Breeding biofortified crops to alleviate micronutrient malnutrition

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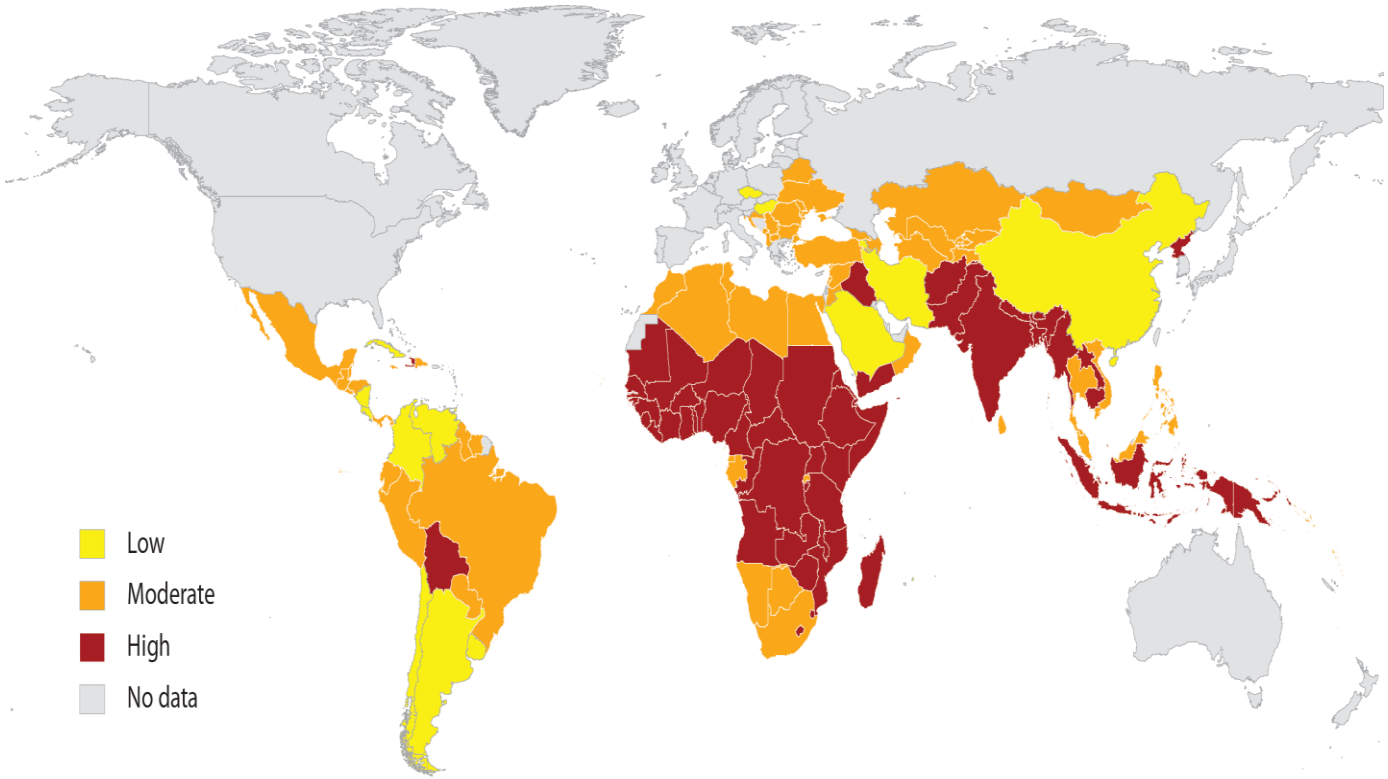
RESEARCH PROGRAM ON Agriculture for Nutrition and Health

Hidden hunger is caused by a lack of vital minerals and vitamins in the diet. HarvestPlus focuses on *three* critical micronutrients recognized by the World Health Organization as most lacking in the diets of the poor (Vitamin A, Zinc & Iron).



