Fertilizer management research in Bangladesh with emphasis on biofortified crops

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RESEARCH PROGRAM ON Agriculture for Nutrition and Health
CGIAR
Led by IFPRI

Talking points

- Biofortified crops
- Fertilizer management research options

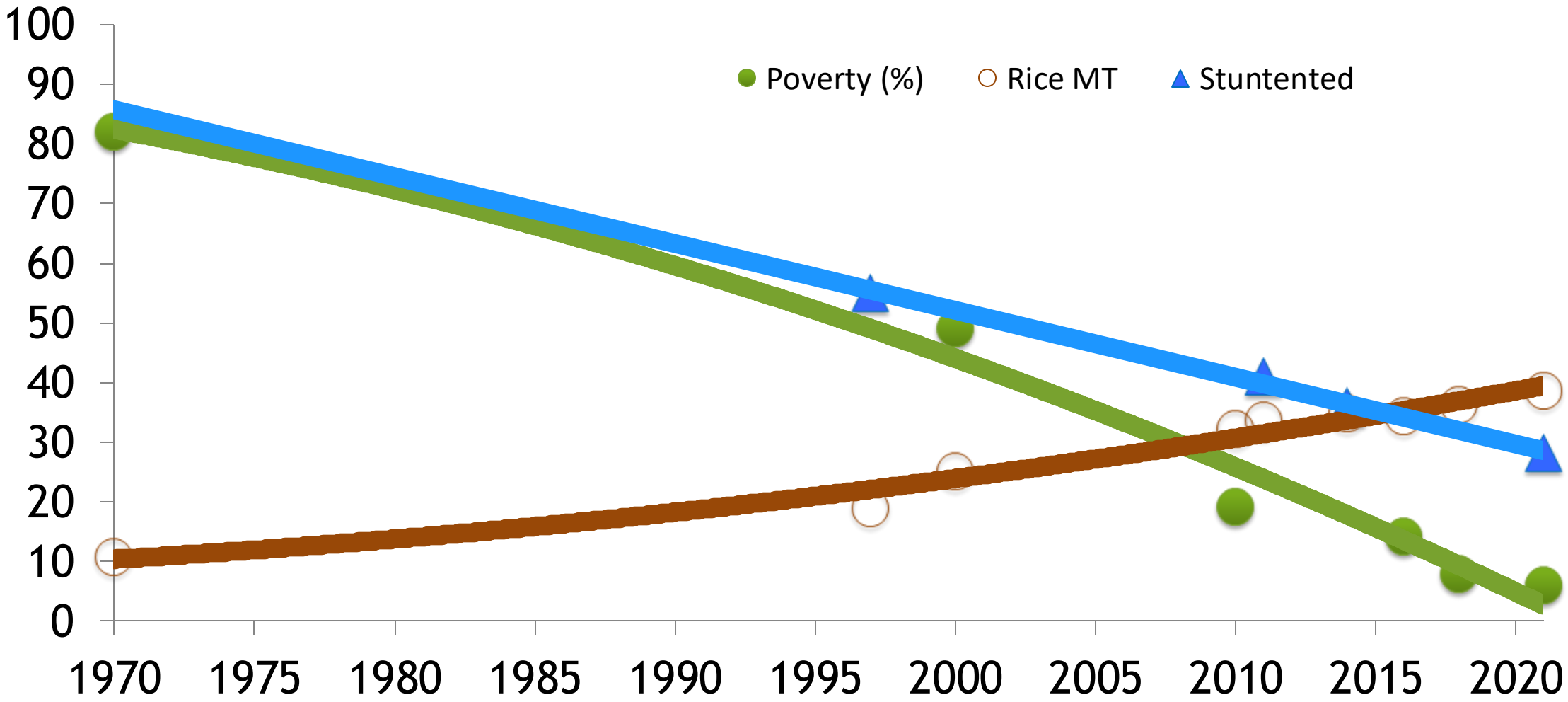
Rice plate in 1960

Peter Jennings 1966

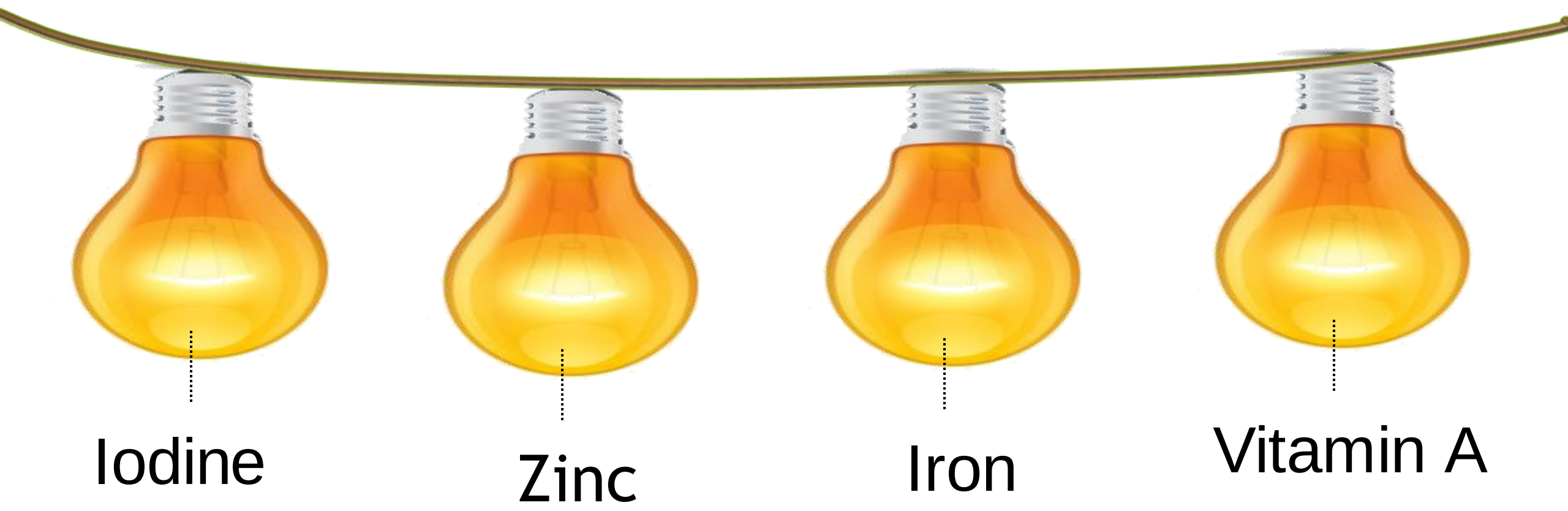
IRRI'S FIRST rice breeder, Peter Jennings, briefs visitors on IR8 in April 1966 just 7 months before its official release.

Rice plate in 2021

Rice plate in 1960 and 2021


100
90
80
70
60
50
40
30
20
10
0
Poverty (%)
Rice MT
Stuntented
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

