

# ***Golden Rice :*** **A biofortification catalyst**

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**ABIC 2006**  
**Melbourne, 8 August 2006**

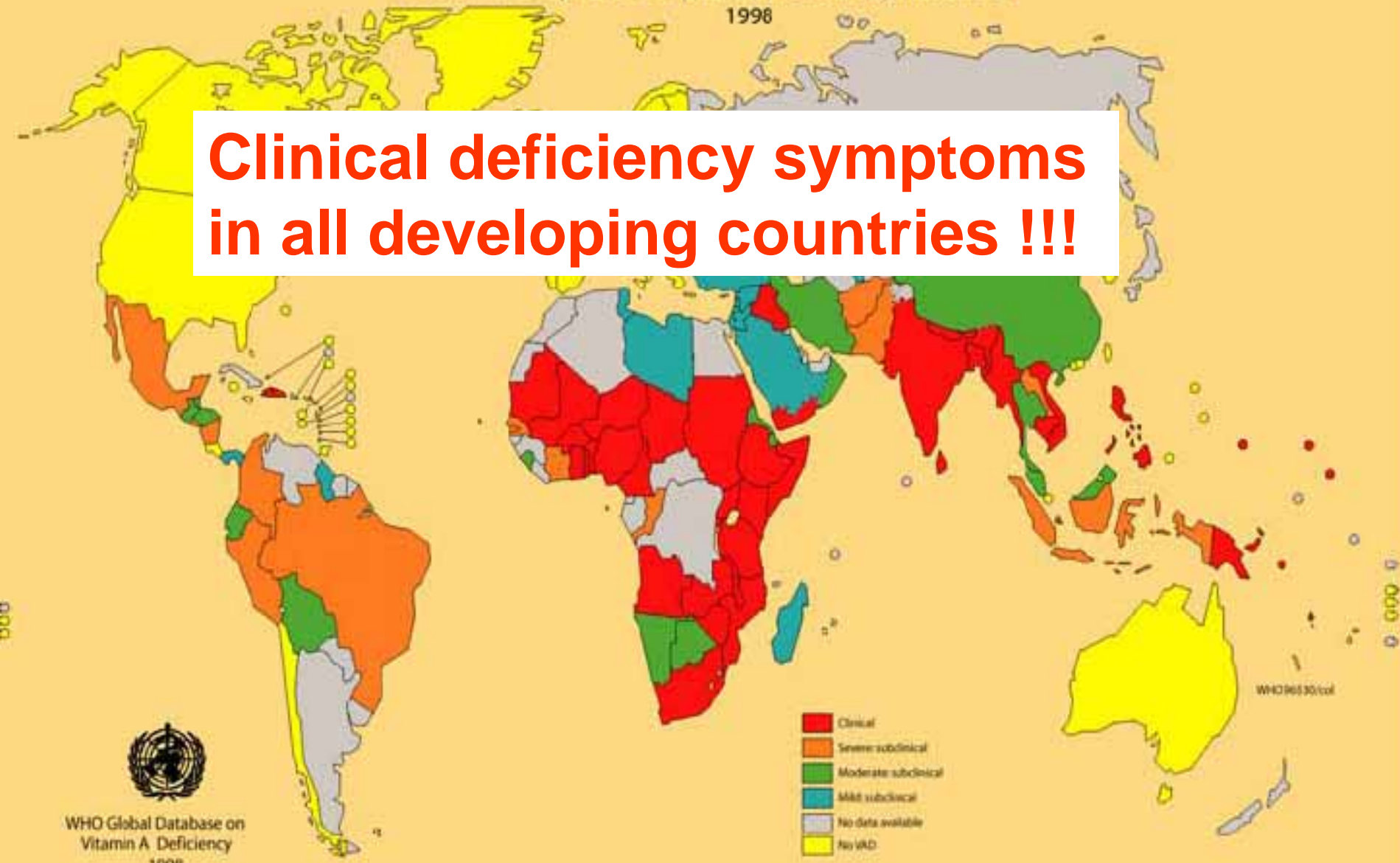
# One of eight UN MDGs is to reduce under-five child mortality by two-thirds between 1990 and 2015

- Global child deaths estimated at 10.8 million for the year 2000.
- 90% of child deaths concentrated in 42 countries.
- Breastfeeding, complementary feeding, vitamin A, and zinc supplementation could save 2.4 million children each year (25% of total deaths).
- Vitamin A alone could save 225,000 children (proportion of all deaths 2%).
- Zinc supplementation could save 459,000 (5%).

