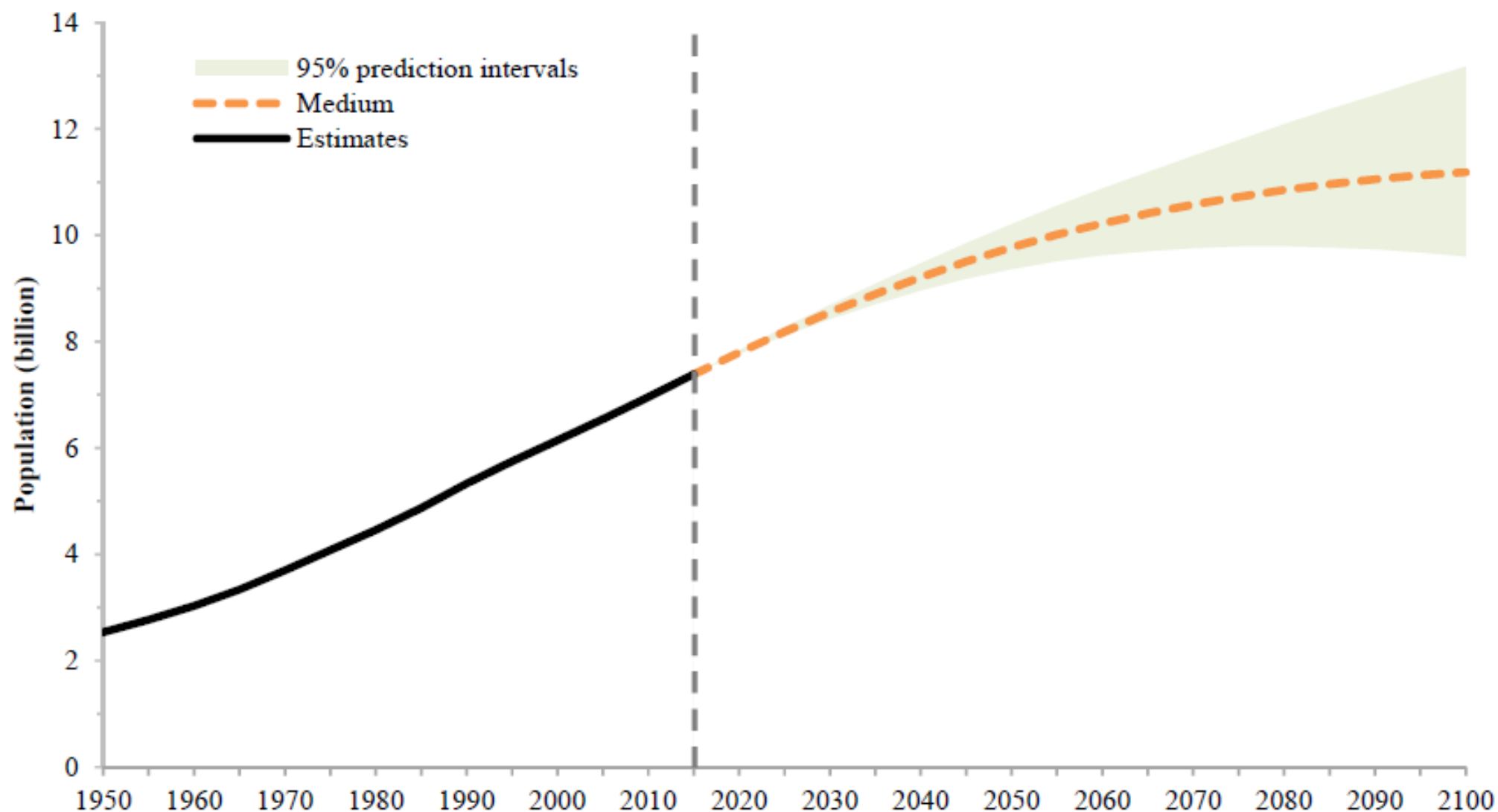
Buenos Aires.

**World Food Day**

16 Octubre 2018

*With thanks to Howdy Bouis, Founding Director Harvest Plus, for some of his slides.*

**Figure 2. Population of the world: estimates, 1950-2015, and medium-variant projection with 95 per cent prediction intervals, 2015-2100**



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017).  
*World Population Prospects: The 2017 Revision*. New York: United Nations.

**Per-Capita Food Production as a Share of Per-Capita Production  
in 1961-2001, Various Years**

<b>Continent</b>	<b>1961-65</b>	<b>1971</b>	<b>1981</b>	<b>1991</b>	<b>2001</b>
<b>Africa</b>	<b>100</b>	<b>103</b>	<b>94</b>	<b>90</b>	<b>90</b>
<b>Asia</b>	<b>100</b>	<b>104</b>	<b>114</b>	<b>134</b>	<b>173</b>
<b>South America</b>	<b>100</b>	<b>100</b>	<b>115</b>	<b>118</b>	<b>144</b>
<b>World</b>	<b>100</b>	<b>107</b>	<b>112</b>	<b>115</b>	<b>126</b>

Southgate & Graham. (2007):  
Growing Green The Challenge of sustainable agricultural development in Sub-Saharan Africa.

# The Green Revolution: Indian Cereals

	Population	Rice Production m t	Wheat Production m t
1960	350m	34.6	10.3
2013/14	1,300,000m	154.0 (exported 10.7, #1)	97.0
1960/2013-4	<b>3.7x</b>	<b>4.6x</b>	<b>9.4x</b>

Data source : Khush GS. IRRI and the green revolution in India April 2015.

