NUTRITIONAL SECURITY THROUGH BIOFORTIFICATION - AN OVERVIEW

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ABSTRACT

The United Nations Food and Agriculture Organization have estimated that around 792.5 million people across the world are malnourished, out of which 780 million people live in developing countries. Malnutrition is an alarming problem in the world. People in developing countries are the major victims of this problem. Progress has been made to control micronutrient deficiencies through supplementation and food fortification, but needs food based solution. No single intervention will solve the problem of micronutrient malnutrition this can be overcome by different methods namely, agronomic biofortification, breeding and transgenic approaches. Biofortification is the process of adding nutrients into food crops, provides a comparatively cost-effective, sustainable, and long-term means of delivering more micronutrients. Biofortified staple foods cannot deliver as high level of minerals and vitamins per day as supplements or industrially fortified foods, but they can help by increasing the daily adequacy of micronutrient intakes among individuals throughout the lifecycle. Thus biofortification sounds a very effective way to attain nutritional security and its effectiveness on human population will be discussed in this paper.

Keywords: malnutrition, biofortification, food crops, effective, human population.

INTRODUCTION

Nutritious diet is vital for proper growth and development in humans. It helps preventing diseases, besides maintaining the body metabolism for physical and mental- wellbeing. Food provides energy, protein, essential fats, vitamins, antioxidants and minerals to meet our daily metabolic requirement. Most of them cannot be synthesized in human body, therefore are to be supplemented through diet. Further, anti-nutritional factors present in edible parts of the food exert adverse effects on human health. Consumption of unbalanced foods affects billions of people worldwide, and leads to poor health and socio-economic. The focus has been on the development of high yielding varieties primarily to feed the ever increasing populations. India is the leading producer of millets accounting for about 80% of the global millet production (**FAO, 2015**). Nutritional security is the key to improve the health status of the world's population as mankind is primarily dependent on plant-based diets. Half of the global population, especially people from Asia and Africa suffer from nutrition deficiency as they rely on cereal and millet crops for food.

It has vast genetic variability for key mineral elements like, iron, zinc, and calcium when compared to other cereal crops.

Besides hunger, malnutrition resulting from the intake of food poor in nutritional quality, particularly lacking in crucial micronutrients, has been recognized as a serious global health problem, more so among children, women of reproductive age, and pregnant and lactating women in the developing world. Efforts are underway to address this hidden hunger by various means. Biofortification is a sustainable option to combat micronutrient malnutrition and complements dietary diversification, food fortification, and supplementation that are currently employed to address micronutrient deficiency in human diets.

What is Biofortification

"Biofortification" or "biological fortification" refers to nutritionally enhanced food crops with increased bioavailability to the human population that are developed and grown using modern biotechnology techniques, conventional plant breeding, and agronomic practices. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions (**Garg *et al.*, 2018**).

Need for Biofortification

Reaching consumer in first rural and then urban areas, in contrast to complementary interventions, such as fortification and supplementation. Biofortification provides a feasible means of reaching mal-nourished rural populations who may have limited access to diverse diets, supplements, and commercially fortified foods. The biofortification strategy seeks to put the micronutrient-dense trait in those varieties that already have preferred agronomic and consumption traits, such as high yield. Marketed surpluses of these crops may make their way into retail outlets, reaching consumers in first rural and then urban areas, in contrast to complementary interventions, such as fortification and supplementation, that begin in urban centers. Unlike the continual financial outlays required for supplementation and commercial fortification programs, a one-time investment in plant breeding can yield micronutrient-rich planting materials for farmers to grow for years to come. Varieties bred for one country can be evaluated for performance in, and adapted to, other geographies, multiplying the benefits of the initial investment. While recurrent expenditures are required for monitoring and maintaining these traits in crops, these are low compared to the cost of the initial development of the nutritionally improved crops and the establishment, institutionally speaking, of nutrient content as a legitimate breeding objective for the crop development pipelines of national and international research centers. Currently, agronomic, conventional, and transgenic biofortification are three common approaches. Agronomic biofortification can provide temporary micronutrient increases through fertilizers (**Saltzman *et al.*, 2013**).