Vitamin A deficiency (VAD).  
Prevalence by level of public health significance

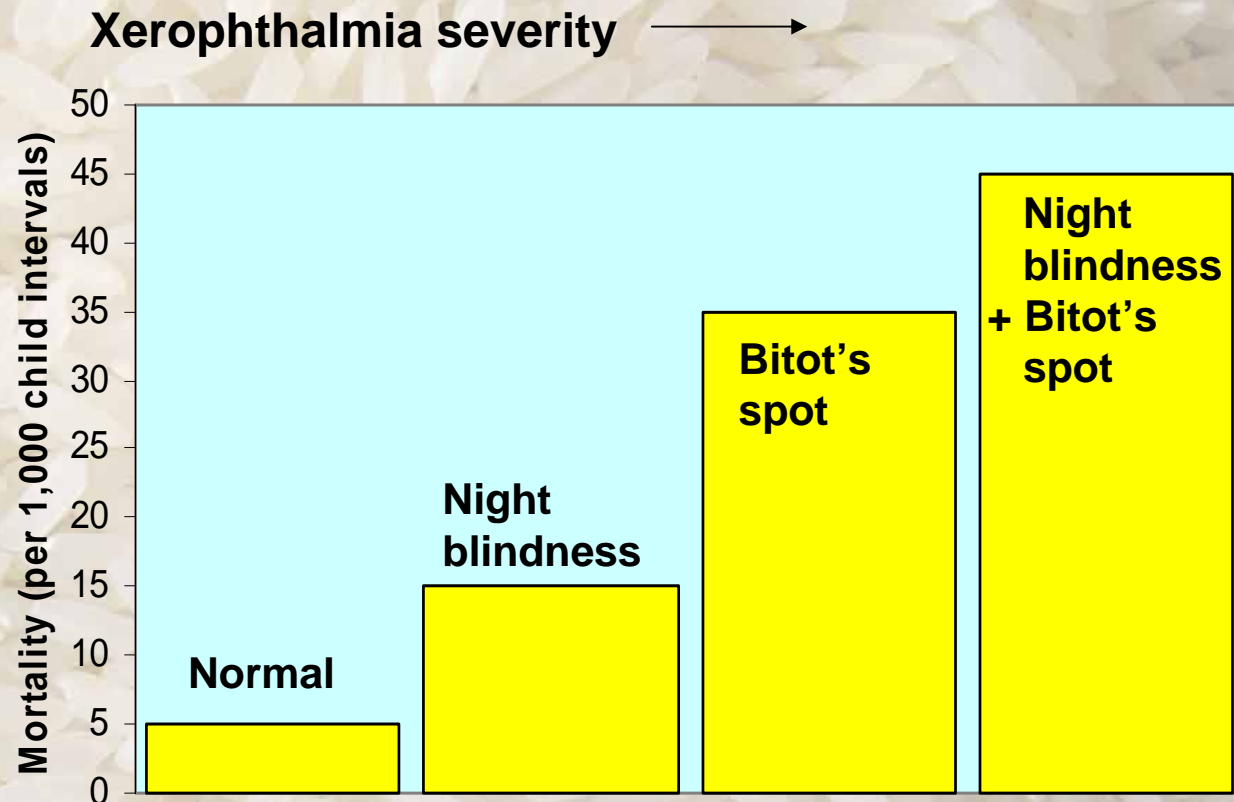
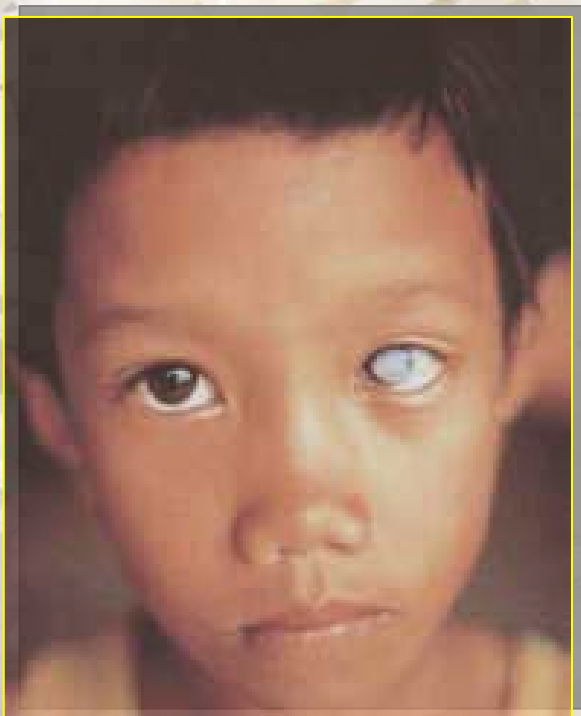
1998

**Clinical deficiency symptoms  
in all developing countries !!!**



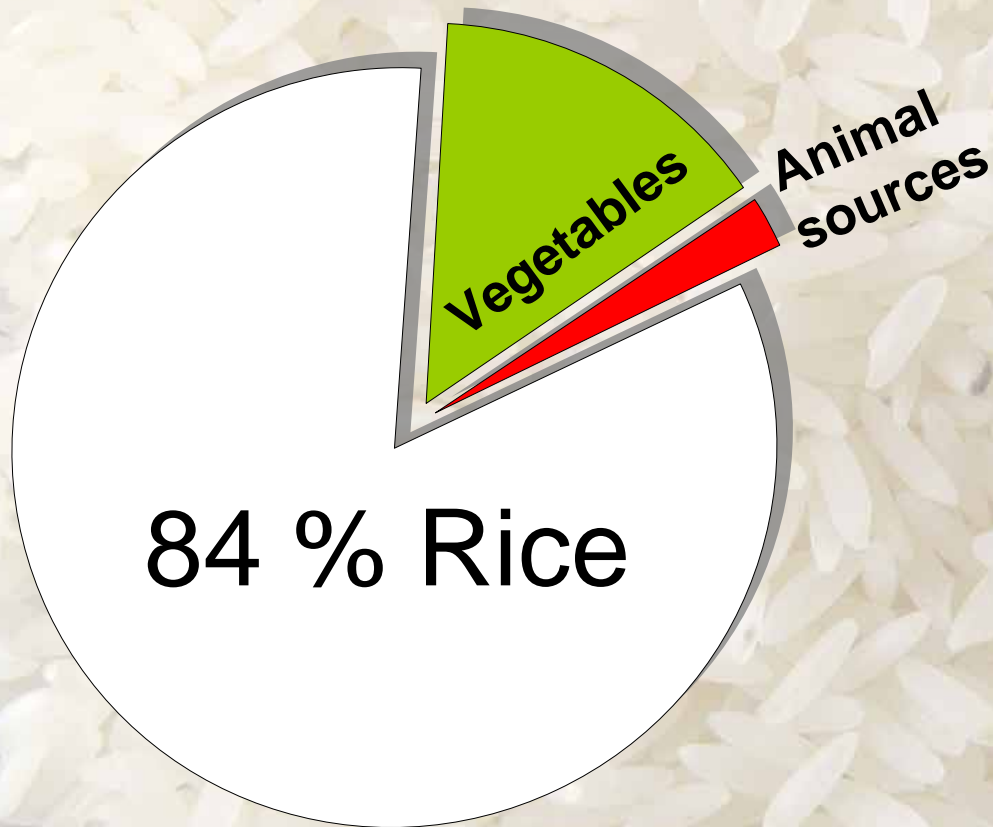
The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines represent approximate border lines for which there may not yet be full agreement.

# VAD and children mortality: Children's eyes tell a sad story



Symptoms and severity of these eye diseases give us direct information about the vitamin A status of the affected children. Severe cases correlate with **a 900 percent mortality increase!**

# Daily nutrient intake in rural Bangladesh



Onesided diets are typical for SE Asia. They are dictated by tradition but also by poverty. Rice is cheap, and most importantly, it is amenable to long-term storage, as opposed to fruits and vegetables.