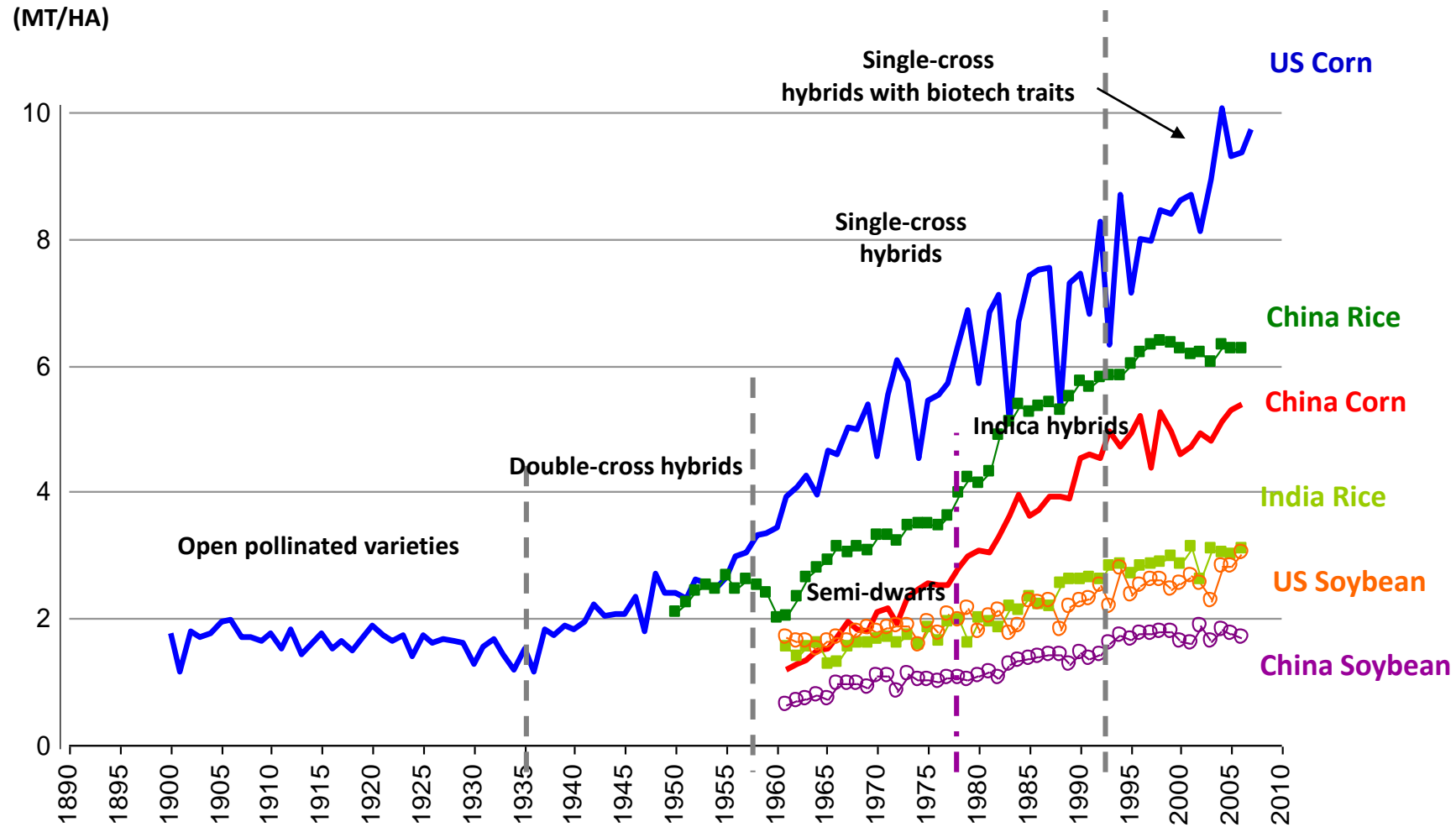


**What remains (in orange) are the naturally highly-fertile soils that feed the world**

**In reality, this amounts to around 13% - 18% of the land surface**



# Science and Innovation Drive Yield Improvements



**FAO 2003; WHO 2006; G20 Agriculture Ministers 2016 ; FAO 2017 & 2018:**

## Dietary Deficiencies: 2003 to 2018

*800 million lack energy = chronically hungry*

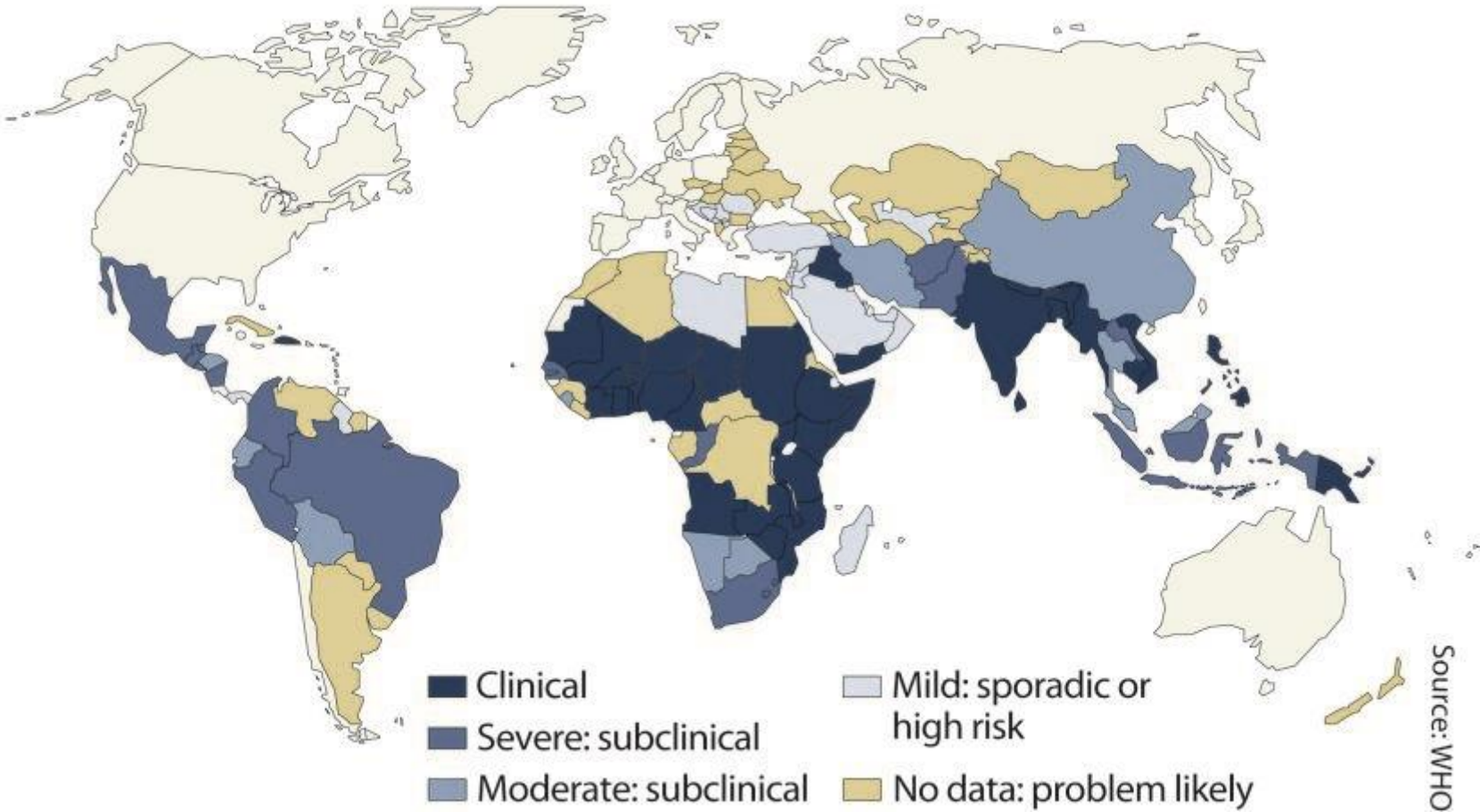
*2 billion lack micronutrients = hidden hunger*

# Human Nutrition

- Food must provide a source of macronutrients: carbohydrates, protein and fats.
- Also extremely important for human health are micronutrients: minerals (eg iron and zinc) and vitamins (eg Vitamins A, C, D and the vitamin B 'complex').



Public health importance of vitamin A deficiency, by country



Global mortality figures (millions)	2010	2014	2016/2017
Vitamin A deficiency	1.9-2.8	1.4-2.1	1.3-1.9 (2016)
HIV/AIDS	1.8	1.2	0.94 (2017)
TB	1.4	1.1	1.6 (2017)
Malaria	0.7	0.6	0.45 (2016)

Iron, Zinc & Folate deficiencies have similar country distribution.

# Interventions for Micronutrient deficiencies:

- *A varied diet*
- *Supplementation (eg pills)*
- *Fortification (adding micronutrients to staples)*

