



Biofortification: enhancing the micronutrient contents of staple crops

Erick Boy, MD, PhD
Chief Nutritionist, R&D Director,
IFPRI/IPSU-HarvestPlus

HarvestPlus.org



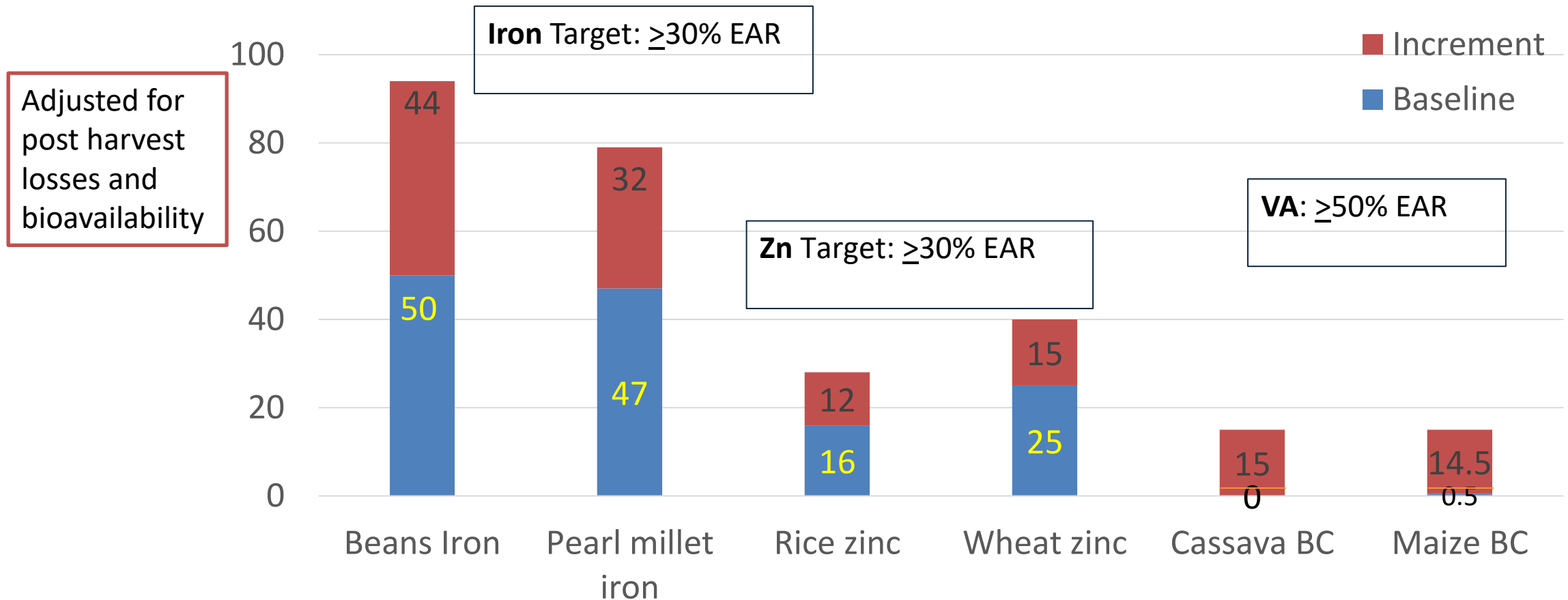
RESEARCH
PROGRAM ON
Agriculture for
Nutrition
and Health

Led by IFPRI

Biofortification

- Increases staple crop nutrient concentration **without sacrificing agronomic traits** (i.e. yield, pest resistance, drought resistance)
- Focuses on **conventional plant breeding** and agronomic management
- Iron, provitamin-A carotenoids, zinc
- Targets the poor rural farming populations
- Cost-effective: upfront investment in research & development → **sustainable public good**

Nutrient breeding target increment by crop ($\mu\text{g/g}$) & % of the estimated average requirement (EAR) for Women



30 years later:

Biofortified Crops Developed by HarvestPlus and CGIAR Partners

Iron



Pearl Millet

up to 80% daily iron needs.
High yielding, mildew resistant,
drought tolerant.