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Hidden Hunger

2 billion+ affected

Photo: C. Hotz

Hidden Hunger addressed by

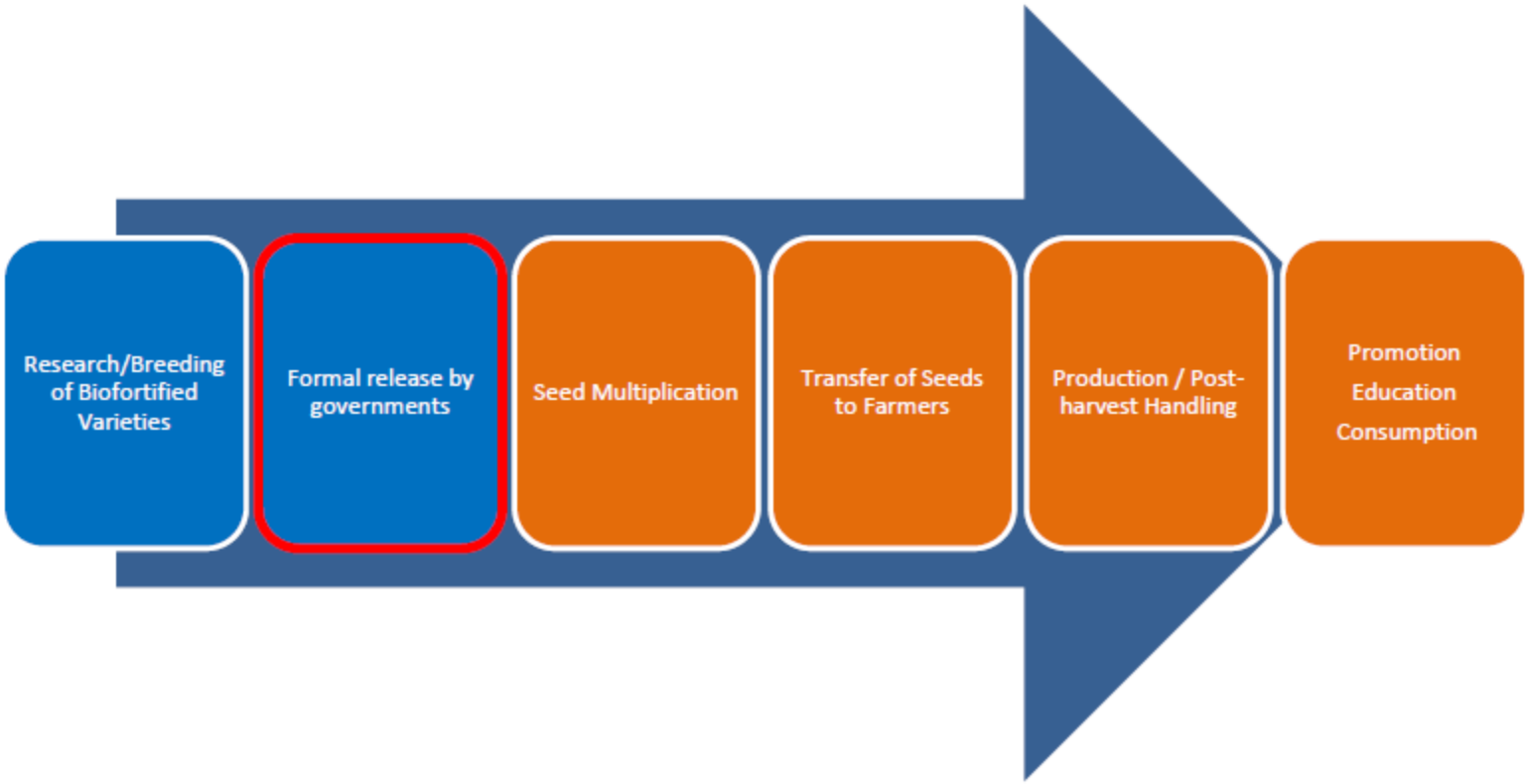
HarvestPlus - an interdisciplinary, global alliance of more than 200 scientific and implementation partners in over 40 countries

HarvestPlus is a joint venture between two CGIAR Centers, the International Center for Tropical Agriculture (CIAT) based in Cali, Colombia and the International Food Policy Research Institute (IFPRI) based in Washington, D.C.