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*-Biofortification (production of plants accumulating minerals and or vitamins in the edible part)*

Year	A Biofortification Timeline
1991	Ingo Potrykus starts research looking for a yellow rice
1997	European opposition to gmo crops starts
2000	Potrykus & Beyer publish ‘Proof of Concept’ – first [biofortified] crop – [Golden Rice]
2002	“Biofortification” term first published - Ross Welch: “Plant Breeding: A New Tool for Fighting Micronutrient Malnutrition". Symp. Ed. H Bouis
2003	HarvestPlus project starts by 2 CGIAR centres : IFPRI & CIAT. Howarth ‘Howdy’ Bouis is Director
2004	Welch & Graham: defined “‘biofortification’ is a word coined to refer to increasing the bioavailable micronutrient content of food crops through genetic selection via plant breeding“ Journal of Experimental Botany, Vol. 55, No. 396, pp. 353-364, February 2004
2005	Improved Golden Rice published: Paine et al 2005.
2016	World Food Prize for Biofortification to Bouis for Harvest Plus; Andrade, Mwanga, Low for Orange Sweet Potato
2017	World Bank recommends the use of biofortified cereals, including Golden Rice as an example, as the norm rather than the exception in addressing malnutrition
2018	Golden Rice achieves registrations in Australia, Canada, New Zealand & USA (defensive move against importation)