# Strategies and their drawbacks

A young boy with dark hair and a serious expression is walking through a field of tall, golden-brown rice stalks. He is carrying two large, heavy bundles of harvested rice on his shoulders, one on each side. He is wearing a light-colored, sleeveless shirt and orange shorts with a blue number '7' on the left leg. He has several beaded bracelets on his left wrist. The background is a lush green field with more rice plants.

## Interventions

- Education
- Industrial fortification (e.g. butter, oil, flour)
- Supplementation (capsules)

## Limitations

- Distribution (10-thousands of helpers needed)
- Trained medical personnel lacking
- Centralised food processing required
- Limited applicability (does not reach remote areas)
- Economically unsustainable

(> US\$2 Mio per country and year)

# THE KATHMANDU POST

Printed simultaneously in Kathmandu, Biratnagar and Bharatpur

## LEISURE & ENT

Madonna surprises NY college students Pg 7

## BUSINESS

NOC's monthly loss touches Rs 550m Pg 5

## INTERNATIONAL

Saddam pleads not guilty Pg 3

## SPORTS

Henry becomes top scorer for Arsenal Pg 8



## Vitamin A administering to children starts

By A Staff Reporter

KATHMANDU, Oct. 18: Children under five will be given Vitamin A capsules and medicines for worm from Wednesday, National Vitamin A programme press release said.

Children from six months to five years will be given vitamin A capsules while the children from one to five years will be provided with medicines for worms.

The programme will be conducted

throughout the country from early morning tomorrow and local women volunteers will be mobilised for the purpose.

The programme will be continued on Thursday for those who miss to take the medicines, the press release said.

A study report has shown that 78 per cent of children under five are suffered from anemia caused by worms. It is estimated that 30,000 children are saved each year since Vitamin A programme was initiated in 2050 B.S.

for dialogue with Maoists to make the ceasefire fruitful," said a press statement issued by alliance leaders after the meeting.

Party leaders said they would not make public the names of the

on Wednesday, invited all political organizations and parties to register their names with the EC from Thursday and get recognition for the forthcoming municipal elections purposed for

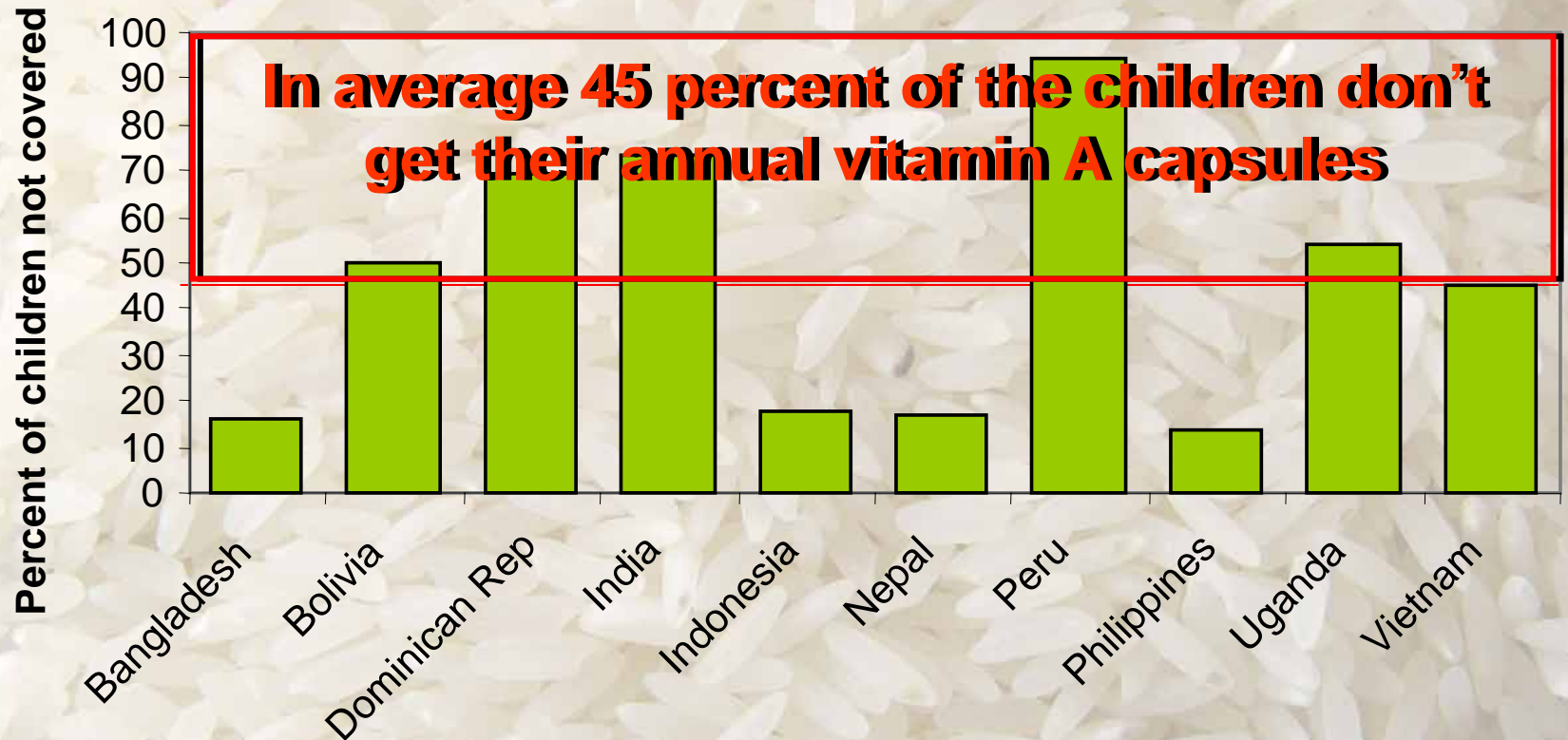
interested in taking part in the municipal elections would have to register their names within 30 days effective from Thursday as per clause 1 of Article 113 of the Constitution.

December 15 to garner support against the pre-February 8 polls. The party termed the King's direct election commission to be a parliamentary polls by April "meaningless talk."

Volunteer administers Vitamin A drops to a child at Dhukur Pokhari, Nau Danda VDC, Kaski on Wednesday during the nationwide Vitamin A capsule and deworming tablets distribution.