Biofortification: breeding food crops that are more nutritious

Food-Based Strategies Can Reduce Hidden Hunger

Breeding to Consumption



Breeding Biofortified Crops

- Conventional Breeding

- Utilizing Genomic Tools

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Molecular Marker Development & Application

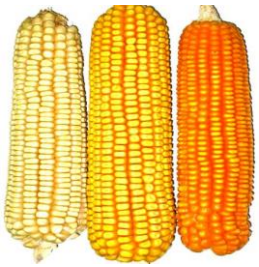
Lycopene Epsilon Cyclase *LCYE*
affects ratio of carotenoids

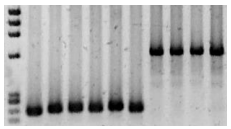
Harjes et al., Science 2008

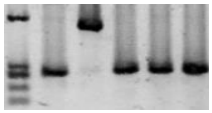
β-hydroxylase *HYDB1* large effect on β-carotene levels & β-carotene / total carotenoids ratio

Yan et al., Nature Genetics 2010

HYDB3 3rd gene







Non destructive - Leaf or Seed DNA

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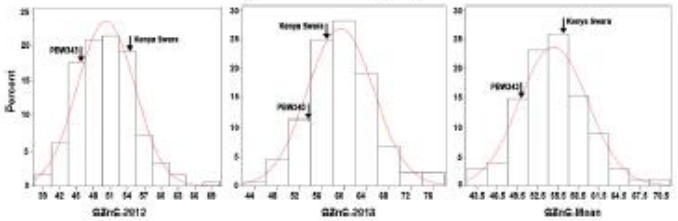
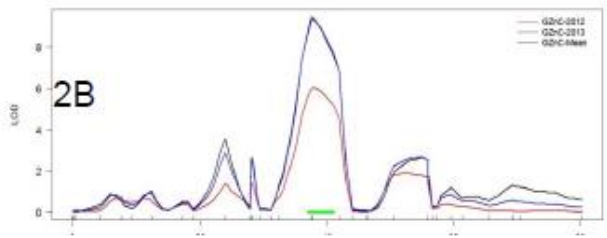
QTL mapping for grain Zn in wheat

PBW 343 x Kenya Swara population

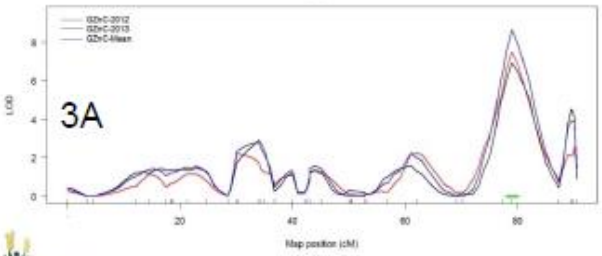


PBW343/Kenya Swara 177 RILs; PBW343: 50.1 mg/kg; Kenya Swara: 56.1 mg/kg
RILs: 44.0 to 70.6 mg/kg (means)

QTL detection on chromosome 2B for high grain zinc content in different environments

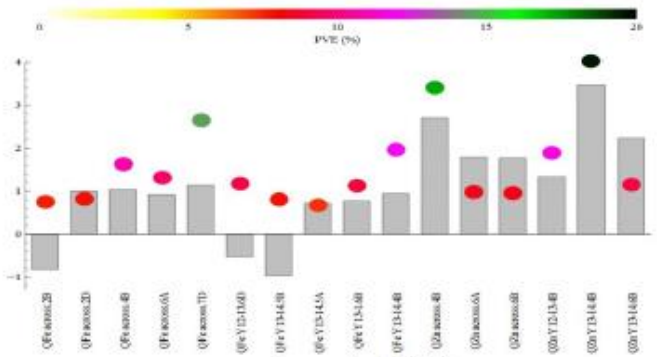


QTL detection on chromosome 3A for high grain zinc content in different environments