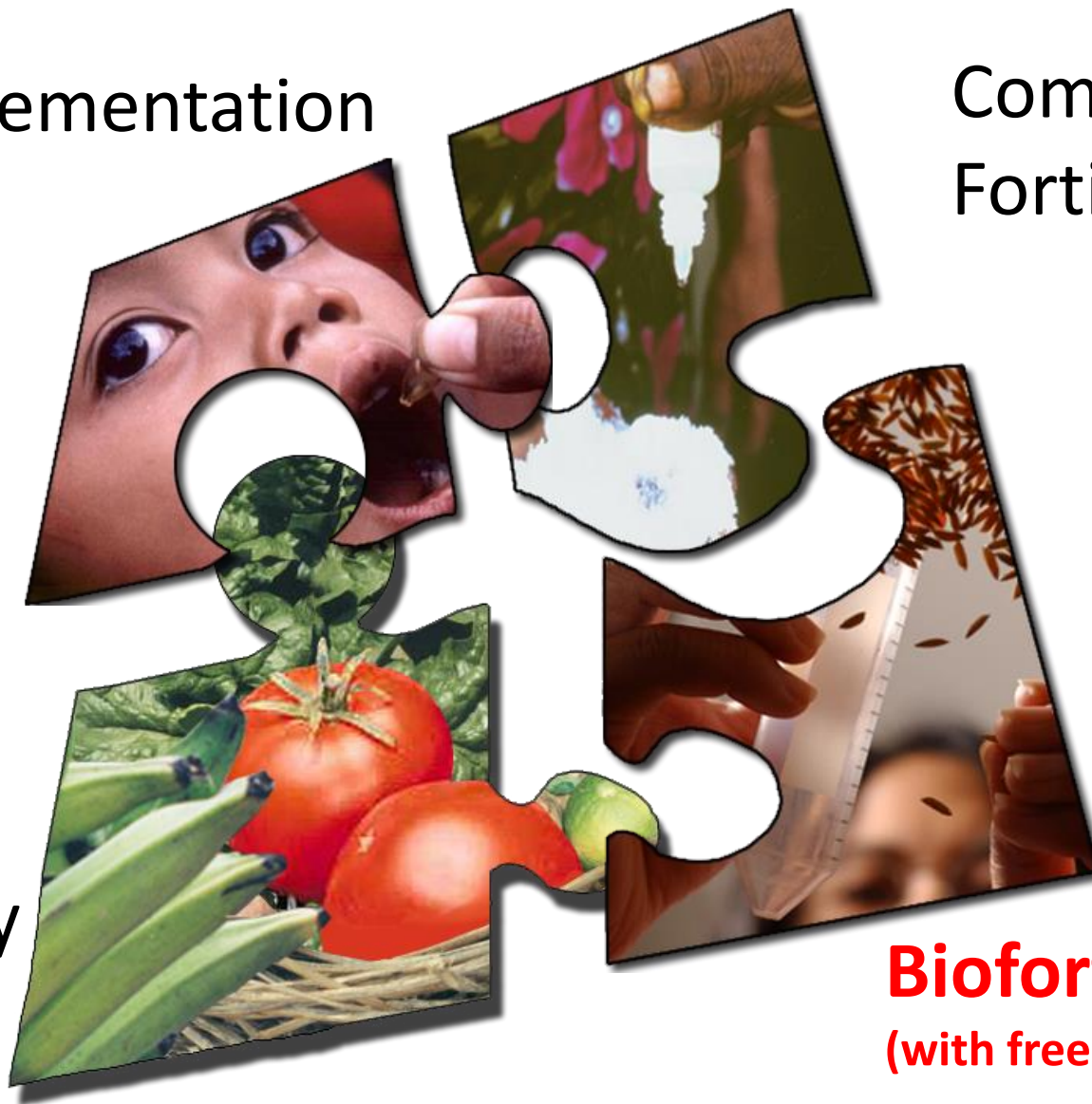


# Biofortification - A Piece of the Puzzle

Supplementation

Commercial  
Fortification

Dietary  
Diversity



**Biofortification**  
(with free micronutrients)





HarvestPlus  
2003 -

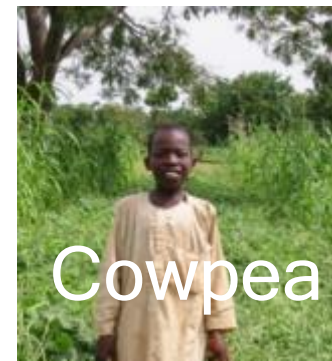
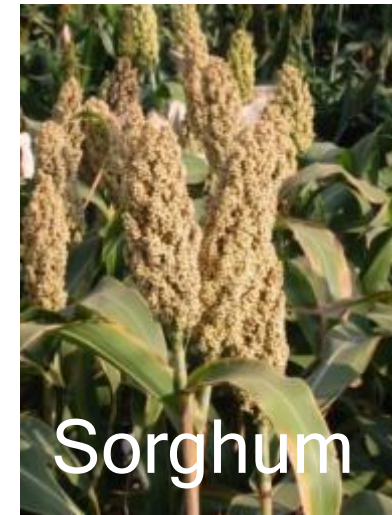