Criteria for Biofortification

- Crop productivity must be maintained /enhanced to guarantee farmer acceptance (high yielding).

- Micronutrient enrichment levels must have significant impact on human health (effective).
- Enriched levels must be relatively stable (stability).
- Bioavailability in enriched lines must be tested in humans to ensure that they improve the micronutrient status of people preparing and consuming them (efficacious).
- Consumer acceptance has to be tested (taste and cooking quality).

Agronomic Approach

Agronomic biofortification is the application of micronutrient containing mineral fertilizer to the soil and/ or plant leaves (foliar), to increase micronutrient contents of the edible part of food crops. It is cost effective, rapid result, accessibility and ease in application of agro-techniques over breeding and biotechnology based biofortification. Zinc is mobile in the soil, applications of zinc sulphate can increase yield and zinc concentrations in cereals and legumes (**White and Broadley, 2005**). For other essential micronutrient elements (e.g., nickel, iodine, and selenium) increasing soil-available supply to food crops can result in significant increases in their concentrations in edible plant products. Iodine and selenium are also mobile in soil and plants, thus biofortification with iodine and selenium fertilisers has been particularly successful. Like supplements and fortification, agronomic intervention is probably best applied in niche situations or in combination with other strategies (**Graham *et al.* 2017**).

Genetic approaches

The possibilities of improving micronutrient nutrition through plant breeding are numerous. They include (1) increasing the concentration of minerals (iron or zinc), or vitamins (beta-carotene); (2) reducing the amount of anti-nutrients such as phytic acid; and (3) raising the levels of sulphur-containing acids, which can promote the absorption of zinc. Molecular biology supports classical cereal breeding to select for particular genes and includes analysis of quantitative trait loci (QTL) and marker assisted selection (MAS). It has been recommended to cross wild species with cultured varieties to increase the micronutrient concentration. New traits can also be introduced directly into commercial varieties by mutagenesis. Both conventional breeding and transgenic improvement have several common concerns. Micronutrient bioavailability can be defined as the amount of nutrient retained after storage, processing, and cooking in a typical diet once the nutrient is ingested. Biofortified crops must win over farmers by maintaining the yield productivity along with offering a benefit to human health, the micronutrient enrichment traits must be relatively stable across various edaphic environments and climatic conditions, and finally the must meet consumer acceptance according to final use including taste and cooking quality (**Welch and Graham 2004**). **Example:** Iron Pearl millet, Vit. A Sweet Potato, Vit. A Cassava, High Protein Wheat and Iron Beans.

Transgenic approach

Transgenic approach can be a valid alternative for the development of biofortified crops when there is a limited or no genetic variation in nutrient content among plant varieties. It relies on the access to the unlimited genetic pool for the transfer and expression of desirable genes from one plant species to another which is independent of their evolutionary and taxonomic status. Furthermore, when a particular micronutrient does not naturally exist in crops, transgenic approaches remain the only feasible option to fortify these crop with the particular nutrient. The ability to identify and characterize gene function and then utilize these genes to engineer plant metabolism has been a key for the development of transgenic crops. Furthermore, pathways from bacteria and other organisms can also be introduced into crops to exploit alternative pathways for metabolic engineering. Transgenic approaches can also be used for the simultaneous incorporation of genes involved in the enhancement of micronutrient concentration, their bioavailability, and reduction in the concentration of antinutrients which limit the bioavailability of nutrients in plants. In addition, genetic modifications can be targeted to redistribute micronutrients between tissues, enhance the micronutrient concentration in the edible portions of commercial crops, increasing the efficiency of biochemical pathways in edible tissues, or even the reconstruction of selected pathways. Example: QPM, High Iron rice.