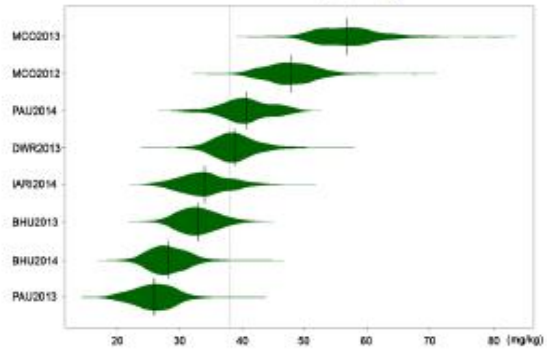
Hao et al, 2014 Mol breeding

Seri M82 x Synthetic population



Crespo et al, 2015 in press

HP Association Mapping Panel



Frequency distributions of grain zinc concentration in eight environments

CIMMYT

QTL mapping, GWAS, Genomic Selection -CIMMYT

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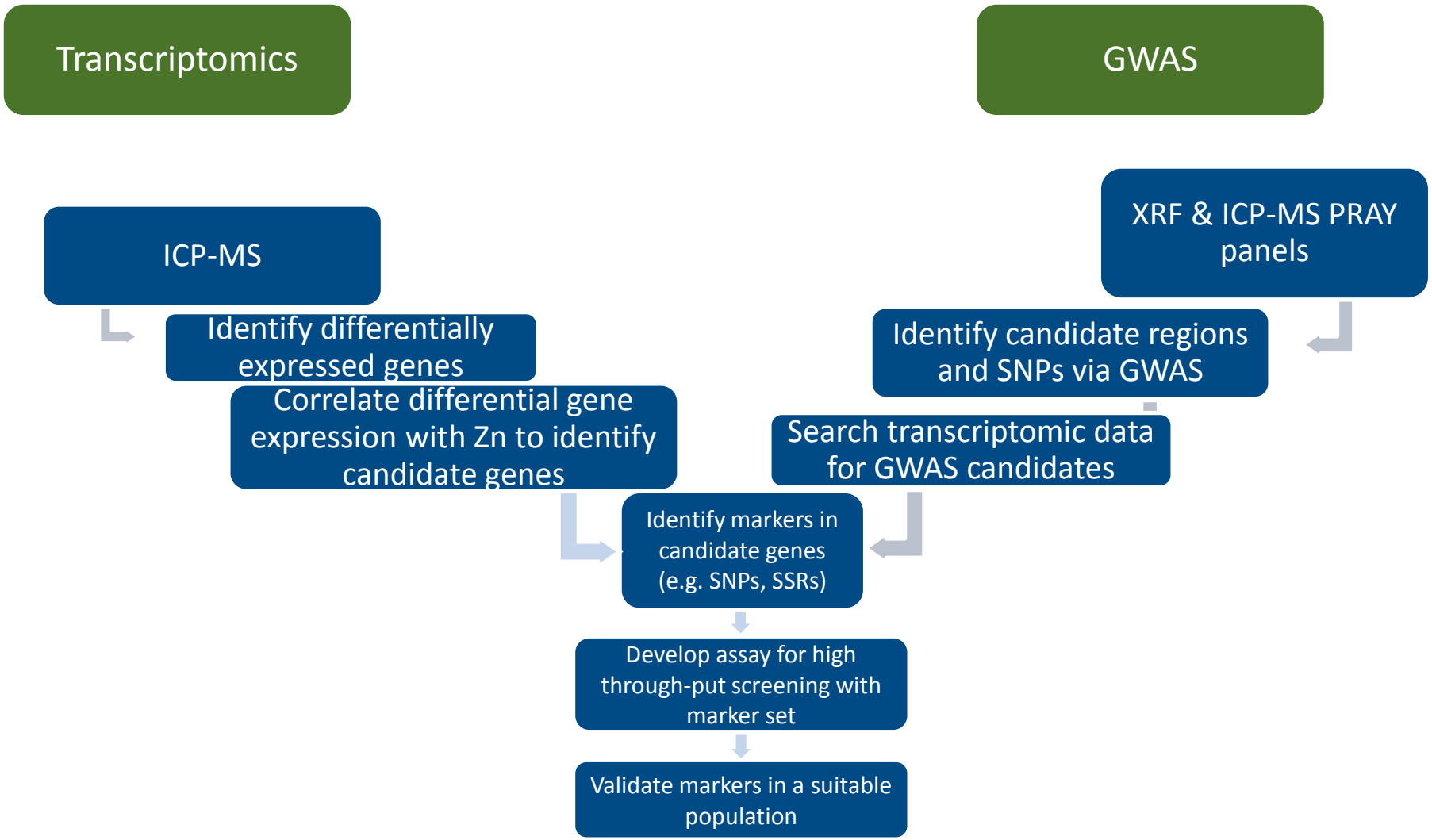
RICE