**Cost-effective: central one time  
investment in Plant Breeding**



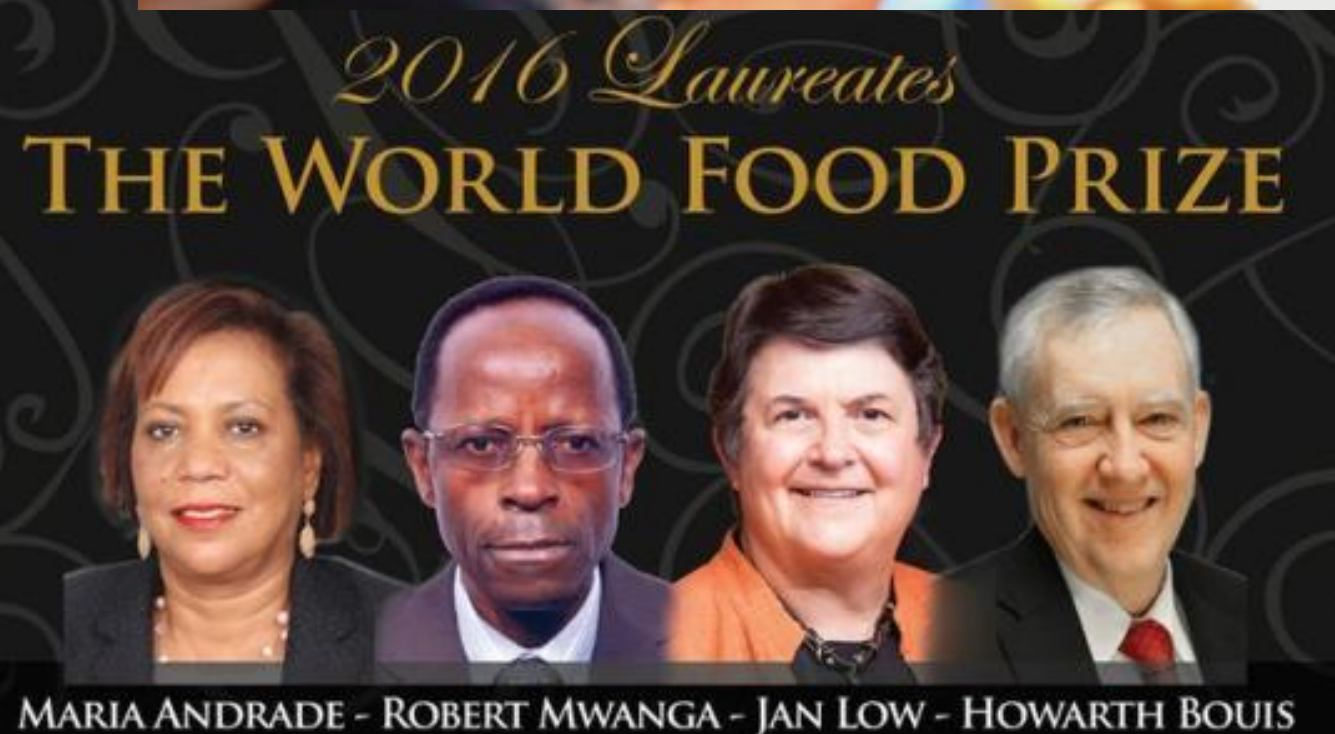
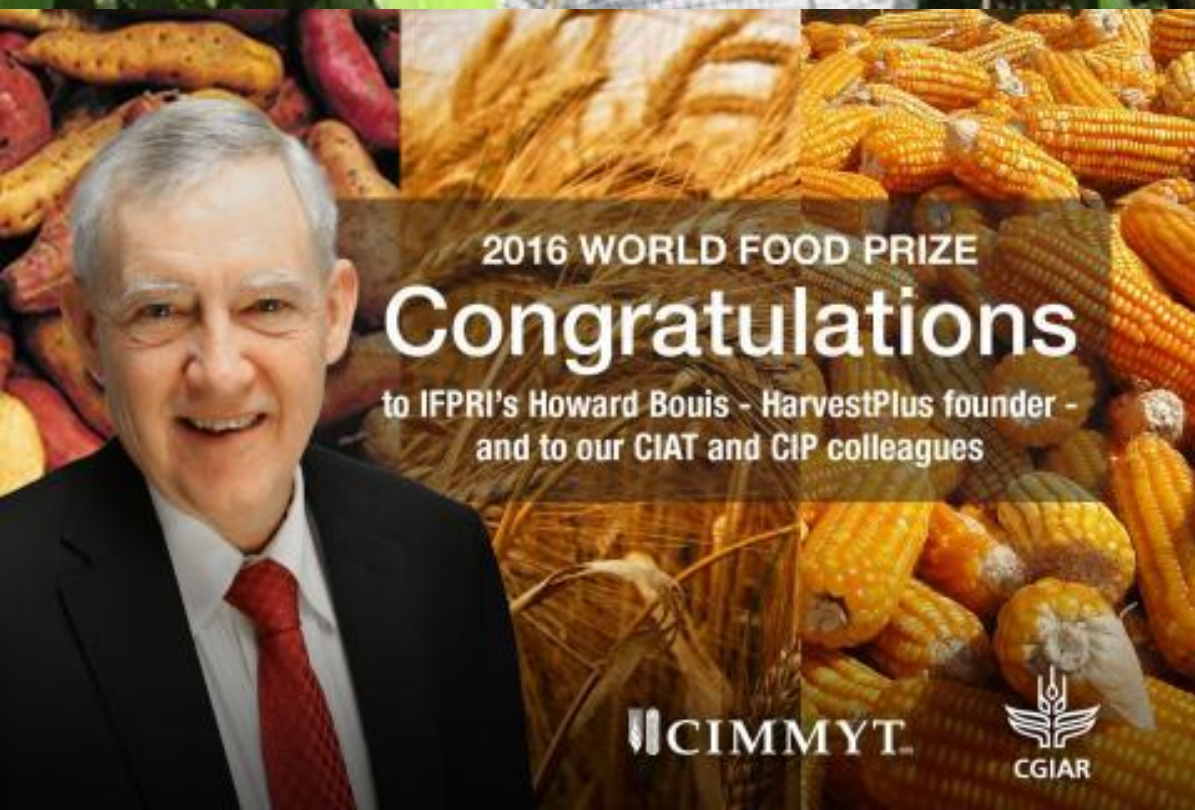
Biofortified crops released in **30 countries**