We have enough to eat but deficiencies in

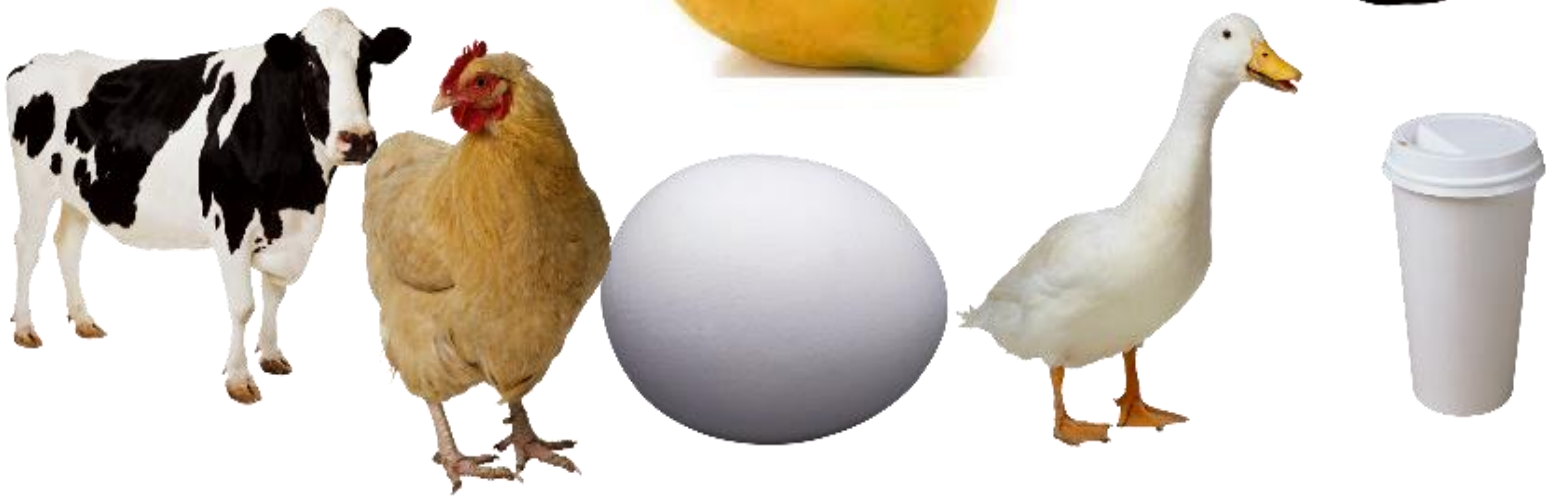


Change in apatite

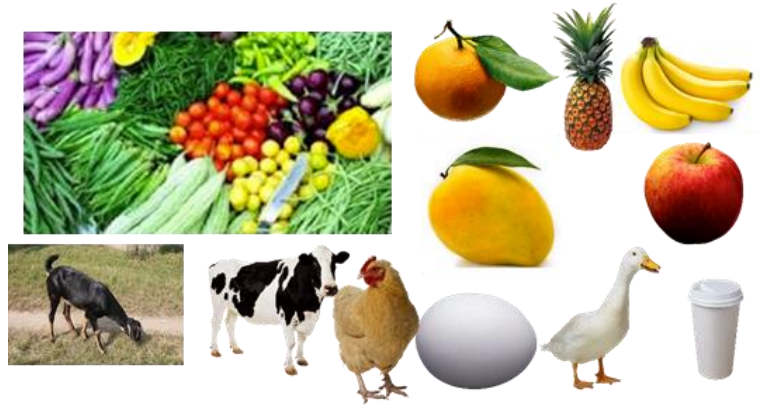
Change taste and smell

Poor concentration and memory

Food diversity



Constraints to consumption of diversified food



- Availability
- Accessibility
- Ability to pay
- Willing to pay
- Willing to eat

Weapons to Fight Deficiency:

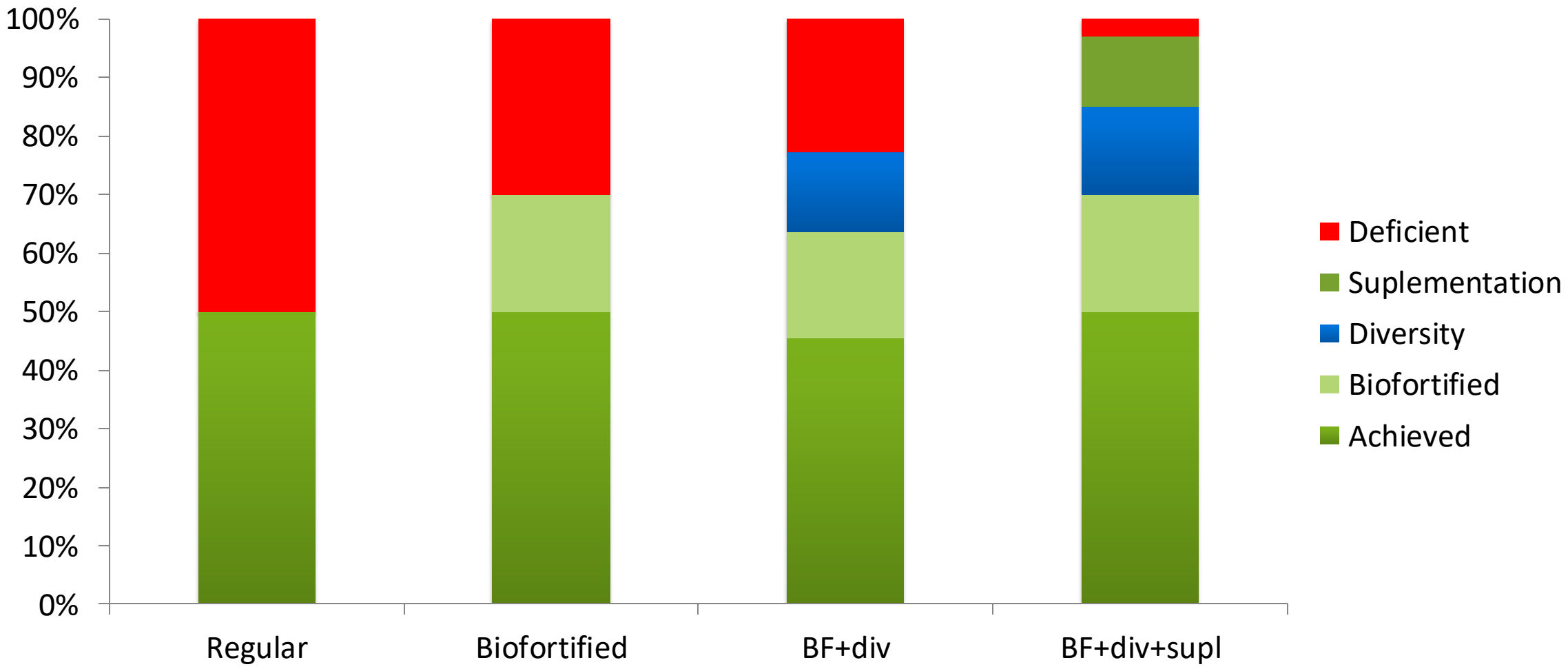
Supplementation

Commercial Fortification

Dietary Diversity

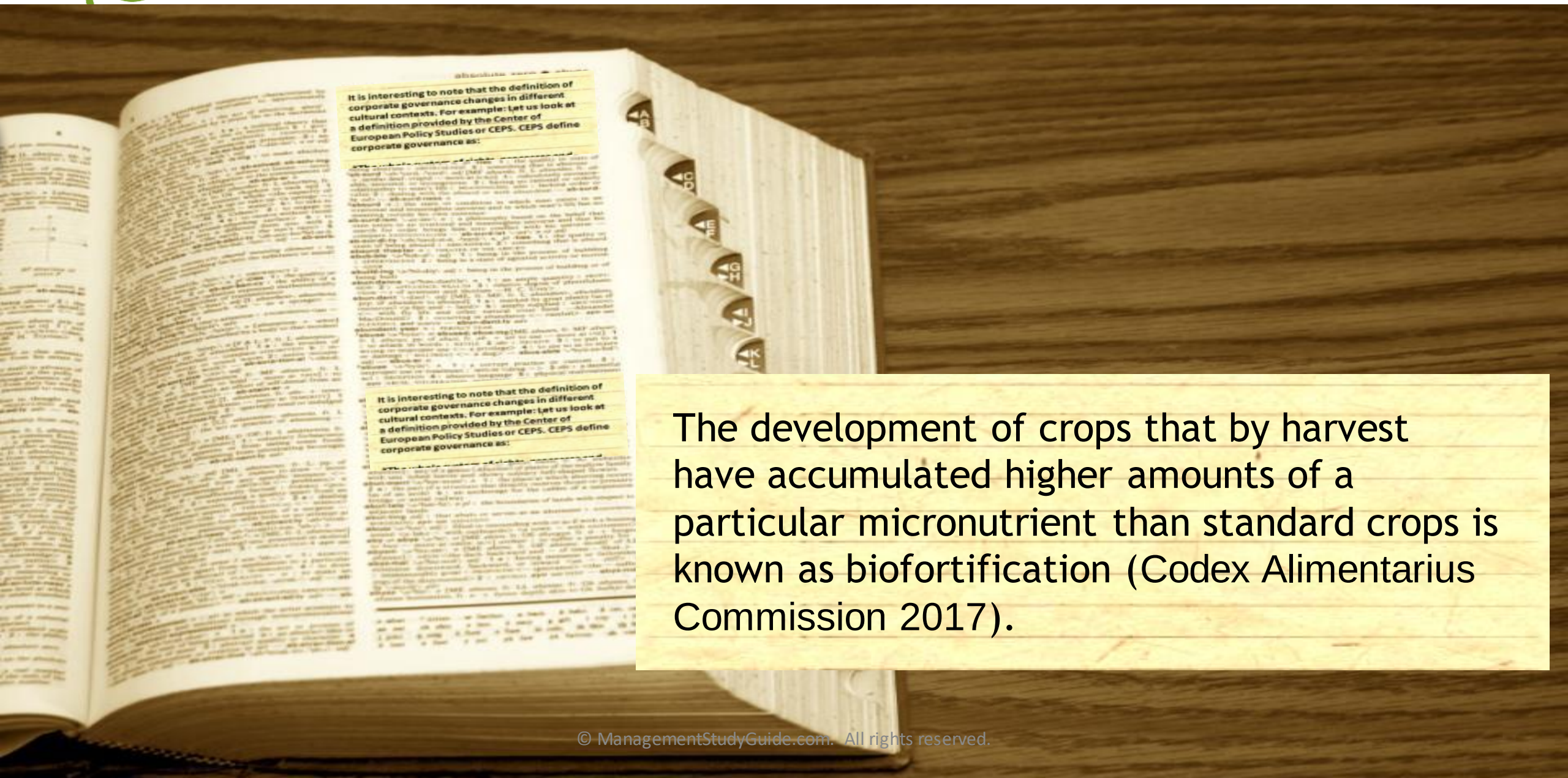
Biofortification

Strategies contributing to nutrition combat



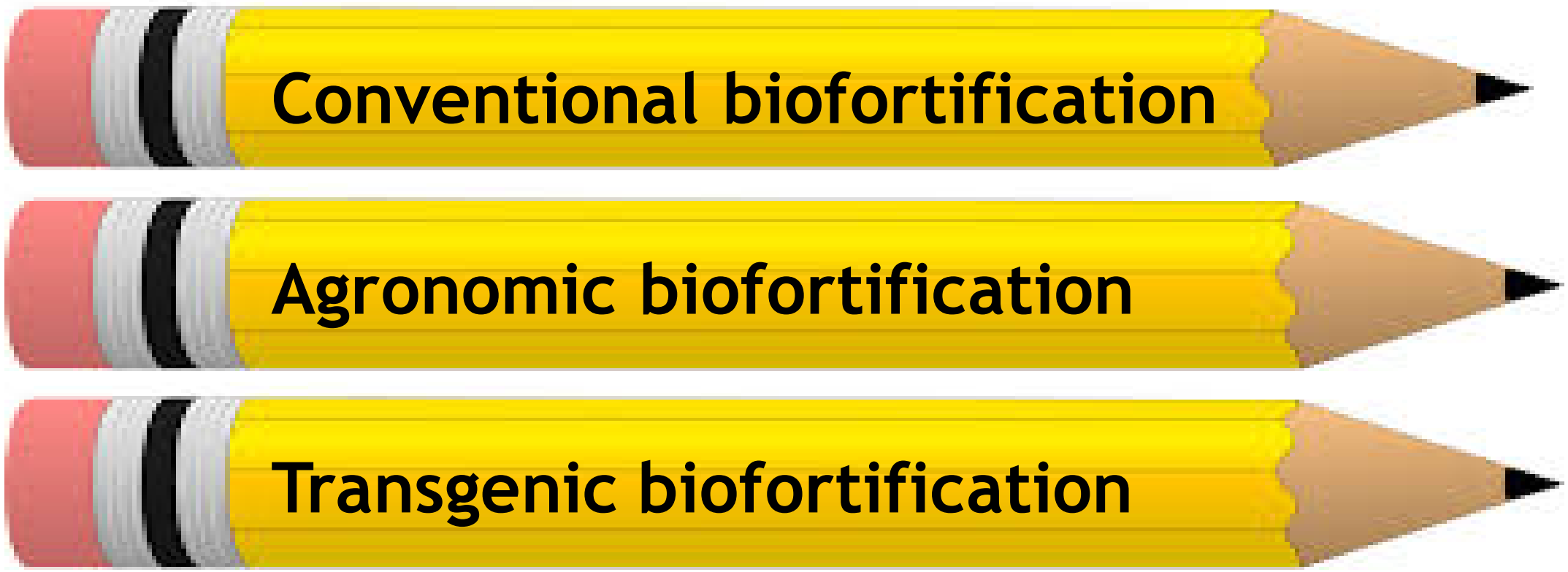
Pioneer of BF revolution- Dr. Howarth Bouis

Definition – Biofortification



The development of crops that by harvest have accumulated higher amounts of a particular micronutrient than standard crops is known as biofortification (Codex Alimentarius Commission 2017).

Types of biofortification



Conventional biofortification

Selecting plants which naturally contain higher amounts of a micronutrient of interest and cross-breeding using conventional methods to produce staple crops with desirable nutrient and agronomic traits.

