BIOFORTIFICATION OF CEREALS TO MITIGATE HIDDEN HUNGER

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INTRODUCTION:

The Green Revolution increased production and solved the food security problem in developing countries like India, where individuals get enough calories with less nutritious food. Micronutrients plays a vital role in the human body which not only involved in mental, physical development but they also act as a cofactor in the proper functioning of many enzymes, regulating different metabolic pathways. Many people in underdeveloped countries are experiencing silent epidemics of deficiency diseases due to inadequate intake of zinc, iron, iodine, vitamin A, vitamin D, and vitamin E in their cereal-based diets. There are four main types of intervention to prevent malnutrition: Supplementation, dietry diversification, agronomic interventions and biofortification (Figure 1). The most practical technique for combating micronutrient deficiency is to increase micronutrient content in staple food crops through biofortification using plant breeding and biotechnology.

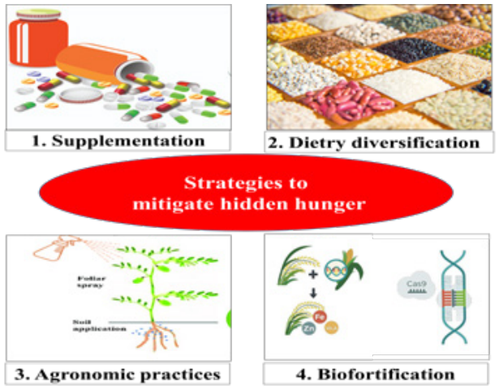

Figure 1: Interventions to mitigate hidden hunger

MICRONUTRIENTS AND THEIR IMPORTANCE

Zinc: Zinc is one of the essential minerals that the body needs for various biological processes, such as cell division, cell growth, and immune function. Human body does not store zinc for long periods of time. So, there is a constant need for a zinc-enriched diet to prevent its deficiency. Zinc deficiency is related to many diseases which include night blindness, weight loss, impaired taste acuity, emotional disturbance, dermatitis, delayed wound healing, poor appetite, alopecia, and poor immunity.

Iron: In the human body, iron is present in every cell, part of many enzymes; a key component in hemoglobin protein, the most important function of iron is the transportation of oxygen from the lungs to tissues. In developing countries, iron deficiency is the most common condition and is the leading cause of anemia, which especially affects young women and children. According to the World Health Organization, over 2 billion people are affected by anemia worldwide; its deficiency may result in other complications such as fatigue, hair loss, pagophagia, pallor, and restless leg syndrome. Severe or untreated iron deficiency may lead to death.

Iodine: Iodine is an essential mineral for human health, as it is required for the biosynthesis of two thyroid hormones triiodothyronine (T3) and thyroxine (T4). Iodine deficiency results in the enlargement of thyroid tissue, a condition known as goiter. Moreover, iodine deficiency during pregnancy may result in impaired neurodevelopment of the offspring, whereas, during childhood, it affects somatic growth and cognitive functions.

Vitamin A: Vitamin A, a fat-soluble vitamin, is required for a healthy immune system, growth of epithelial cells, eyesight, reproduction, and regulation of genes. Among pregnant women, its deficiency also causes night blindness, maternal mortality, and other poor consequences in pregnancy and lactation. Vitamin A is essential for the normal functioning of the visual system, epithelial integrity, immunity, reproduction, and the maintenance of cell growth and function.

Vitamin B: Vitamin B, is a water soluble vitamin, exist in eight forms: vitamin B1, B2, B3, B5, B6, B8, B9, and B12. All these forms act as co-factors in different metabolic mechanisms, such as carbohydrate metabolism and protein synthesis. Deficiency of each form results in different symptoms like skin inflammation, a weak immune system, fatigue, and depression.

Vitamin C: Vitamin C is a plant based water-soluble vitamin, plays an important role in boosting the immune system, especially against allergies due to its antioxidant properties. Its deficiency results in joint pains, bone and connective tissue disorders, poor healing, and a weak immune system.

HIDDEN HUNGER

In general, hidden hunger is defined as a lack of minerals and vitamins combined with adequate energy consumption. Hidden hunger is believed to affect over two billion people globally; primarily in low- and middle-income nations where people rely on low-cost staples, their diets are monotonous, and their choices are constrained by poverty. A successful plan to combat hidden hunger must be long-term, cost-effective, and able to reach the most isolated and marginalized areas. Dietary supplements, food diversity, and biofortification are all approaches for combating hidden hunger. Due to low economic conditions and insufficient food supply in some areas, people cannot afford to supplement their diets or diversify their diets. As a result, delivering nutritional benefits through biofortified crops is seen as a more promising and cost-effective approach to mitigate the problem of hidden hunger. Now agriculture is undergoing a shift from producing more quantity of food crops to producing nutrient-rich food crops in sufficient quantities. This will help in fighting “hidden hunger” or “micronutrient malnutrition” especially in poor and developing countries, where diets are dominated by micronutrient-poor staple food crops.

WHAT IS BIOFORTIFICATION?