Flinders University & IRRI

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PLoS one

Constitutive Overexpression of the *OsNAS* Gene Family Reveals Single-Gene Strategies for Effective Iron- and Zinc-Biofortification of Rice Endosperm

Alexander A. T. Johnson[1,2]*, Bianca Kyriacou[2,3], Damien L. Callahan[4], Lorraine Carruthers[2], James Stangoulis[3], Enzo Lombi[5], Mark Tester[2]

www.nature.com/scientificreports

SCIENTIFIC REPORTS | 6:19792 | DOI: 10.1038/srep19792

SCIENTIFIC REPORTS

OPEN

Biofortified indica rice attains iron and zinc nutrition dietary targets in the field

Received: 11 September 2015
Accepted: 07 December 2015
Published: 25 January 2016

Kurniawan R. Trijatmiko[1,10], Conrado Dueñas[1], Nikolaos Tsakirpaloglou[1], Lina Torrizo[1], Felichi Mae Arines[1], Cheryl Adeva[1], Jeanette Balindong[1], Norman Oliva[1], Maria V. Sapasap[1], Jaime Borrero[2], Jessica Rey[1], Perigio Francisco[1], Andy Nelson[3,4], Hiromi Nakanishi[5], Enzo Lombi[6], Elad Tako[7], Raymond P. Glahn[7], James Stangoulis[8], Prabhjit Chadha-Mohanty[1], Alexander A. T. Johnson[9], Joe Tohme[2], Gerard Barry[1] & Inez H. Slamet-Loedin[1,11]

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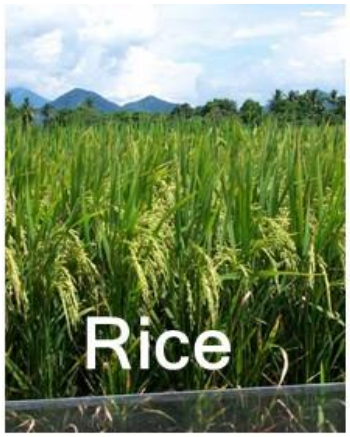
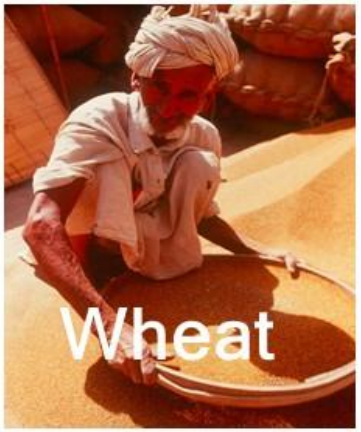
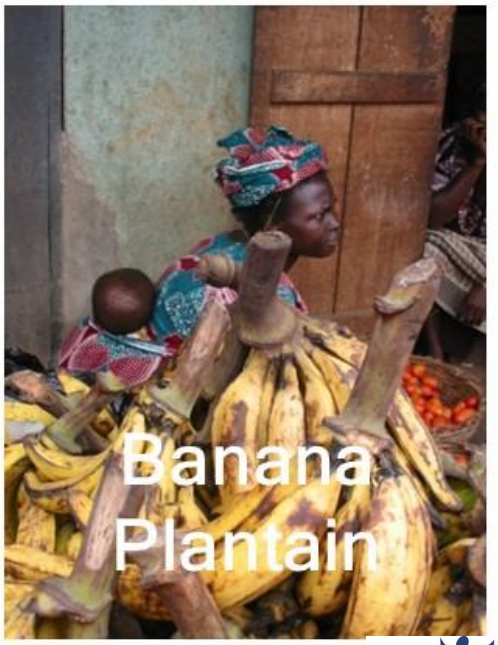
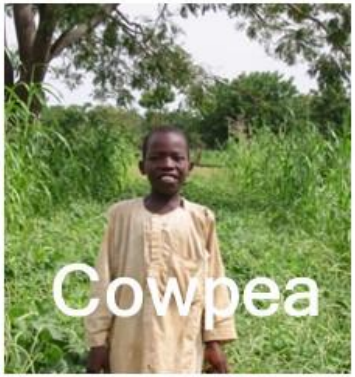
>130 *varieties released in 25 countries*
In-testing in 55 countries