POST PHOTO/PRAKASH MATHEMA

# Too many children don't receive any supplementation



# Cost efficiency of biofortification

- **One-off investment.**
- **Minimal maintenance costs after initial R&D phase.**
- **Biofortified seeds can be distributed worldwide and introgressed into locally adapted varieties.**
- **Biofortification is compatible with ongoing conventional fortification, supplementation and education programmes.**



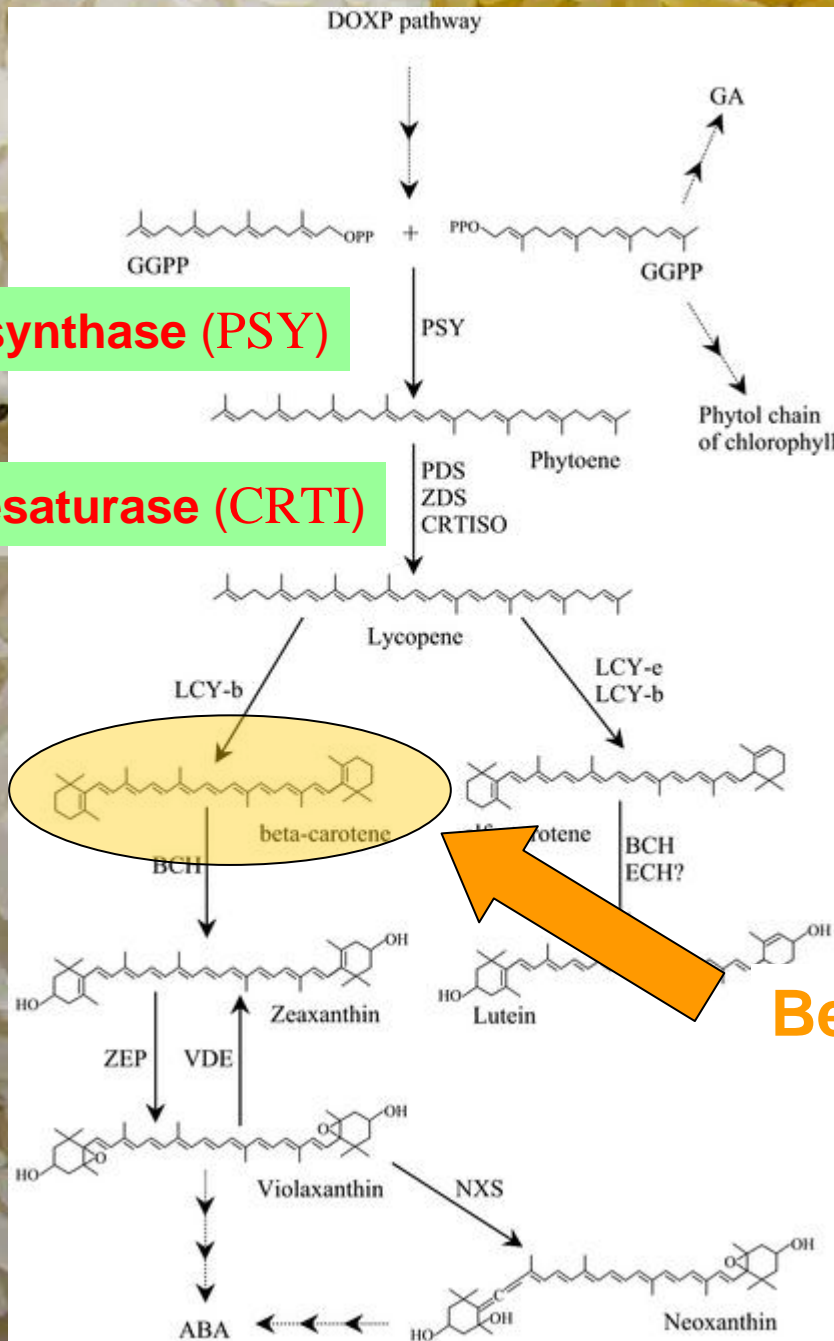
**GR1: *Narcissus***  
**GR2: *Zea mays***

**Phytoene synthase (PSY)**

**Carotene desaturase (CRTI)**

***Erwinia uredovora***

**Filling  
a gap**



Reactivation of a dormant metabolic pathway assisted by two introduced genes.

**Beta-carotene**

**Golden Rice**  
goldenrice.org

While opponents relied on sensationalism without hard data ...



... scientists introduced further improvements!