In-testing in another **25 countries**





26<sup>TH</sup> June 2016





**“Pathways to influence diet quality :**

- **Own production and trade** are two ways to increase **diversity of the food supply**. .....
- **Ensuring that biofortified cereals are the norm, ... ,rather than the exception**: ..... Some biofortified crops use traditional plant breeding techniques .....Others use transgenic modification techniques such as Golden Rice.....
- A review of food-based approaches to reduce iron and Vitamin A deficiency found that **only those food-based Interventions with education, social, or mass media demonstrated impact on nutritional outcomes.**”



# HarvestPlus Delivery Goals

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## **Short-Term Goal By 2020**

- 100 million people in farm households will be growing and consuming biofortified nutritious food crops

## **Globally By 2030**

- One billion people will be benefitting from biofortified nutritious foods.

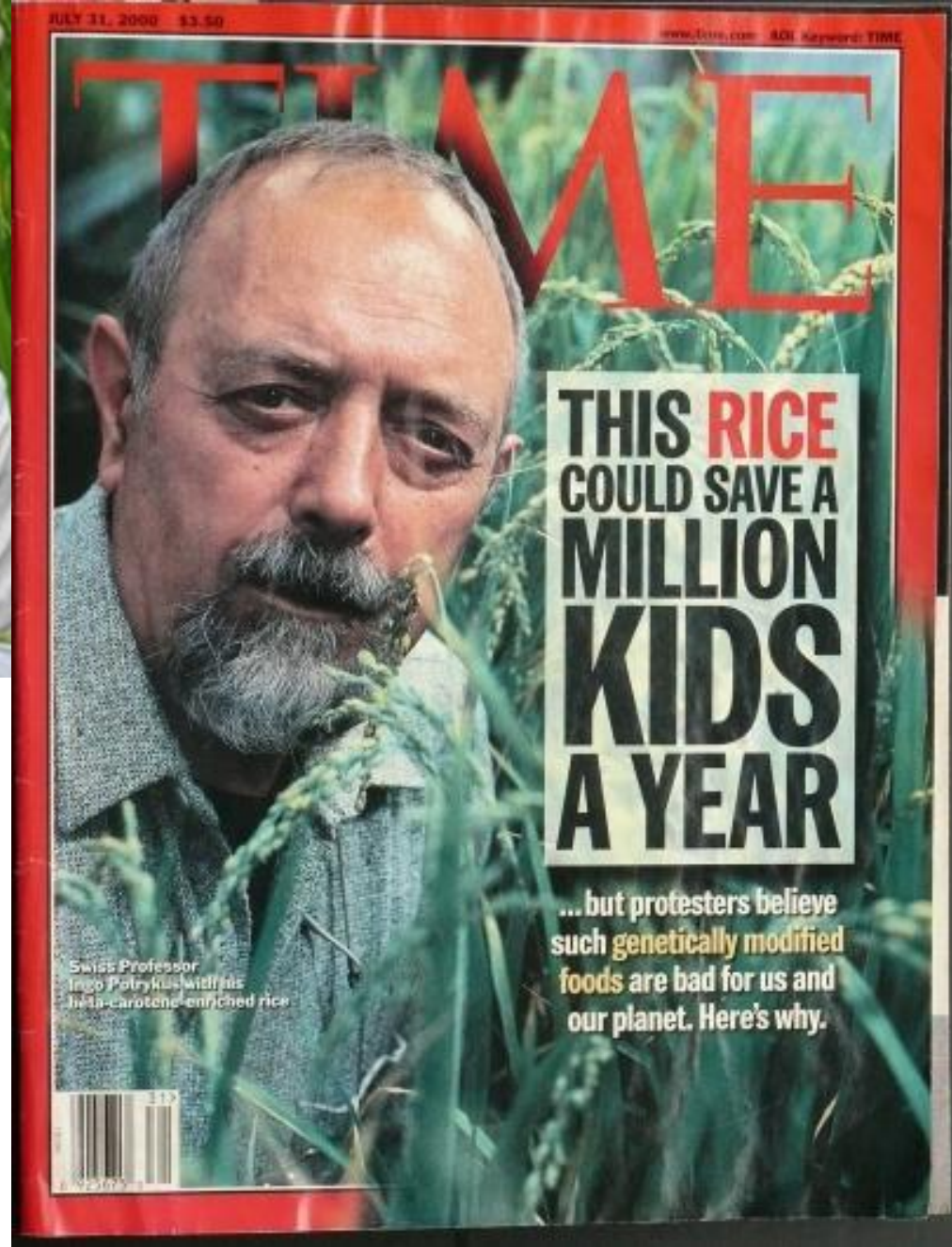
# Rice feeds 3,000,000,000 people – half the world – every day!