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Crops Released: Africa

OSP

ProVitamin A

Uganda

Cassava

ProVitamin A

Nigeria

DR Congo

Maize

ProVitamin A

Nigeria

Zambia

Beans

Iron (Zinc)

Rwanda

DR Congo

Crops are high-yielding and with other traits farmers want

Crops Released: Asia

Pearl Millet

Iron (Zinc)

India

Rice

Zinc

Bangladesh

India

Wheat

Zinc

India (TLS)

Pakistan(2015)

Crops are high-yielding and with other traits farmers want


Photo: EMBRAPA


Photo: CIAT

Photo: EMBRAPA

Biofortification is an evidence-based intervention linking agriculture and nutrition

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What is the evidence that Biofortification actually works?

Iron-rich Pearl Millet Reverses Iron Deficiency in Children

A Randomized Trial of Iron-Biofortified Pearl Millet in School Children in India[1,2]

Julia L Finkelstein,[3,7] Saurabh Mehta,[3,7] Shobha A Udipi,[4] Padmini S Ghugre,[4] Sarah V Luna,[3] Michael J Wenger,[3,5] Laura E Murray-Kolb,[6] Eric M Przybyszewski,[3] and Jere D Haas[3]*

[3]Division of Nutritional Sciences, Cornell University, Ithaca, NY; [4]S.N.D.T. Women's University, Mumbai, India; [5]University of Oklahoma, Norman, OK; and [6]The Pennsylvania State University, University Park, PA

The Journal of Nutrition. First published ahead of print May 6, 2015 as doi: 10.3945/jn.114.208009.

The Journal of Nutrition
Community and International Nutrition

What is the evidence that Biofortification actually works?

‘Orange’ vitamin A maize increases vitamin A storage in children’s bodies

Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial

First published October 8, 2014, doi: 10.3945/ajcn.114.087379

The American Journal of CLINICAL NUTRITION

What is the evidence that Biofortification actually works?

ELSEVIER
www.elsevier.com/locate/worlddev

CrossMark

World Development Vol. 74, pp. 15–24, 2015
0305-750X/
http://dx.doi.org/10.1016/j.worlddev.2015.04.007

Using Agriculture to Improve Child Health: Promoting Orange Sweet Potatoes Reduces Diarrhea

KELLY M. JONES and ALAN DE BRAUW*
International Food Policy Research Institute, Washington, United States

British Journal of Nutrition (2012), **108**, 163–176

doi:10.1017/S0007114511005174

A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women

Christine Hotz[1,2*], Cornelia Loechl[3], Alan de Brauw[4], Patrick Eozenou[1], Daniel Gilligan[4], Mourad Moursi[1], Bernardino Munhaua[3], Paul van Jaarsveld[5], Alicia Carriquiry[6] and J. V. Meenakshi[1]

What is the Way Forward? Mainstreaming

Challenges for Phase 3 (2014-18)

Mainstream Breeding

- Make breeding for minerals and vitamins "core" breeding objectives at CGIAR Centers and NARS
  - Develop markers
  - Lower costs of breeding
  - All elite breeding lines should have the relevant genes that convey the high mineral and vitamin traits; any cross will contain these genes

Additional Efficacy Evidence

- 1,000 Days – mothers pre-pregnancy and infants

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Mainstreaming Through Key Stakeholders

- National governments & regional frameworks (e.g. Brazil, Nigeria, Rwanda)
- Seed companies (e.g. Nirmal in India)
- Wholesaling, retailing
- International NGOs (e.g. World Vision)
- Multi-lateral agencies (e.g. World Food Program, Codex)
- International financial institutions

NGOs

- HarvestPlus works closely with NGOs (national, regional and international) for delivery activities in Asia and Africa where the markets are not mature for;
  - Seed production
  - Seed distribution
  - Promotions of biofortified crops in the communities
  - Capacity buildings e.g. Training programs