0  $\mu\text{g/g}$

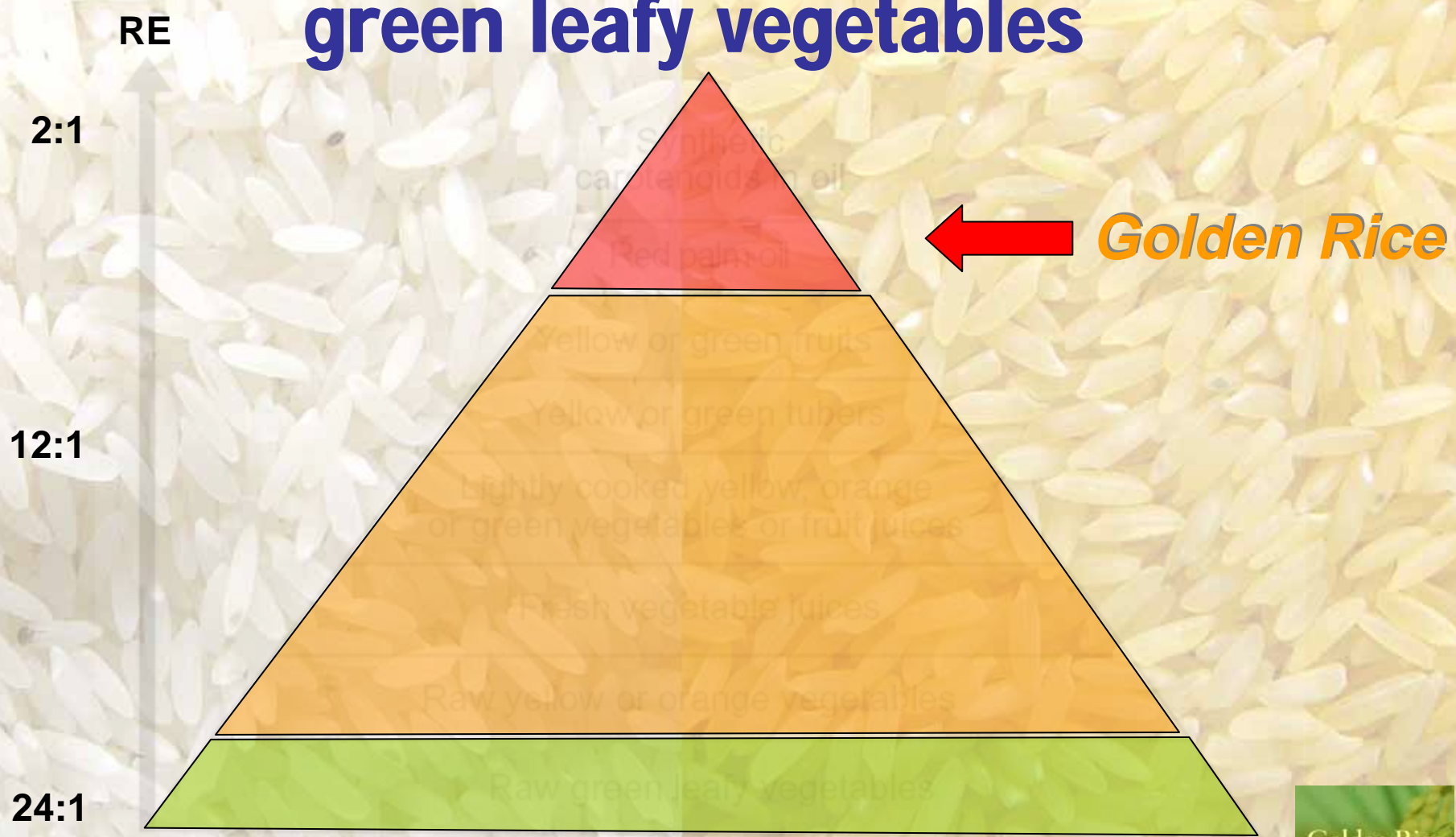
Provitamin A

1.6

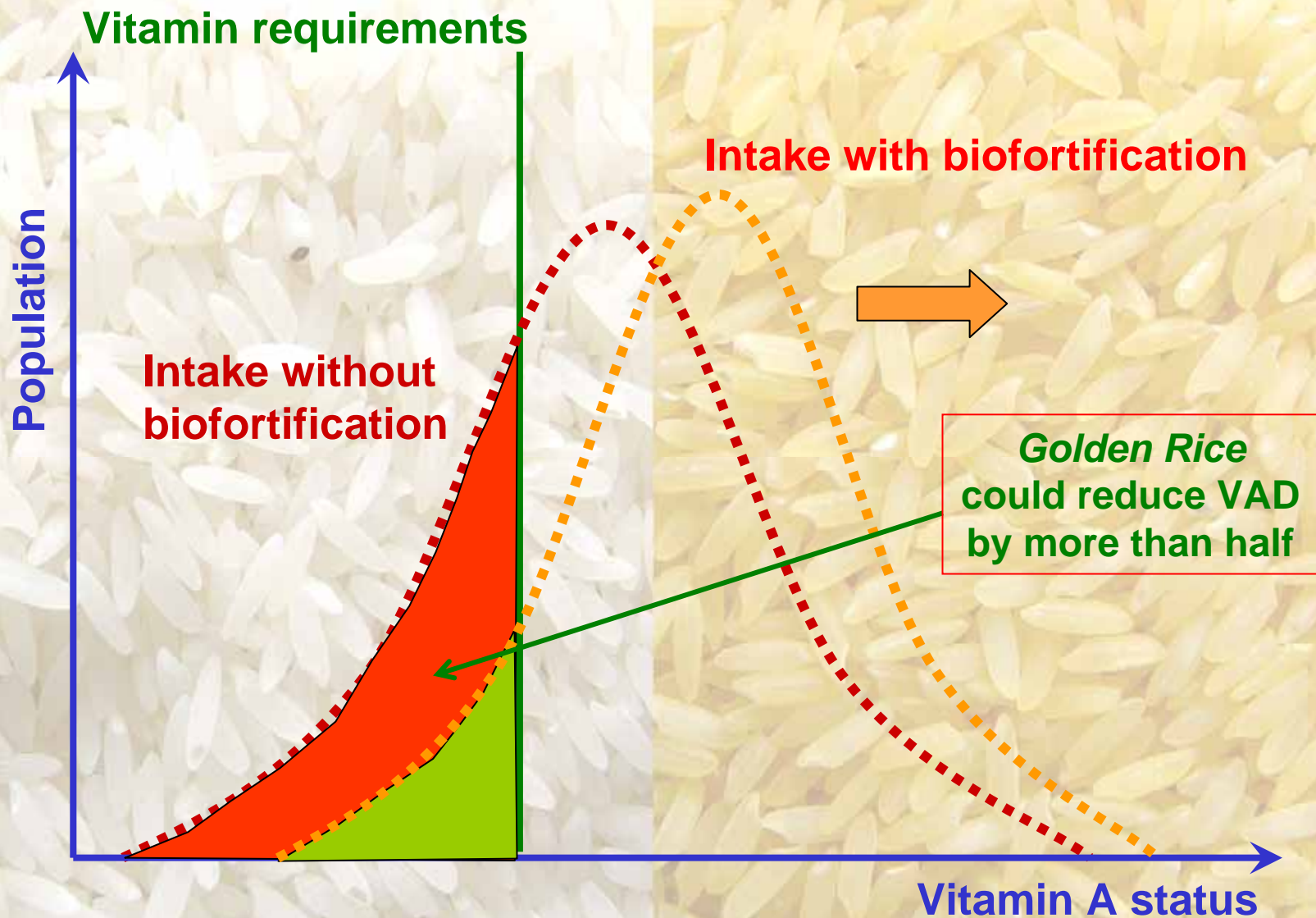
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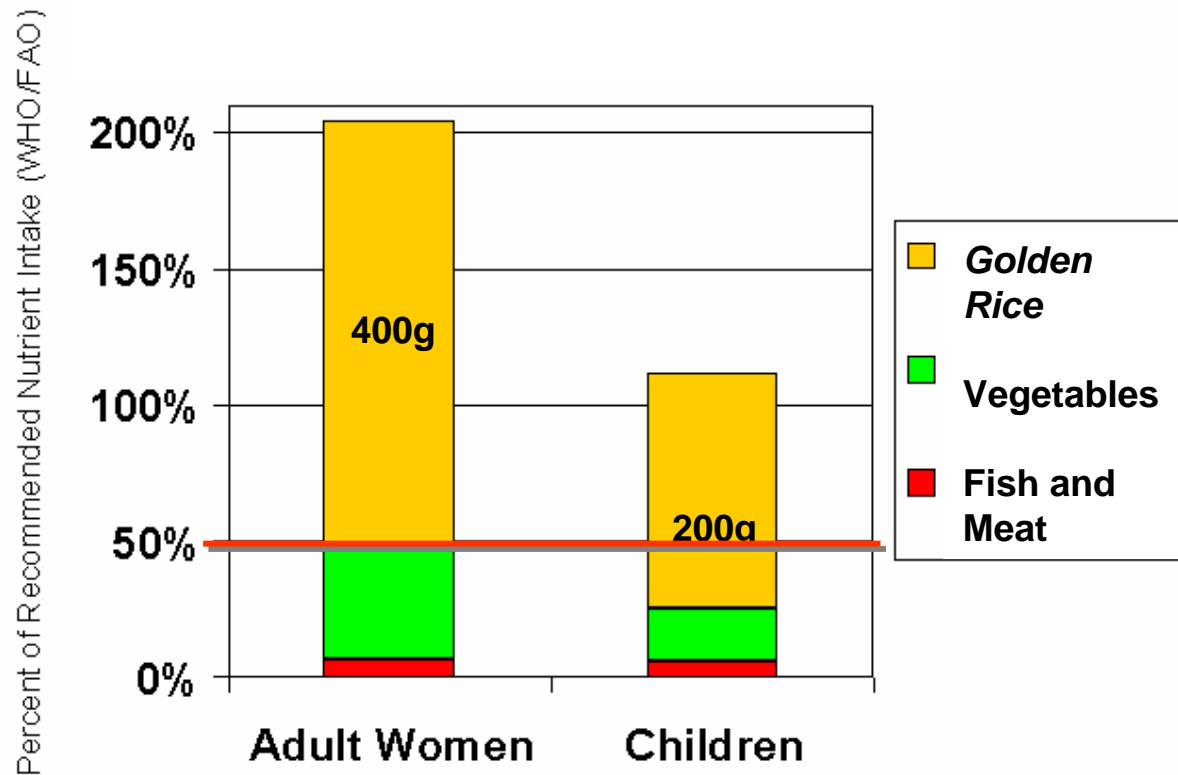
# The body can utilize only 1 in 24 provitamin A molecules from green leafy vegetables