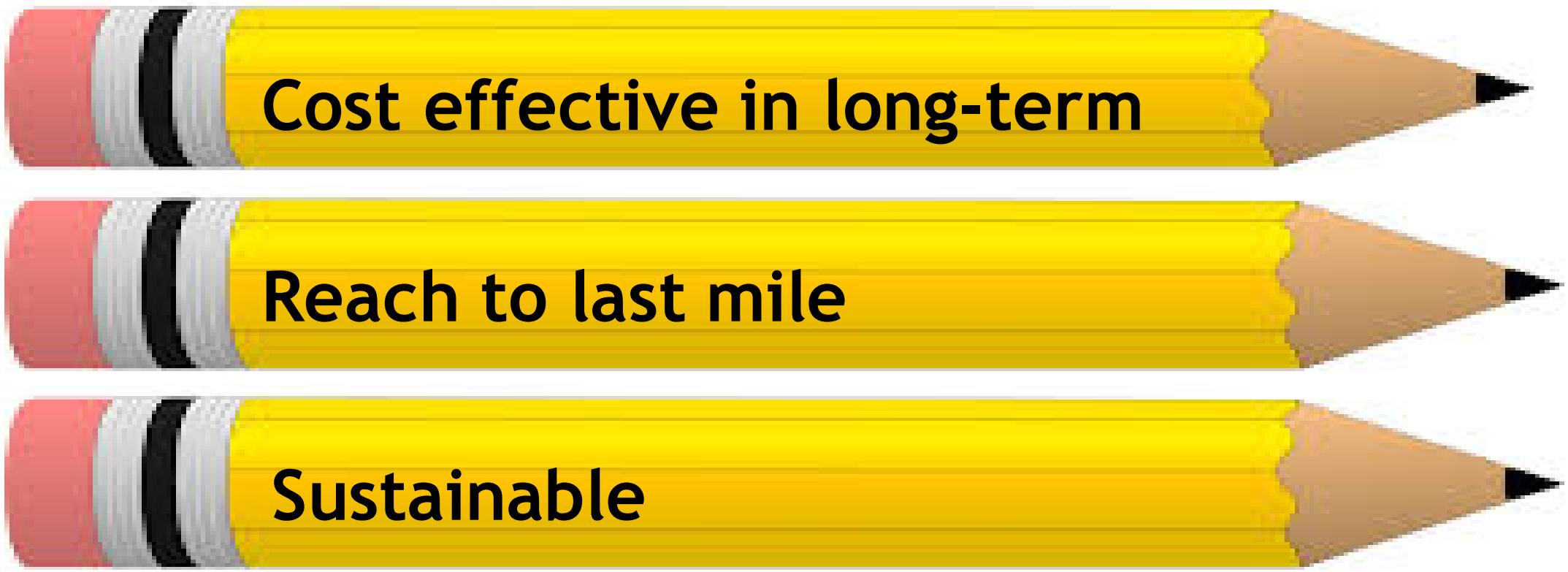
Agronomic biofortification

Use of micronutrient rich fertilizers or sprays which are temporarily taken up by the edible portion of the crop.

Transgenic biofortification

Inserting genes needed for the accumulation of a micronutrient which would not otherwise exist in that particular crop.

Advantages of biofortification



Biofortified crops in Bangladesh

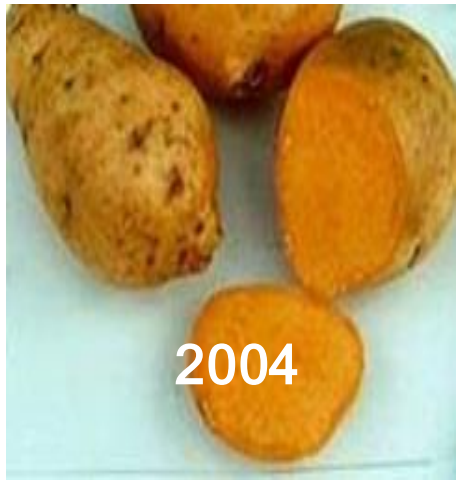
- *These complementary crops together cover*
- *3 of the 4 nutrients, considered essential for health by WHO*

Rice

Zinc

Lentil

Zinc & Iron



Sweetpotato

Vitamin A

Wheat

Zinc

Biofortified Zinc Rice in Bangladesh

- BRRI Released
  - BRRI dhan62
  - BRRI dhan64
  - BRRI dhan72
  - BRRI dhan74
  - BRRI dhan84
  - Bangabandhu dhan100
  - BRRI dhan102
- BSMRAU released
  - BU hybrid dhan 1
  - BU dhan2
- BINA released
  - BINA dhan20

Available high zinc rice varieties (Boro)

Year	Variety	Yield (MT/ha)	Life cycle (days)	Zinc (mg/kg)	Season
2014	BRRI dhan64	6.0-6.5	150-152	24	Boro
2015	BRRI dhan74	7.0-7.5	145-147	24	Boro
2017	BRRI dhan84	6.5	140-145	27	Boro
2021	Bangabandhu dhan100	7.7 - 8.8	148	25.7	Boro
2022	BRRI dhan102	8.1 - 9.6	150	25.5	Boro

Available high zinc rice varieties (Aman)

Year	Variety	Yield (MT/ha)	Life cycle (days)	Zinc (mg/kg)	Season