Average Total Consumption (Million Calories Per Day) from 2002-04						
Crop	Africa	Latin America	South Asia	Central Asia	Southeast Asia	TOTAL
Rice	125,124	75,238	1,130,648	14,880	660,979	2,006,869
Wheat	107,419	154,173	987,887	227,197	71,196	1,547,872
Maize	256,286	190,759	67,481	3,100	63,906	581,532
Cassava	174,719	24,214	16,263	0	44,074	259,271
Groundnut	49,335	5,291	6,595	271	166,372	227,864
Millet	82,889	0	81,977	1,799	1,221	167,885
Sorghum	104,694	1,019	59,129	0	0	164,842
Potato	13,464	18,608	46,465	40,903	3,324	122,764
Beans, dry	39,258	42,325	26,384	0	8,278.88	116,246
Barley	14,771	20,659	7,037	53,399	4,326	100,192
Plantain	36,424	29,303	19	0	26,364	92,109
Banana	6,751	27,478	11,345	902	11,336	57,811
Yam	42,787	99	0	0	80	42,966
Sweetpotato	23,789	2,155	3,008	0	7,526	36,478
Lentils	603	807	11,589	0	0	12,999

Table data courtesy: Harvest Plus



- As a source of vitamin A Golden Rice can be as effective as milk, eggs or butter.
- Only 40 grams a day is expected to prevent death and blindness, with no possibility of overdosing.



Time : US Edition : July 31<sup>st</sup> 2000



### 2018:

- Independent Regulators - Australia, Canada, New Zealand & USA - have confirmed Golden Rice is safe for consumption.
- Other national regulatory decisions are awaited.



# Golden Rice: a long-running story at the watershed of the GM debate



Global Greenpeace 2001



China 2012

~18 years political controversy



Philippines 2013

## Converts



Patrick Moore  
Ex-President of  
Greenpeace



Stephen Tindale  
Former UK Executive  
Director of Greenpeace



Mark Lynas  
British author,  
journalist and  
environmental activist

### Nobel Laureates letter:

Are you aware of this very important initiative?

<http://supportprecisionagriculture.org/>

Please read and sign on at

[http://supportprecisionagriculture.org/join-us\\_rjr.html](http://supportprecisionagriculture.org/join-us_rjr.html)



**News from Ghana:** The former leader of the Peasant Farmers' Association, Ghana's primary anti-GMO farmers group, has switched sides to adopt a pro-GMO position.

**Mohammed Adams Nasiru** attributed his shift to receiving accurate information on agricultural biotechnology from the scientific community.



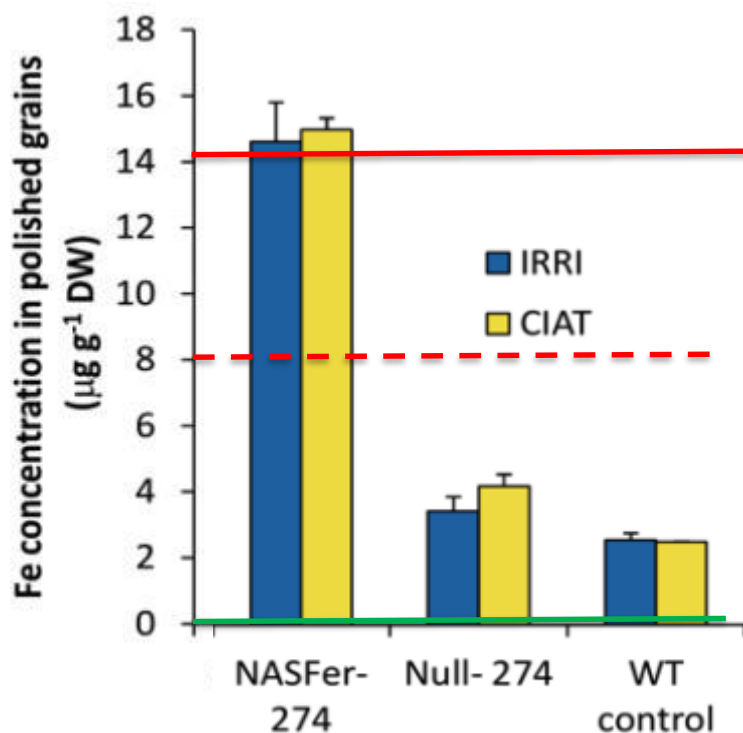
# TRANSGENIC Fe- AND Zn-DENSE RICE

**Proof of concept achieved:**  
Trijatmiko et al., 2016

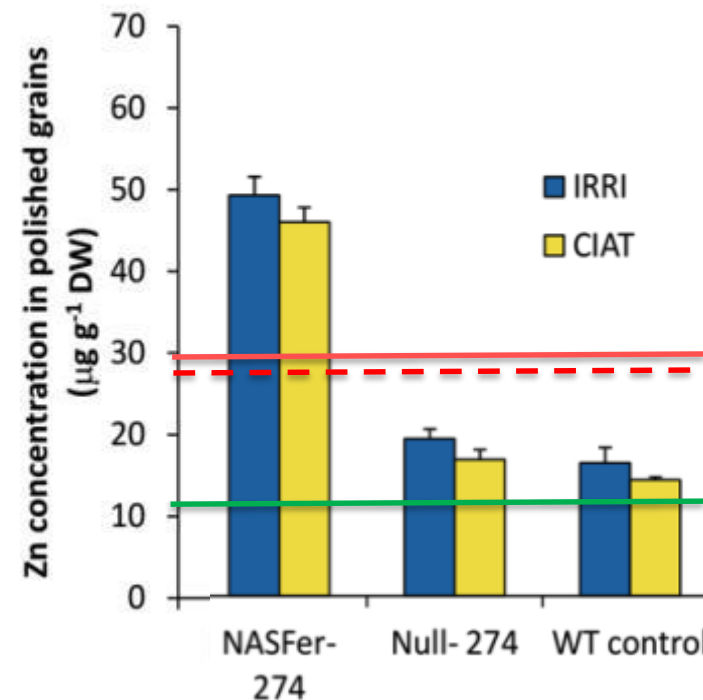
[www.nature.com/scientificreports](http://www.nature.com/scientificreports)