# Improving the population's health status



# Vitamin A uptake from foodstuff in rural Bangladesh with *Golden Rice*



H. Bouis, HarvestPlus

**50 percent RDI is enough to prevent VAD!**  
**People with 40 percent caloric intake from rice would be protected.**

# How long still?

- *Golden Rice* has been around since 1999.
- Because of a wrong interpretation of the so-called precautionary principle, it could take another six years before *Golden Rice* reaches the farmers' fields.
- While millions of children are dying unnecessarily year after year, every imaginable, yet improbable danger is being overrated and the "*benefactory principle*" totally ignored.



# Development of Golden Rice

1992 – Golden Rice POC phase – 1999



- Licence Agreement 2001
- Transfer to indica rice varieties 2002
- Regulatory clean events .....
- GR2 at >35 µg/g carotenoids 2004
- US field trials agronomically OK 2004+5
- Bioinformatic analysis OK 2006
- Bioavailability in humans 2006

- Field trials in Asia 2007
- Regulatory approval 2008 ?
- Varietal registration 2010 ?

# *A Golden Deal*

- The inventors\* have assigned their rights to *Golden Rice* to Syngenta.
- In exchange, Syngenta has provided the inventors access to required technologies and a humanitarian licence that allows them to deliver *Golden Rice* to smallholders in developing countries free of charge.
- The farmers can replant their harvested seeds and trade them locally.

\* Ingo Potrykus (ETH Zürich) and Peter Beyer (Univ of Freiburg)