2013	BRRI dhan-62	4.0-4.5	100	22	Aman
2015	BRRI dhan-72	5.0-5.5	125-130	23	Aman
2016	BU Hybrid dhan1	5.0-5.5	112-115	22	Aman
2016	BU dhan2	5.0	120	22	Aman
2017	BINA dhan-20	4.5	125-130	27	Aman

Biofortified lentil and wheat in Bangladesh

Varieties	Yield (t/ha)	Zinc (mg/kg)	GD (days)
Barimasur-4	2.3	51	110
Barimasur-5	2.2	59	110
Barimasur-6	2.3	63	110
Barimasur-7	2.3	61	100 - 105
Barimasur-8	2.0	60	110 - 115
BARI-GOM33	3.0 - 4.5	33	112 - 120

Contribution of zinc rice to zinc intake by people of different food habit

Type of diet group	Rice type	% calories intake from rice	% protein intake from rice	Zinc intake (mg/day)
Below average animal protein	Regular rice	88.8	76.7	7.6
	Zinc rice	88.8	76.7	13.7
Average animal protein	Regular rice	82.4	52.7	8.1
	Zinc rice	82.4	52.7	13.8
Above average animal protein	Regular rice	52.5	16.4	11.7
	Zinc rice	52.5	16.4	15.4

Biofortification in policy level

- National agricultural policy 2018
- Bangladesh second country investment plan 2016 – 2020
- National strategy on prevention and control of micronutrient deficiencies, Bangladesh (2015 – 2024)

Challenges and recommendation for biofortified varieties

- All the biofortified varieties are not equally suitable for all over the country.
- More biofortified varieties need to be developed with farmers and consumers desirable traits.

