AGRIBLOSSOM
www.agriblossom.net
A monthly peer reviewed e-magazine for Agriculture & allied Sciences

Bio-fortification a Sustainable way to Alleviate Malnutrition

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Introduction

About half of the world's population suffers from micronutrient malnutrition, including Se (Selenium), Zn (Zinc), Fe (Iron) and I (Iodine), which is principally related to low dietary intake of micronutrients in diets with less diversity of food (Mayer et al., 2008). Increasing the Zn and Fe concentration of food crop plants, leading to better crop production and improved human health is a vital global challenge. Among the interventions currently being employed as major solution to micronutrient deficiency in humans, food fortification and supplementation are being widely applied in some countries. However, these approaches appear to be expensive and not easily accessible by those living in developing countries. Alternatively, Bio-fortification of staple food crops with micronutrients through the employment of agricultural tools (e.g., breeding and fertilization) may be a cost-effective and sustainable approach to deal with this problem. However, plant breeding, the foremost powerful agricultural approach, might not effectively add regions where soils have very low plant-available pools of micronutrients because of very adverse soil chemical and physical conditions (Cakmak, 2008). Besides, finding sufficient and promising genotypic variation and maintaining the soundness of targeted micronutrient traits across diverse forms of environments may additionally be difficult. Under such circumstances, agronomic bio-fortification, including the employment of micronutrient fertilizers, is a vital complementary solution (White and Broadley, 2009).

Major reason micronutrient malnutrition

- High Consumption Cereal Based Foods with Low Zinc and Iron Concentrations
- In the rural areas of India, rice and wheat contributes nearly 75 % of the daily calorie intake.
- For a better Zinc and iron nutrition of human beings, cereal grains should contain around 40-60 mg Zn & Fe kg^{-1} but in present, consumption is 10-30 mg Zn & Fe kg^{-1}.

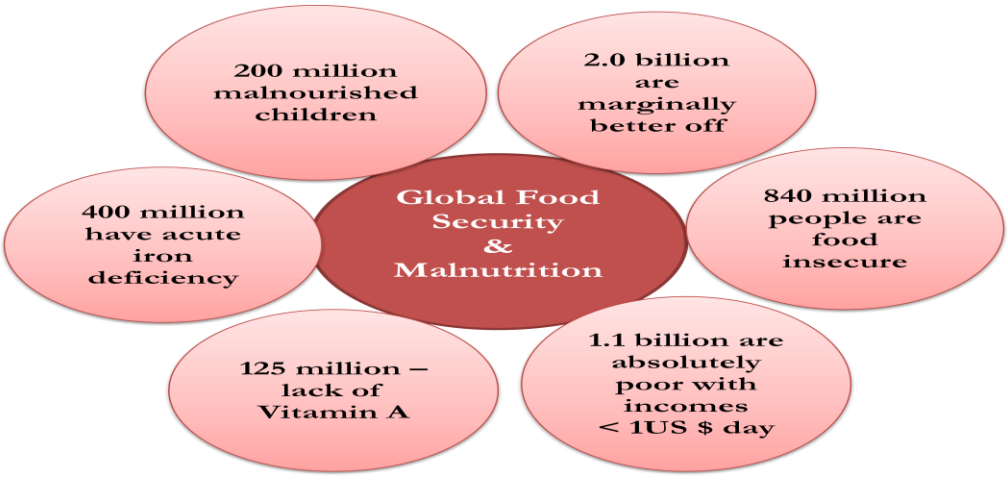

Fig: Global security and malnutrition statistics

Bio-fortification

- "Process of increasing bio available concentration of essential elements in edible portion of crop plant through agronomic or genetic/molecular approach".
- Application of fertilizers to soil and/or foliar to improving grain nutrient concentration and the potential of nutrient containing fertilizers for increasing nutrient concentration of cereal grains
- These crops are "bio-fortified" by loading higher levels of minerals and vitamins in their seeds and roots during growth.

Why biofortification is required?

- Human beings requires at least 49 nutrients to meet their needs
- Primary source : Agricultural products
- Agriculture – fail to provide micronutrients in developing & under developed countries
- Cereals dominate the diet – poor in micronutrients, vitamins, etc.,
- Over 4 billion people affected with micronutrient malnutrition in all over the world
- Food fortification couldn't deliver the desired result
- Good nutrition balance is as important to disease resistance and stress tolerance to plants as it is in humans.

Methods of bio-fortification

Plant breeding bio-fortification

Plant breeding, the most powerful agricultural approach, may not effectively work in regions where soils have very low plant-available pools of micronutrients due to very adverse soil chemical and physical conditions. Plant breeding bio-fortification is one of bio-fortification method, which improves the bio-availability of micronutrient in food crops by crossing high micronutrient variety with high yielding variety by backcross or any other methods.

Agronomic bio-fortification

- Besides, finding sufficient and promising genotypic variation and maintaining the stability of targeted micronutrient traits across diverse types of environments may also be difficult.
- Under such circumstances, agronomic bio-fortification, including the use of micronutrient fertilizers, is an important complementary solution (White and Broadley, 2009).
- Considered as short term solution.
- Safe and accurate application systems to process the fertilizers.
- Flexible; can be used for all crop species and cultivars.
- Fast and cheap.

Table: Examples of Biofortified crops released (Bouis *et al*., 2011)

Crop	Nutrient	Countries of first release	Agronomic trait	Release year
Sweet potato	Provitamin A	Uganda, Mozambique	Disease resistance, drought tolerance	2007
Bean	Iron, Zinc	Rwanda, DRC	Virus resistance, heat and drought tolerance	2012
Pear millet	Iron, Zinc	India	Mildew resistance, drought tolerance	2013
Cassava	Provitamin A	Nigeria, DR Congo	Disease resistance	2011
Maize	Zinc, Iron	Zambia, Nigeria	Disease resistance, drought tolerance	2012
Rice	Zinc, Iron	Bangladesh, India	Disease and pest resistance, cold and submergence tolerance	2013

Wheat	Zinc, Iron	India, Pakistan	Disease and lodging resistance	2013

Advantages of Biofortification

- Capitalizes the regular daily intake of food staples. Implicitly targets low-income households.
- After the one-time investment to develop fortified seeds, recurrent costs are low; and fortified seeds shared internationally.
- Once in place, the biofortified crop system is highly sustainable.
- Fortified seed not incur a yield penalty. May have important indirect effects in increasing farm productivity by helping plants resist to disease and other environmental stresses.
- To overcome the mal-nutritions in human beings.
- Increment of nutritional quality in daily diets.
- Improvement of plant or crop quality and increment of variability in germplasm.

Conclusion

Biofortification is a cost-effective, feasible means of reaching populations who may have limited availability and access to diverse diets, supplements, or commercially fortified foods. Because biofortification combines increased micronutrient content with preferred agronomic, quality, and market traits, biofortified varieties match or outperform the usual varieties that farmers grow and consume. Marketed surpluses of biofortified crops make their way into retail outlets in both rural and urban areas, reaching additional populations who may be likely to suffer from micronutrient deficiency. A one-time investment in plant breeding yields micronutrient-rich varieties for farmers to grow for years to come, and the same varieties can be evaluated in other target geographies with similar agro ecological conditions, thus multiplying the benefit of the initial investment. Biofortification is one solution among many that are needed to solve the complex problem of micronutrient deficiency, and it complements existing interventions. While the right mix of interventions is country, we can scale up the use of biofortified crops has the potential to benefit millions of people.

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