Discovery and development of micronutrient-rich germplasm

Determine retention, bioavailability, efficacy

Adaptive, participatory breeding and varietal selection

# End user activities

Diagnostic analyses

Develop products and markets

Farmer adoption  
Extension programs      Seed systems

Demand creation

Monitoring and feedback

Increased intake and improved micronutrient status

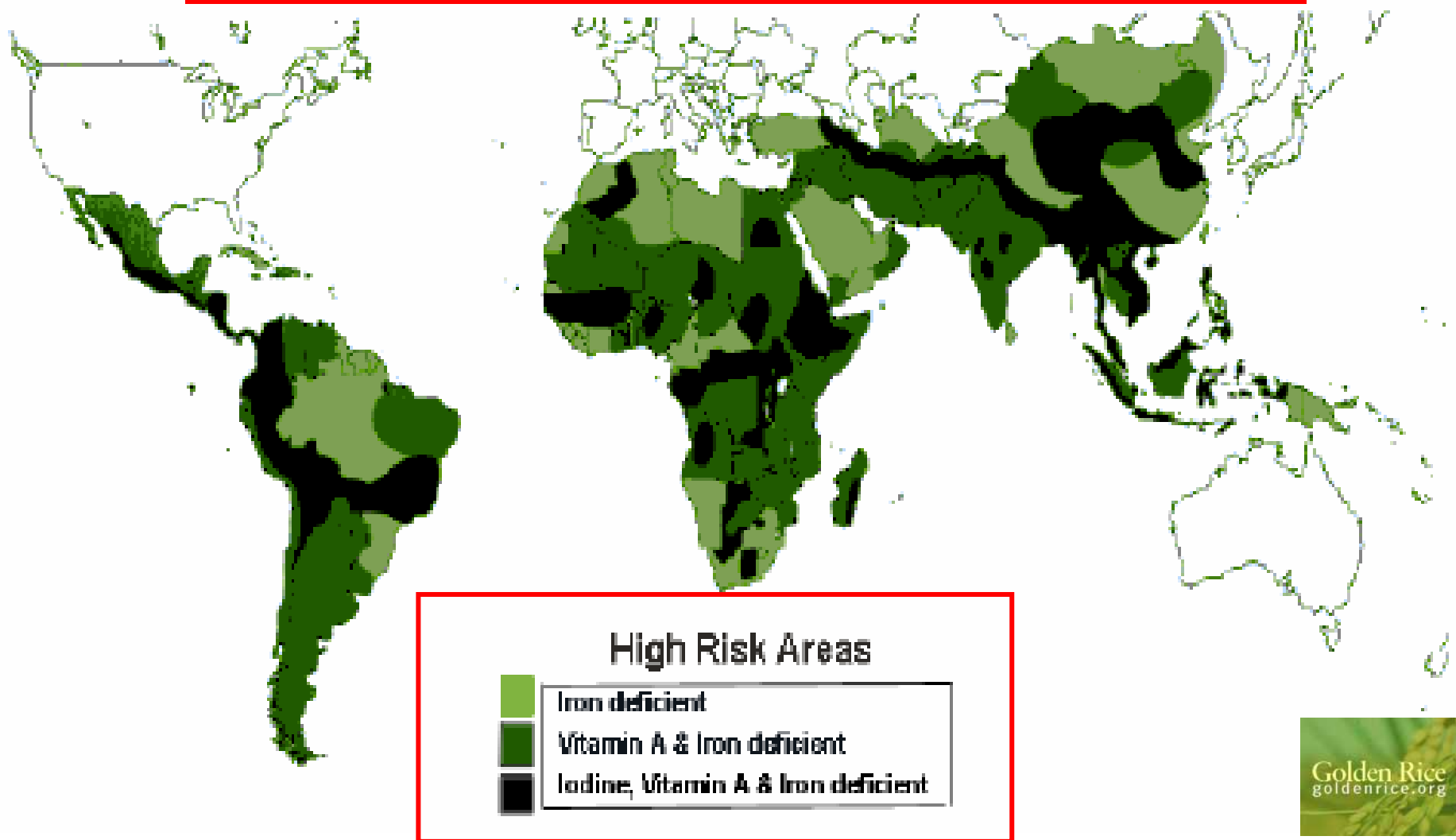


# Sweetpotato South Africa Trial

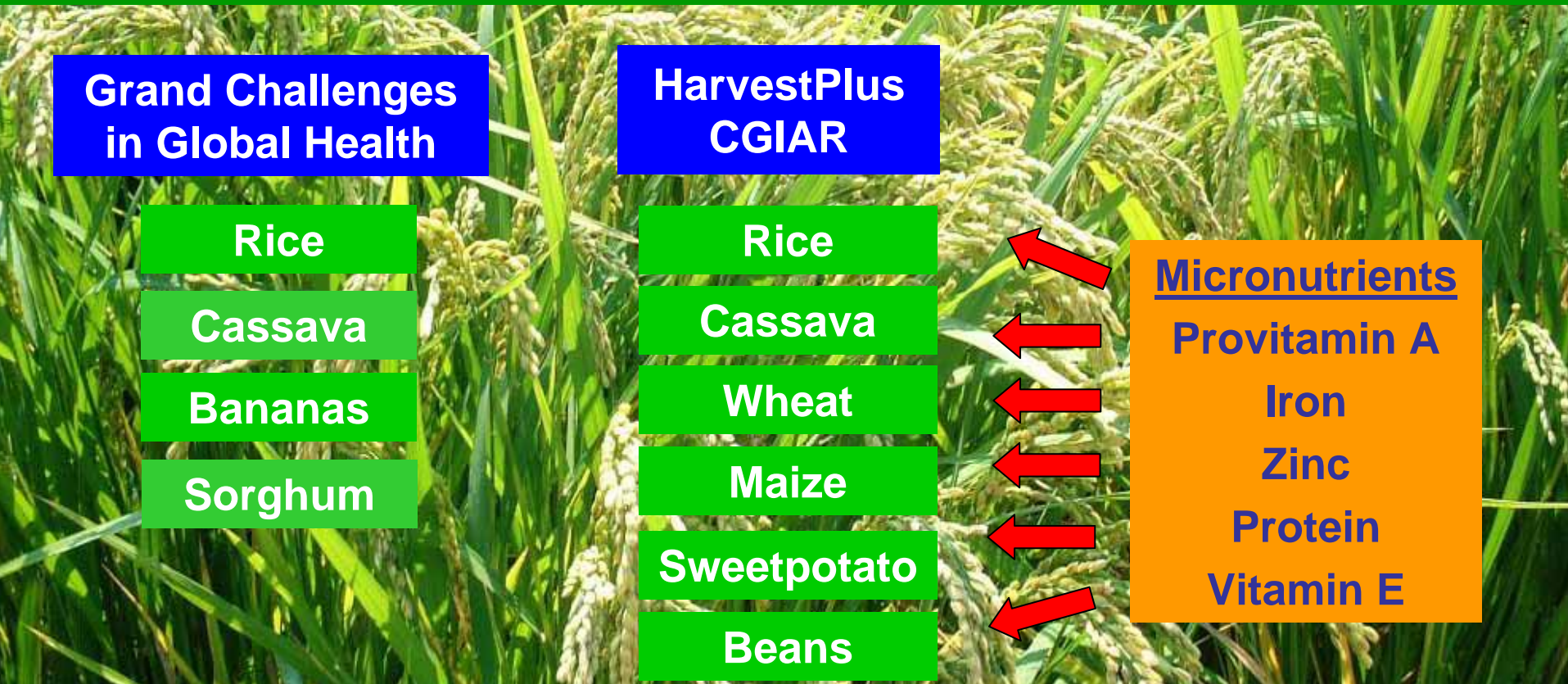
Supervised feeding; 125 g x 5 d/wk for 10.5 wk; 1030  $\mu\text{g}$  RAE OFSP vs 0  $\mu\text{g}$  RAE WFSP; 90% compliance; 250% RDA



# Micronutrient deficiencies, the hidden hunger worldwide



# *Golden Rice* has inspired new approaches to biofortification



International programmes, most notably those supported by the Bill & Melinda Gates Foundation, are working towards the biofortification of the most important basic foodstuffs of developing countries using conventional and modern methods.