Crop Development , Testing & Commercialization Partnership

Public Sector:

DWR – (ICAR)
IARI - Delhi
PAU - Ludhiana
BHU - Varanasi

CIMMYT

Private Sector:

Ankur Seeds, Ajeet Seeds, Astha Beej Ltd, Bayer Crop Science, DCM Shriram Ltd., Krishidhan, Mahyco, Nirmal Seeds, Nuziveedu Seeds, Pantnagar Tarai Agri Seeds, Rasi Seeds, Shakati Vardhak, Sri Sai Seeds, Shriyanshi Seeds

Food processing Engagement

HPlus in beginning to initiate partnership with food companies for value added products

- **In India – Test marketing zinc wheat flour in collaboration with millers ; Orange maize cereal (Kellogg's)**

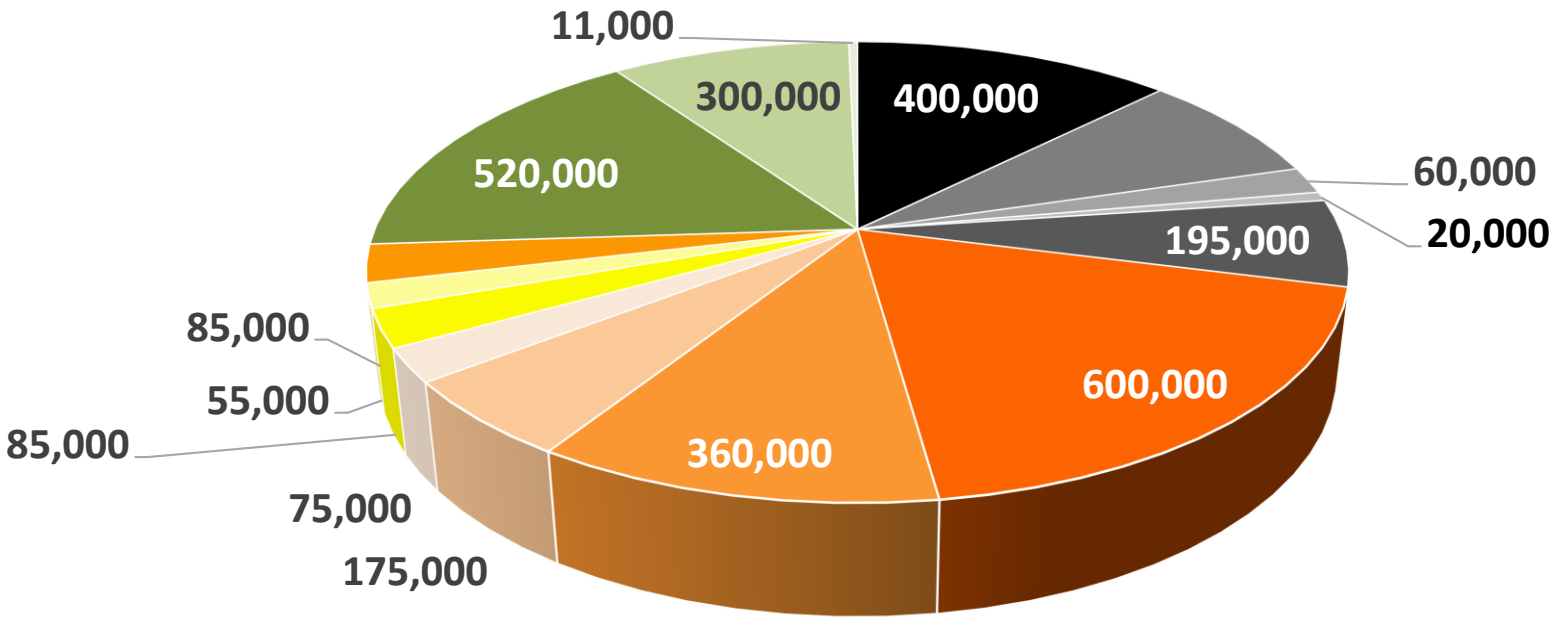
- **In Zambia – Vita-A maize flour through retailers and flour mill association (in partnerships with government)**