"Biofortification" is introducing into crops the capacity to accumulate micronutrients by agronomic methods (e.g. addition of nutrient-rich fertilizer), plant breeding or biotechnology. There is a lot of work being done on biofortification all throughout the world. Agronomic approaches include micronutrient fertilization and exogenous foliar application of a crop. Micronutrients, such as zinc, iron, boron, and selenium, have also been improved in several cereal crops through soil and foliar treatment. Alternative strategies should be adopted to improve the micronutrient content of grain foods if fertilizer option is not efficient. Biofortification is the most sustainable strategy to modify the genetic makeup of the plant to increase micronutrient content. Several biofortified cereal crop varieties that have been developed worldwide are given in Table 1. Plant breeding has greatly improved the micronutrient status of various crops. To generate genotypes with high micronutrient content, it is critical to identify genetic resources in various food crops with high concentrations of necessary micronutrients.

Table 1: Examples of biofortified varieties of various cereal crops.

S.no.	Crops	Trait	Released varieties
1	Rice	Fe and Zn	BRRIdhan 62, BRRIdhan 72, BRRIdhan 64
		Fe	IR68144-3B-2-2-3 (improved line)
		Zn	Jalmagna
		Protein	CR Dhan310
2	Wheat	Zn	BHU 1, BHU 3, BHU 5, BHU 6, BHU 17, BHU 18, NR 419, 42, 421, Zincol, PBW1Zn
		Fe and Zn	WB02, HPBW01
		Carotene	HI 8627
		Anthocyanins	Black-grained wheat, Indigo
3	Maize	Vitamin A	GV662A, GV664A, GV665A , Ife maizehyb-3, Ife maizehyb-4, Sammaz 38 (OPV), Sammaz 39 (OPV) ,CSIR-CRI Honampa (OPV),
		Lysine and Trypto-phan	CML176, CML176 × CML186, HQPM-1, HQPM4, HQPM-5, HQPM-7, VivekQPM-9, FQH-4567,CML140, CML194, P70 , QS-7705,GH-132-28 ,Obatampa, Susuma, BR-451, BR-473,FONAIAP,INIA , ICA , HQ-31,HQ-61 , HB-Proticta , NB-Nutrinta, HQ INTA-993, Pusa HM4, Pusa HM8, Pusa HM9
		Provitamin-A, Lysine and Tryptophan	Pusa Vivek QPM9 Improved
4	Sorghum	Fe	ICSR 14001, ICSH 14002, 12KNICSV (Deko)-188 12KNICSV-22 (Zabuwa); Hybrids: ICSA 661 × ICSR 196, ICSA 318 × ICSR 94, ICSA 336 × IS 3760,
5	Bajra	Fe and Zn	HHB 299, Dhanashakti, Hybrid ICMH 1201 (Shakti-1201)
		Fe	AHB 1200
6	Lentils	Fe and Zn	Barimasur-4, Barimasur-5, Barimasur-6, Bari-masur-7, Barimasur-8, ILL 7723- Khajurah-1, Khajurah-2, Shital, Sisir, Shekhar and Simal, L4704 and Pusa Vaibhav,Alemaya,Idlib-2 and Idlib-3
		Fe	Pusa Ageti Masoor
7	Cow Pea	Fe	Pant Lobia-1, Pant Lobia-2, Pant Lobia-3, Pant Lobia-4
8	Beans	Fe and Zn	RWR 2245, RWR 2154, MAC 42, MAC 44, CAB 2, RWV 1129, RWV 3006, RWV 3316, RWV 3317, RWV 2887

WHY BIOFORTIFICATION?

- Other biofortification interventions, such as dietary supplementation and food fortification, typically miss rural people. But biofortified foods can reach rural communities.
- An effective way to use plant-based foods to deliver more micronutrients to malnourished populations.
- It costs initially to develop biofortified crop variety, but once it's done, the trait is permanent. It provides a complementary and cost-effective way to increase micronutrient intake in vulnerable populations.
- This technique is based on common meals that individuals consume on a daily basis. Once the biofortified plant is developed, the seed can be extensively distributed and replicated by farmers year after year. Farmers can usually save seeds or cuttings for replanting and freely share them with their neighbours.

ORGANIZATIONS INVOLVED IN BIOFORTIFICATION

The Consultative Group on International Agricultural Research (CGIAR) is a global agriculture research association dedicated to ensuring food security in the future. Harvest Plus is part of the CGIAR on Agriculture for nutrition and health and advances public health and nutrition by producing and marketing vitamin and mineral-rich biofortified food crops, as well as offering global leadership on biofortification evidence and technology. Harvest Plus is based at the International Food Policy Research Institute (IFPRI), and it works with a number of CGIAR centers and partners. Under the Harvest Plus initiative, biofortification research began in the 1990s. Furthermore, given the likelihood of a large population rise in the developing countries over the next few decades, as well as changing climate circumstances, achieving food security will become more difficult. Other organisations such as the World Health Organization, The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Rice Research Institute (IRRI) International Maize and Wheat Improvement Center (CIMMYT), International Center for Tropical Agriculture (CIAT) and National biofortification research programmes have been established to address all aspects of strategy development for research and development of nutritionally enhanced high-yielding biofortified crops.