Fe



Zn



- Target density to achieve significant public health impact
- - - Maximum achievable with conventional breeding



## Value for Money | Estimated benefit of every dollar invested in better nutrition



Discount rate = 3%  
Final working age = 50



Source: Copenhagen Consensus 2015

The Wall Street Journal





Photo: Neil Palmer (CIAT)

# What is the Way Forward?





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



Photo: Neil Palmer (CIAT)

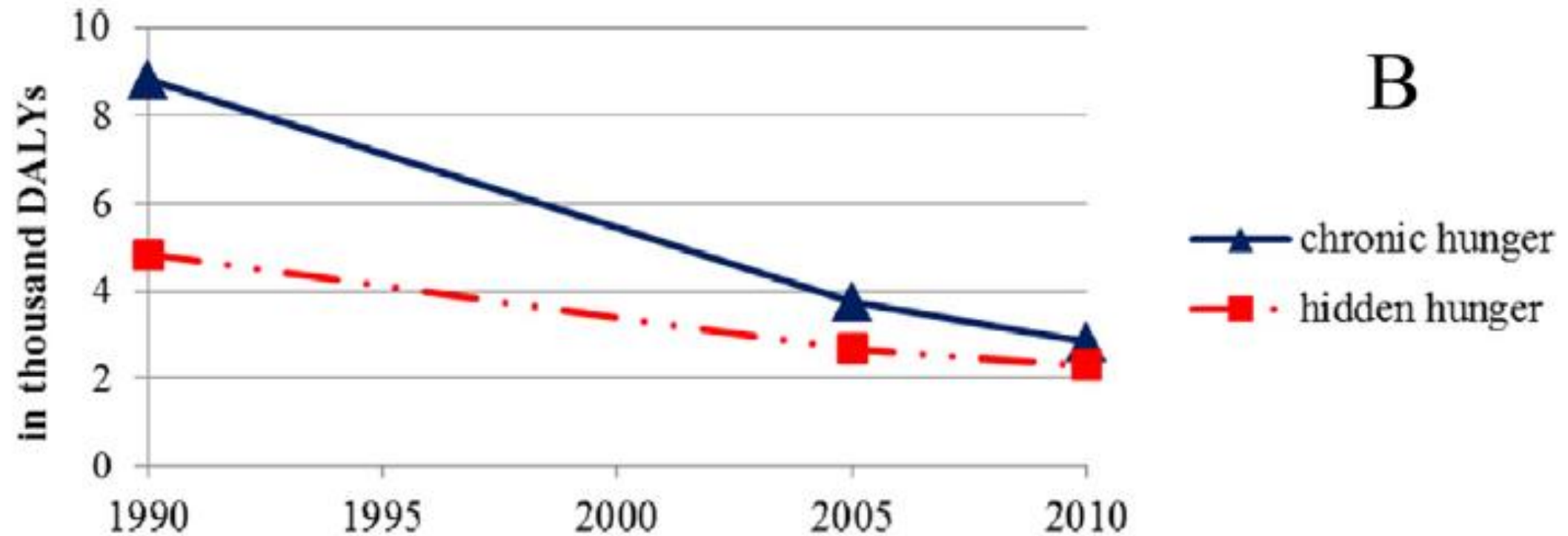
## What is the Way Forward? Mainstreaming

# Biofortification & some UN Sustainable Development Goals 2015 – 2030

Goal #	Goal	Potential Impact of Biofortification
1	<b>No Poverty</b>	Reduce effects of poverty by providing micronutrients in cheap staple grains
2	<b>Zero Hunger</b>	Whole populations will be micronutrient sufficient
3	<b>Good Health &amp; Wellbeing</b>	Pro-Vitamin A, Iron, Zinc, Folate sufficiency reduces mortality & morbidity
4	<b>Quality Education</b>	Pupils can learn when they are adequately fed: Iron especially important
5	<b>Gender Equality</b>	Biofortified staple grains will be equally available to whole population
8	<b>Decent Work &amp; Economic Growth</b>	Increased labour productivity, arising from biofortified rice alone, will add ~US\$20 billion to Asian GDP*

\*Anderson K, Jackson L, Nielsen C. Genetically modified rice adoption: implications for welfare and poverty alleviation. J Econ Integr. 2005;20(4):771–88.





B DALYs per 1000 capita lost due to chronic hunger and hidden hunger between 1990 and 2010.

Part of Figure 2 from: The global burden of chronic and hidden hunger: Trends and determinants. Gödecke, Stein, Qaim: Global Food Security 17 (2018) 21–29

**“In the future the hidden hunger burden will be larger, unless targeted efforts to reduce micronutrient malnutrition are implemented at larger scale.”** Matin Qaim: April 2018