CG Partner: ICRISAT



Beans

up to 100% daily iron needs.
High yielding, virus resistant, heat and
drought tolerant

CG Partner: Bioversity/CIAT

Zinc



Wheat

up to 50% daily zinc needs
: High yielding, disease
resistant, terminal heat
tolerance

CG Partner: CIMMYT



Rice

up to 40% daily zinc needs
High yielding, disease and
pest resistant

CG Partners: IRRI and
Bioversity/CIAT



Maize

up to 70% daily zinc needs
Drought resistant

CG partners: CIMMYT

Vitamin A



Sweet Potato

up to 100%+ daily vitamin A needs
High yielding, virus resistant, drought
tolerant

CG Partners: CIP



Cassava

up to 100% daily vitamin A needs
High yielding, virus resistant

CG Partners: IITA and
Bioversity/CIAT



Maize

up to 50% daily vitamin A needs
High yielding, disease resistant,
drought tolerant

CG Partners: CIMMYT and IITA

***340+ varieties
biofortified crops
released so far in
30 countries.
Many more
varieties in the
pipeline**

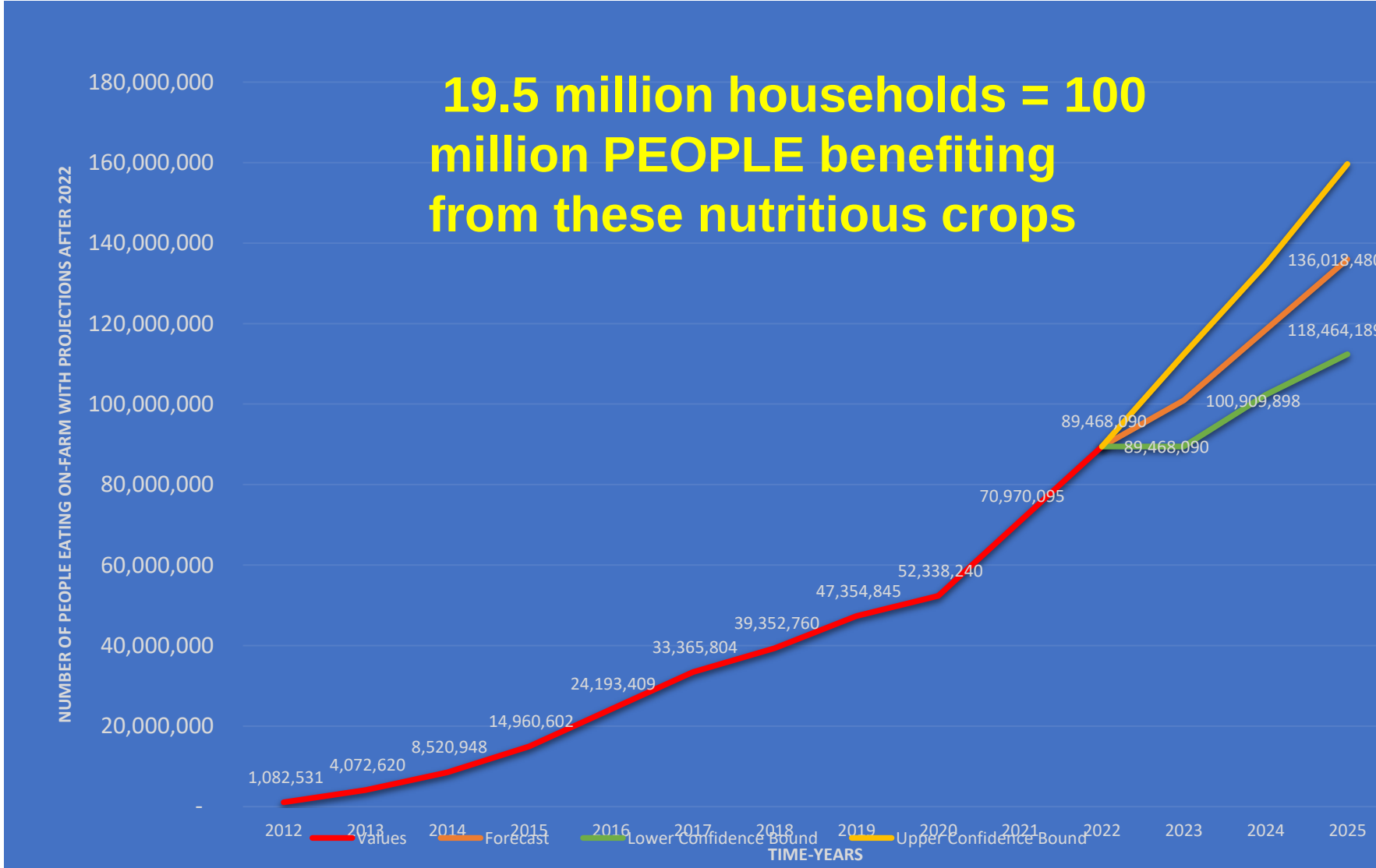
Engage Partners All Along the Biofortification Value Chain