- **In LACs Baby food (Nestle)**

Marketing - Consumer Goods

Create demand in particular for main channel processed products such as flour in generating pull in market development

Cumulative Reach: 4 million Farming Households = access to Biofortified Food for 20 million



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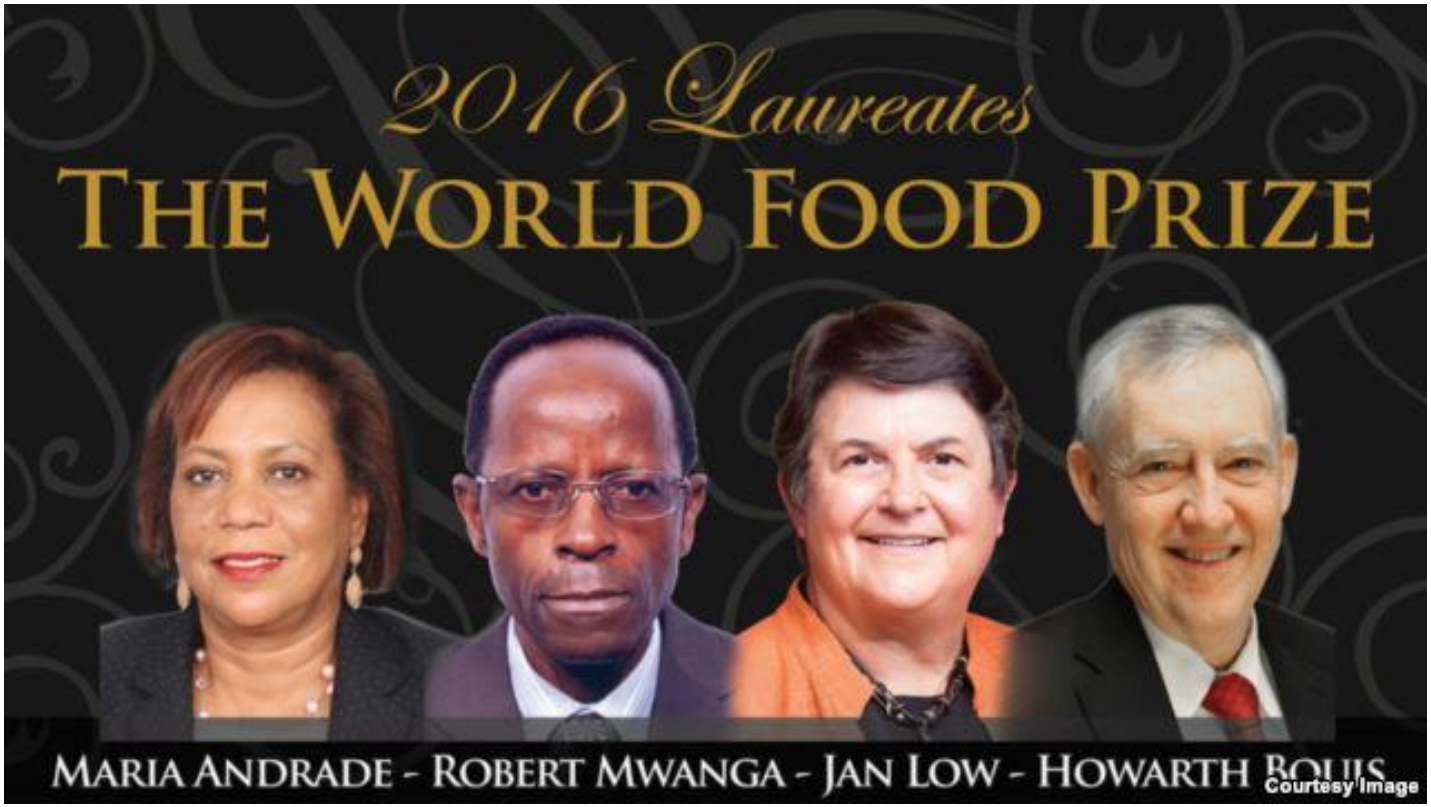
World Food Prize for Combating Malnutrition

- **Biofortification recognized as a Global Intervention**



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World Food Programme

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