Fertilizer management research options

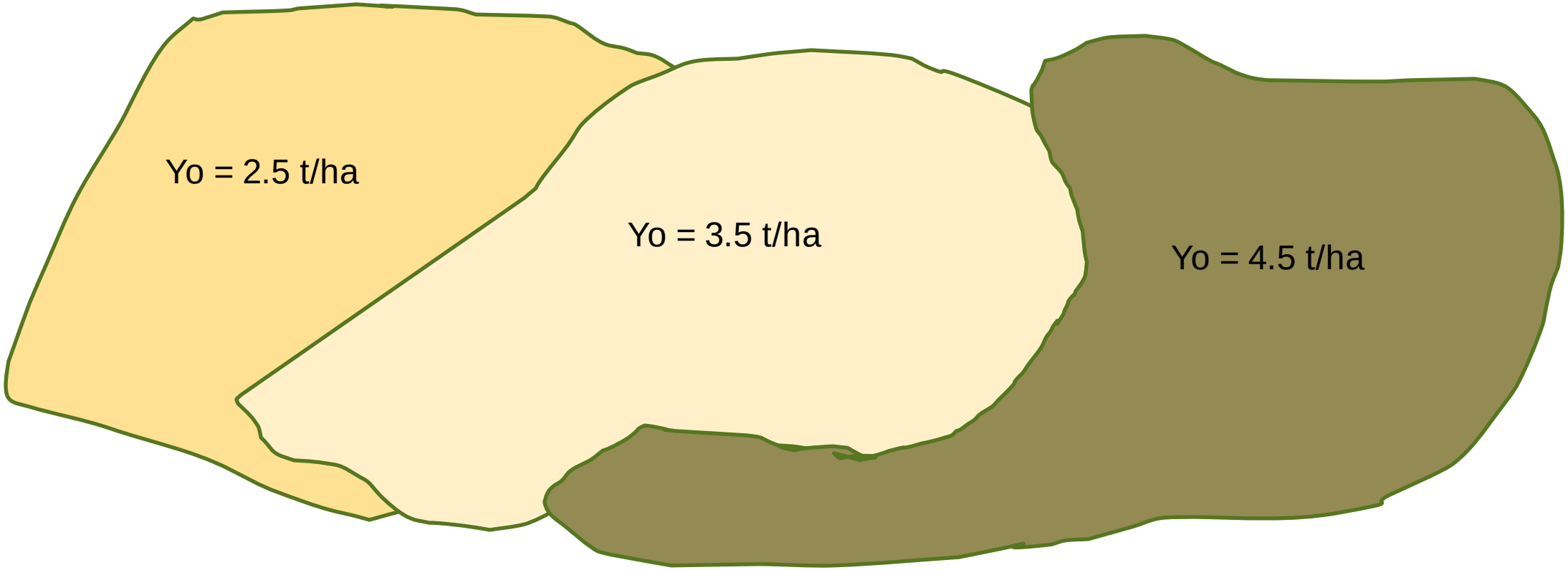
Productivity potentials of soils

Compositional diagnosis of plant nutrients

Extrapolation domain of soil research results

Productivity potentials of soils

- All soils may not support same yield of a given crop even with applying all required fertilizers and organic manures



Productivity potentials of soils

- Soil organic matter
  - Quantity of SOM
  - Nature of SOM
  - Saturation index of SOM
- Soil pH
- Texture
- Structure
- Tortuosity factor
- Rooting depth

Concept of soil test value interpretation

- SLAN concept: Sufficiency level of available nutrient concept
- BCSR concept: Basic cation saturation concept

Development of soil test-based fertilizer application

- Modification of QUEFTS model in the context of soil and crops of Bangladesh

Compositional nutrient diagnosis

- Deficiency of one element may influence the utilization efficiency all other elements.
- Fertilizer application results are reflected in absorption of nutrients by plants.
- Reflection of fertilizers in plant nutrient absorption may differ from soil to soil.

Nutrient simplex

calculated. Compositional nutrient diagnosis (CND) row-centered log ratios for $d + 1$ nutrient proportions including d nutrients and a filling were determined according to Khiari et al. (2001a) as follows:

$$S^d = [(N,\ P,\ K,\ \ldots\ldots R_d) :\ N > 0,\ P > 0,\ K > 0,\ \ldots\ldots\ldots\ Rd\ >\ 0,$$
$$N + P + K + \ldots + R_d = 100]$$

where S^d simplex made of d nutrient, 100 is the dry matter concentration (%); N, P, K, ... are nutrient proportions (%), and R_d is the filling value between 100% and the sum of d nutrient proportions computed as follows:

Filling value

(%); N, P, K, ... are nutrient proportions (%), and R_d is the filling value between 100% and the sum of d nutrient proportions computed as follows:

$$[R_d = 100 - (N + P + K + \ldots\ldots)]$$

Geometric mean of the nutrient proportions

The nutrient proportions become scale invariant after they have been divided by the geometric mean (G) of the d + 1 components including R_d as follows:

$$G = [N \times P \times K \times \ldots\ldots \times R_d]^{\frac{1}{d+1}}$$

Row-centered log ratio

Row-centered log ratios were computed as follows:

$$V_X = \ln\left(\frac{X}{G}\right)$$

where V_X is the CND row-centered log ratio expression for nutrient X and G is the geometric mean of the nutrients composition including the filling value. By definition, the sum of tissue components is 100%, and the sum of their row-centered log ratios including the filling value must be zero.