Adoption of HarvestPlus-Facilitated Crops by Smallholder Families



340+ Varieties Biofortified Crops HAVE BEEN Released in 30 Countries...many more Varieties In the Pipeline!



*When consumed,
can the increase in
iron make a
significant impact
on human nutrition?*





The efficacy of pro-vitamin A crops

- 50-100% of vitamin A requirements in children.
- Efficient conversions of provitamin A to retinol.
- Increase in serum retinol and/or total body retinol.
- Improves breast milk retinol



Photo: HarvestPlus



Photo: CIP



Photo: Menno van Zuijlen

Zambia (maize):
Increased vitamin A stores in
children (3 months) and higher
retinol in breast milk
(Gannon et al., 2014,
Palmer et al., 2016b; 2021)

Uganda and Mozambique (OFSP):
Improved serum retinol &
decreased diarrhea in children <5
years (2 years)
(Hotz et al., 2012,
Jones and De Brauw, 2015, 2019)

Kenya and Nigeria (cassava):
Improves serum retinol in
children 4-8 years.
(6 months) (Talsma et al.,
2016; Melse A et al 2020).

Impact of pearl millet in India

Consumption of iron pearl millet significantly improved:

- Iron status (serum ferritin & TBI) after 4-mo
- Iron deficiency by 6-mo
- Cognitive function; higher scores in perception abilities, attention and memory functions
- Physical activity



Impact of iron-beans in Rwanda

Consumption of iron beans significantly improved:

- Iron status (serum ferritin, TBI, and Hb) after 4.5 mo
- Cognitive function; speed and efficiency of memory and attention tasks
- Behavioral performance and brain activity
- Significant relationship between iron status and work capacity



*What is the
potential impact of
biofortification at
scale?*



Scaling up: simulation of DALYs saved for Rwanda

- Average daily bean consumption, increased nutrient levels, retention and bioavailability are used to **calculate the average daily additional amount of micronutrient supplied by biofortification**
- We then calculate how much biofortification lowers disease incidence rates (expressed as Disability-Adjusted Life Year (DALY))
- A standard value of \$1000 is applied to each DALY to convert DALY saved to a monetary benefit

Simulating DALYs saved for Rwanda

Simulated

(2010-2025)

Scenario 1: Observed HIB production

\$16.2 mil

Value of reduced iron deficiency

Scenario 2: 40% HIB production

\$22.3 mil

Value of reduced iron deficiency

If the population eats 40% of its beans as iron biofortified beans, then:

- The annual burden of iron deficiency in DALYs would be reduced by 30.6%; and
- Impaired physical activity due to iron-deficiency anemia among children <5y and women 15-49y would be reduced by 20% and 16%, respectively.

Multiple biofortified crops “food basket” in Mandapalli, Andhra Pradesh

Sweet Potato Sambar



- Mustard
- Oil
- Onion
- Salt
- Sambar powder
- Tamarind
- Tomato
- Turmeric
- Water
- Sweet potato
- Lentils
- Coriander
- Cumin
- Curry
- Fenugreek
- Garlic
- Green chilies

Pearl millet “rice”



- Mustard
- Oil
- Onion
- Peppercorns
- Salt
- Tamarind
- Turmeric
- Water
- Pearl millet
- Lentils
- Bismillah bhaat seasoning
- Coconut
- Coriander
- Cumin
- Curry
- Jaggery