The principle of provitamin A production is applicable to other crops, like potato



**Without provitamin A**



**With provitamin A**

# ProVitaMinRice Project Objectives

- To introgress the *GR* trait into locally adapted rice cultivars (IRRI, PhilRice, CLRRRI).
  - To combine *GR* with high iron rice lines.
  - To combine *GR* with high-quality protein rice (CUHK).
  - To engineer *GR* to produce vitamin E (UoF).
  - To generate knowledge on the biochemistry of iron bioavailability (BCM, MSU).
- Expected deliverables: Transgenic rice lines with higher concentrations of combined micronutrients and HQ protein; QTLs for iron bioavailability.

# The breeding component



**Marker-assisted introgression of improved *Golden Rice* into locally adapted rice cultivars with emphasis on high iron/zinc varieties in combination with HQP rice lines.**

**... in conjunction with rice germplasm screening for iron / zinc dense materials.**

**IRRI, CLRRRI, PhilRice**



# High-quality protein

I: Lysine-Rich Protein (LRP) gene from winged bean.

MGVFTYEDETTSPVAPAILY**K**AIV**K**DADNIFP**K**AVDSF**K**SVEIVE  
GNGGPGTI**KK**ISFVEDGES**K**FVLH**K**IESIDEANLGYSYSIVGGAA  
LPDTVE**K**ITFES**K**LSAGPSGGSVG**K**LTV**K**YQT**K**GDAEPNEEL**K**  
VG**KAK**GDALF**K**AVEAYLLAHPEYN **10.8 mol % Lys**



LRP gene



- II. Additional copies of a homologous, lysine-rich glutelin gene.
- III. Enhancement of the synthesis and accumulation of free lysine.

# Integration and extension

Humanitarian Board

*Golden Rice Project*

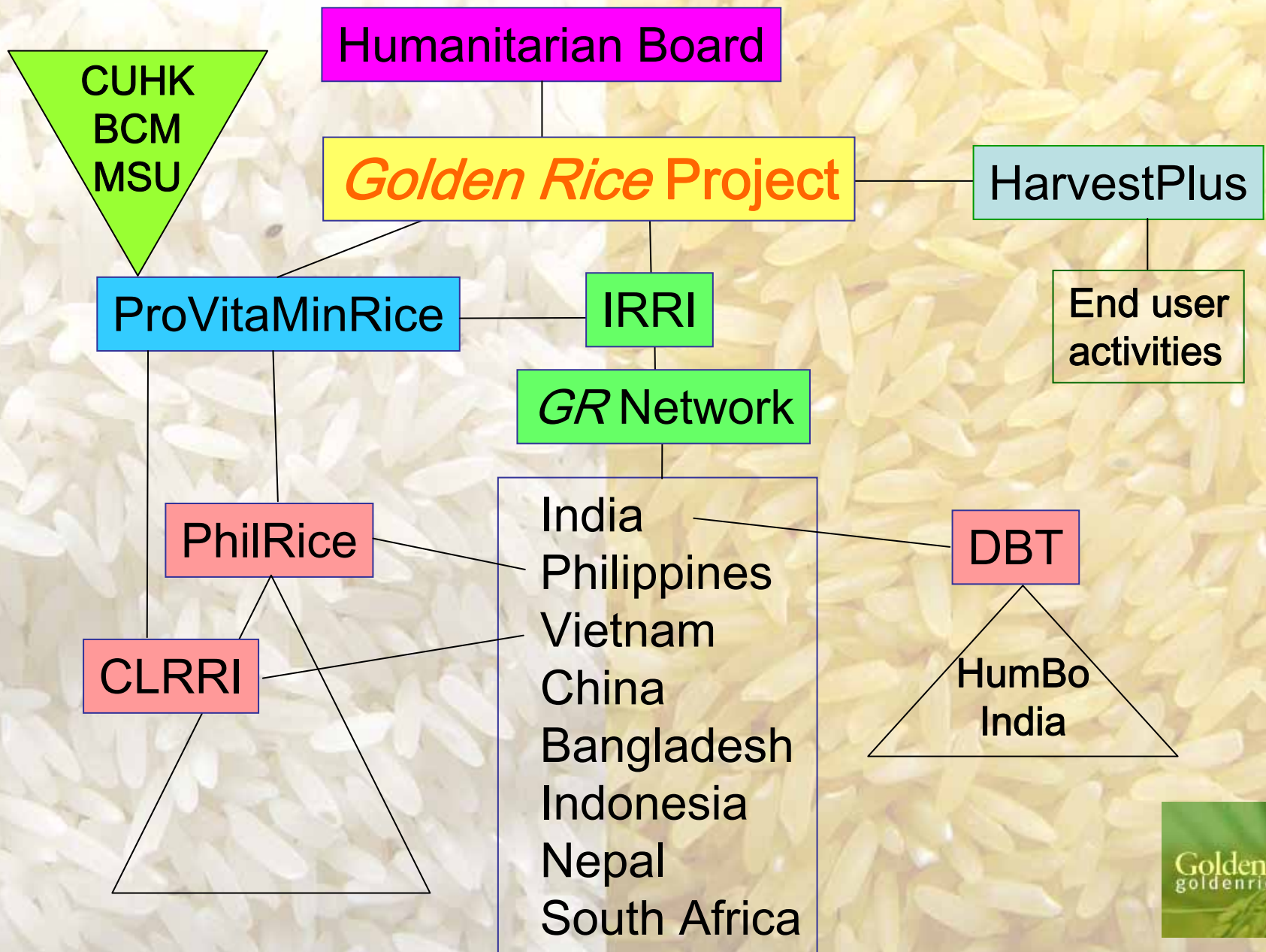
HarvestPlus


IRRI

*GR Network*

India  
Philippines  
Vietnam  
China  
Bangladesh  
Indonesia  
Nepal  
South Africa

# Integration and extension





***Golden Rice* is a  
sustainable solution, and  
compatible with tradition!**

***Golden Rice***  
goldenrice.org