Cumulative variance ratio

Cumulative variance ratio function of each V_X was calculated after Khiari et al. (2001a) as follows:

$$F_i^C(V_X) = \frac{\sum_{i=1}^{n_1-1} f_i(V_X)}{\sum_{i=1}^{n-3} f_i(V_X)} \times 100$$

where $n_1 - 1$ is partition number and n is total number of observations $(n_1 + n_2)$. The denominator is the sum of variance ratios across all iterations, and thus is a constant for component X.

Cut-off

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where $n_1 - 1$ is partition number and n is total number of observations $(n_1 + n_2)$. The denominator is the sum of variance ratios across all iterations, and thus is a constant for component X.

Cut-off yield

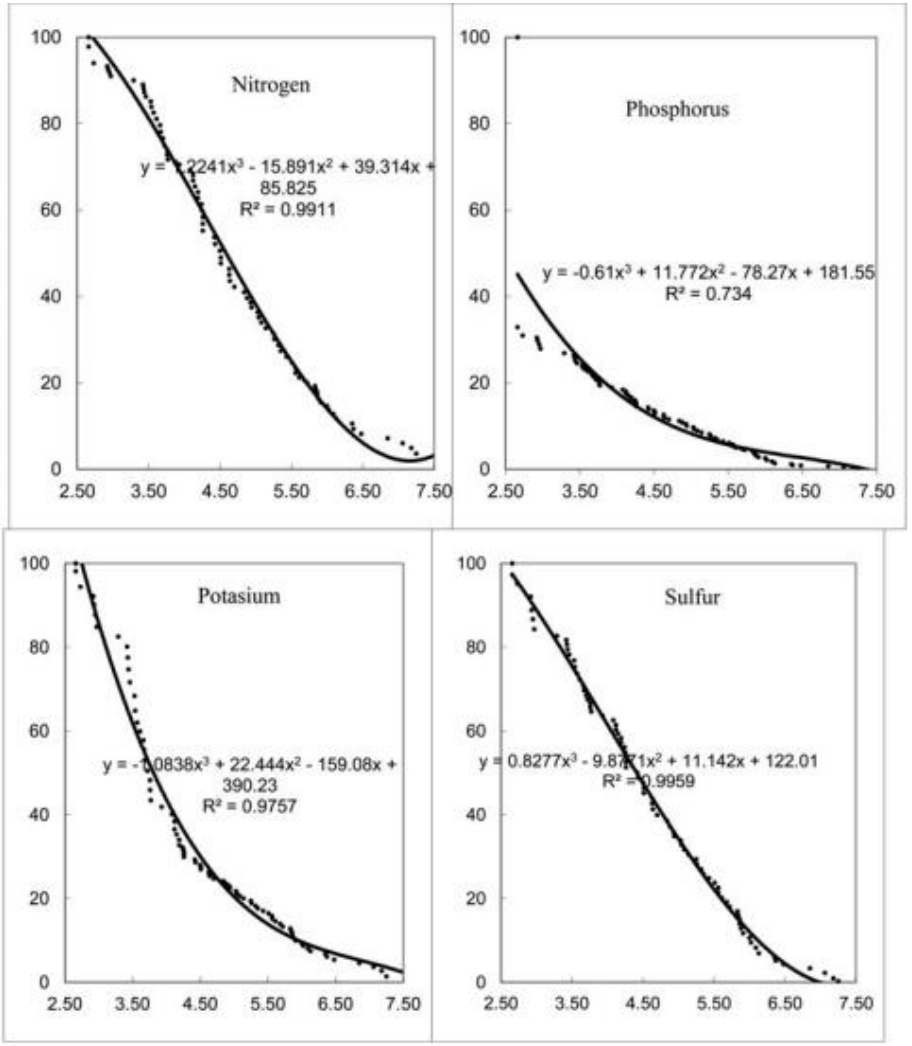

FIGURE 1 Relationship between rice yield and cumulative variance ratio function in N, P, K and S for BRRI dhan28 in farmers' fields (n = 84).

Acknowledgement

- BRRI
- BARI
- CIP
- HarvestPlus
- Google

Thanks for your patience

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