Recent Biofortified varieties

Crop	Variety	Specification	Approach followed
Rice (2016)	CR Dhan 310	Protein 10.3%	Pure line variety
Rice (2016)	DRR Dhan 45	Zn 22.6 ppm	Pure line variety
Wheat (2017)	WB 02	Zn 42.0 ppm	Pure line variety
		Fe 40.0 ppm	
Wheat (2017)	HPBW 01	Zn 40.6 ppm	Pure line variety
		Fe 40.0 ppm	
Maize (2017)	Pusa vivek QPM9 Improved	Provitamin – A 8.15 ppm	Hybrid
		Lysine 2.67%	
		Tryptophan 0.74%	
Maize (2017)	Pusa HM4 Improved	Tryptophan 0.91 %	Hybrid
		Lysine 3.62 %	
Maize (2017)	Pusa HM8 improved	Tryptophan 1.06 %	Hybrid
		Lysine 4.18 %	
Maize (2017)	Pusa HM9 Improved	Tryptophan 0.68 %	Hybrid
		Lysine 2.97 %	

Source: Yadava *et al.*, 2017.

Advantages of biofortification

- Biofortification is built on what poor households grow and eat (stable crops)
- The one time investment to develop seeds that fortify themselves keep recurrent cost low, it can be shared globally and making it highly cost effective.
- Bio fortification is sustainable.
- It reaches country most vulnerable people, living in remote rural area with no access or money for commercially fortified foods.
- It produces higher yields in environmentally friendly way.

Tackling "Hidden Hunger"

- Cost effective
- Sustainable
- Reaches target population
- No involvement of distribution system
- Can reach poor

For low-income households which mostly subsist on starchy and bulky foods like rice and cassava for their calorie requirements finger millet ensures a pragmatic solution that no family member (especially women and children) suffers from Ca deficiency.

Genetic gardens of biofortified crops:

- Different sections based on particular micronutrients, viz., section for vitamin A, iron and iodine section, etc.
- A new kind of botanical garden with emphasis on biofortified genetic resources.
- By walking through the garden, farmers can identify the crops they can introduce in their farming system to address specific micro-nutrient deficiencies.
- Serve both as educational tools and facilitators of nutritional security.

Conclusion

This article has tried to address the role of agricultural solutions in addressing micronutrient malnutrition in India. Most of the farmers in India operate small-scale farms that are fragmented rather than continuous. These farms are not highly productive, such that the annual income hardly fulfills the farmers' requirements. There should be a well awareness in the food diversity issues. There is a need to educate people about the advantage of food diversity and how they can improve their dietary requirement by adopting a kitchen garden in their backyard. Rather than educating people only, it is always better to educate them and then suggesting them feasible solutions. Often the problem with the supplementation programme is proper infrastructure and personnel for addressing the issues. All these issues come to a conclusion that it is not only the scientific approach that is needed but India needs a holistic approach to reduce the problem of malnutrition. It is clear that biofortification sounds a very effective way in solving the malnutrition problem. But to a larger extent social, economical, political and cultural issues need to be looked into for the successfulness of any programme being implemented in India.

References

- FAO, IFAD, WFP, 2015. The State of Food Insecurity in the World-2015. **FAO**, Rome.
- Garg, Sharma, Kapoor, Kumar, Chundari and Arora. 2018. Breeding Crops Generated by Breeding, Agronomy, and Transgenic Approaches are Improving Lives of Millions of people around the world. **Front. Nutr. 5**:12.
- Graham, R.D., R.M. Welch, D.A. Saunders, I. Monasterio, H.E. Bouis, M. Bonierbale, S. de Hann, G. Burgos, G. Thiele, R. Liria, C.A. Meisner, S.E. Beebe, M.J. Potts, M. Kadiajn, P.R. Hobbs, R.K. Gupta, and S. Twomlow. 2017. Nutritious subsistence food systems. **Adv. in Agron. 92**:1–74.
- Saltzman, A., Birol, E., H. Bouis. 2013. Biofortification: progress toward a more nourishing future. **Glob. Food Secur. 2** (1), pp 9–17.
- Welch RM, Graham RD. 2004. Breeding for micronutrients in staple food crops from a human nutrition perspective. **J. Exp. Bot. 55**:353–64.
- White J, Broadley MR. 2005. Biofortifying crops with essential mineral elements. **Trends in Plant Sci. 10**:586–93.
- Yadava D.K., P.R. Choudhury, Firoz Hossain and Dinesh Kumar. 2017. Biofortified Varieties: Sustainable Way to Alleviate Malnutrition. **Indian Council of Agricultural Research**, New Delhi.