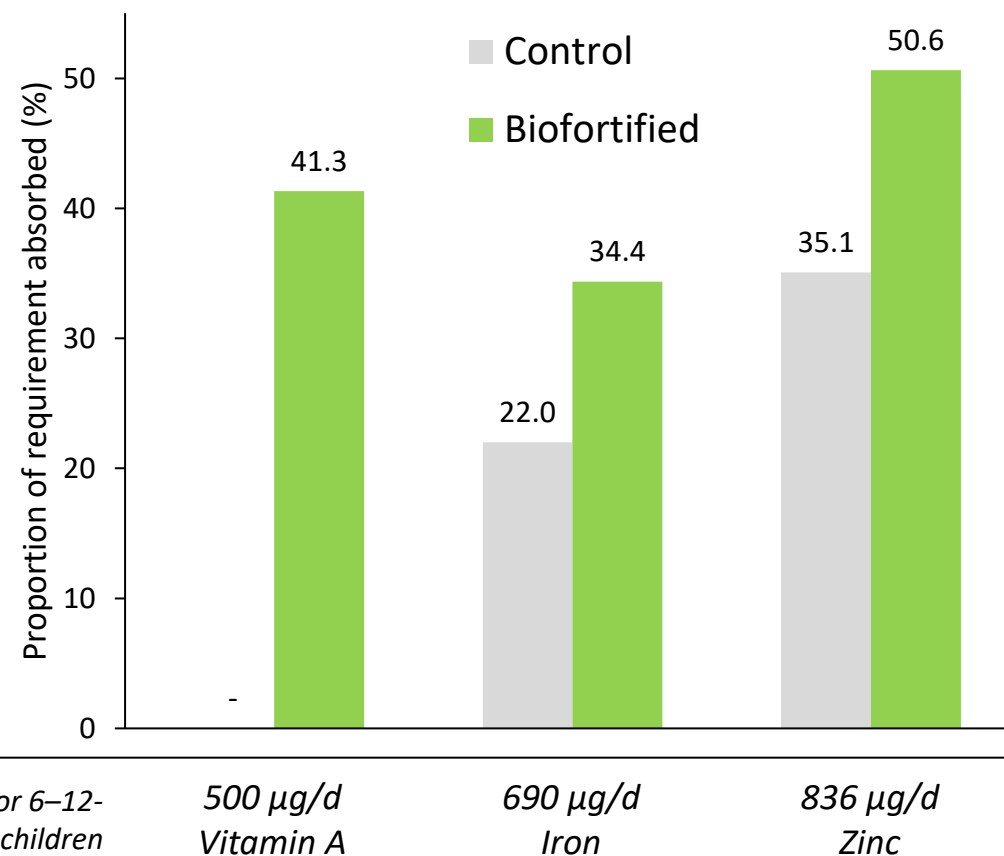
One or more biofortified staples improve the nutrient density of traditional diets and complementary food. (Example: Typical daily menu & micronutrient intake children under 3 years (Mandapalli, AP))

Typical daily menu & micronutrient intake (Andhra Pradesh)

Example daily menu

Breakfast	Main dish	Pearl millet uppma
	Side dish	Sweet potato chutney
Lunch	Main dish	Wheat flour poori
	Side dish	Sweet potato kurmma
Snack	Beverage	Sweet potato sambar
	Dessert	Pearl millet laddoo

% of estimated daily requirement provided to 6–12-month-old children





Summary: Biofortified Crops Improve Nutrition and Health

- Biofortified crops provide 25-100% of a child's average daily vitamin A, iron or zinc needs.
- RCT results demonstrates that biofortified crops are efficacious and effective (OFSP, beans, wheat).
- More effectiveness and program impact evaluations needed.
- Zn deficiency contributes significantly to the global double burden of disease. Zinc can be a double duty action against the double burden of malnutrition.
- Supply chain approach, enabling policy environment, strategic public-private-civil society partnerships, multidisciplinary teams on the ground – keys to successful scaling.



Layers of investments in overcoming malnutrition

Reach more people at lower cost by tackling the foundation of the diet of everyone.

Vision, perseverance, patience are required.

The payoff is resilience and sustainability





THANK YOU!

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e.boy@cgiar.org



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