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POLICY BRIEF

Combating Hidden Hunger through Micro-Nutrient Dense Biofortified Foods

OPPORTUNITIES AND CHALLENGES

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Background

The burden of malnutrition in the world is unacceptably high and is estimated to adversely affect two billion people. The extent of 'hidden hunger' in South Asia is much more widespread than other parts of the world. Anemia among pregnant women (52%) and children of less than five years (58%) in South Asia exceeds the global prevalence (38 and 43%, respectively) as does inadequate zinc intake (at 30% vs. 17%), apart from alarmingly high Vitamin A deficiency to the extent of 31-57% of preschool children. Nearly 45% of children deaths are associated with malnutrition (Harding et al., 2018). Climate change further aggravates this burden of malnutrition in South Asia by reducing iron, zinc and protein in plants like wheat, rice, maize and soybean (Myers et al., 2014). Micro-nutrient deficiencies result in poor health, low cognitive development, low educational outcomes, work productivity and earnings thereby reducing the total welfare in the society. The situation is much more depressing in India with a huge malnutrition related cost of 9.1 million disability adjusted life years and a reduction of national income by 4%.

The diets of the poor in developing countries do not contain required level of micro-nutrient dense foods like dairy and livestock products, fruits, vegetables and pulses. While investments in improvement of staple crops drove down food prices for a long time in the aftermath of the Green Revolution, other foods are both inaccessible and also unaffordable. Therefore, markets fail to bring about dietary diversity needed for nutritional security and state has to play an active role through the alternative ways in the form of supplementation, fortification and the new route called biofortification.

Biofortification is a process of increasing the density of vitamins and minerals in a crop through conventional plant breeding techniques. While fortified foods reach urban areas, rural people consuming staple crop based diets can access biofortified crops. The level of nutrients in biofortified crops cannot be as high as in industrial fortified foods, but can increase daily adequacy of micronutrient intakes. Biofortification complements the existing interventions to provide micronutrients to vulnerable population in a relatively easy, cost effective and sustainable manner. Additionally, predominantly rural nature of poverty and vibrant seed markets place South Asia in an advantageous position in harnessing biofortification. Led by pioneering work of HarvestPlus of the International Food Policy Research Institute with the help of several international organizations, these crops have been diffusing gradually in developing countries. Cultivated by 6.7 million farming households across 14 countries of Africa, Asia and Latin America and the Caribbean in 2017 and benefitting 33 million people, biofortification has a positive impact in reducing hidden hunger especially among lower income groups (Bouis, Saltzman and Birol, 2019).

Biofortification for combating malnutrition

The consumption of biofortified crops by farm households in rural areas help reduction of malnutrition initially and later the urban households as markets develop for these foods. A synthesis of extant literature reveals that these crops provide 35-50% of micronutrients. For children of 4 to 6 years old and for non-pregnant, non-lactating women of reproductive age, biofortification provides an additional 35 percent of the estimated average requirement (EAR) of iron in beans and 40 percent in pearl millet. The additional zinc in wheat and rice provides up to 25 percent and 40 percent of the EAR, respectively. These crops provide the maximum EAR of 50% in case of vitamin A in cassava, maize, and sweet potato.

Randomized control trials conducted in India on the effectiveness of biofortified crops for circumventing micronutrient deficiencies showed positive results. When iron and zinc fortified pearl millet is fed to children aged two years as the major food staple, the quantities of both iron and zinc absorbed is more than adequate to meet the physiological requirements of iron and over 80% of the physiological zinc requirement. Another study found that children eating roti and a savory snack (sev) made with biofortified pearl millet were 64% more likely to become iron replete by six months and reverse the deficiency by increasing serum ferritin and total body iron and also improves cognitive skills like attention, memory and lower reaction time in school children. Eating the high-zinc wheat in New Delhi as whole wheat flour chapatti or porridge resulted in 17% and 39% fewer days with pneumonia and vomiting in children and 9% fewer days with fever in women (Sazawal et al., 2018).

Biofortification is one of the most cost effective solutions to combat hidden hunger as per the Copenhagen Consensus. Studies show that every dollar spent on biofortification provides a benefit worth 17 dollars, apart from the agronomical gains with these crops. It is now proven that this process of infusing micronutrients into cultivars does not entail a yield penalty and in fact help plants in growth and yield (Yadava, Hossain and Mohapatra, 2018). Ex ante studies from India and other countries found that the internal rates of return in the pessimistic scenario are

Table 1: Progress in release of biofortified crop varieties in India

Crop	Variety/Hybrid	Improved vitamin/ Mineral/amino	Developer
Pearl millet	ICTP 8203 ICMH 1201	Iron	HarvestPlus ICAR
	HHB 299,	Iron and Zinc	Chaudhary Charan Sing-Haryana Agrl University&ICRISAT
	AHB 1200	Iron	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani under AICRIP of ICAR
Rice	DRR Dhan 45, DRR Dhan 49	zinc	Indian Institute of Rice Research, Hyderabad
	CR Dhan 310	Protein	National Rice Research Institute, Cuttack
	CR Dhan 311	Protein and zinc	National Rice Research Institute, Cuttack
Wheat	BHU 3 and BHU 6	Zinc	HarvestPlus
	WB 02	Zinc and iron	Indian Institute of Wheat and Barley Research, Karnal
	HPBW 01	Iron and zinc	Punjab Agricultural University, Ludhiana
	Pusa Tejas, Pusa Ujala	Protein, iron and zinc	ICAR-IARI, Regional Station, Indore
	MACS 4028	Protein, iron and zinc	Agharkar Research Institute, Pune
Sweet potato	Orange fleshed Sweet Potato	Vitamin A	HarvestPlus
	Bhu Krishna	Anthocyanin	ICAR
Maize	Pusa Vivek QPM9 Improved	Provitamin A, Lysine and Tryptophan	Indian Agricultural Research Institute, New Delhi
	Pusa HM4 Improved	Tryptophan and Lysine	IARI, New Delhi
	Pusa HM8 Improved	Tryptophan and Lysine	IARI, New Delhi
	Pusa HM9 Improved	Tryptophan and Lysine	IARI, New Delhi
Lentil	Pusa Ageti Masoor	Iron	IARI, New Delhi
	IPL 220	Iron and zinc	Indian Institute of Pulse Research, Kanpur
Soybean	NRC-127	KTI-free	Indian Institute of Soybean Research, Indore
Mustard	Pusa Mustard 30	Low erucic acid	IARI, New Delhi
	Pusa Double Zero Mustard 31	Low erucic acid and low glucosilates	IARI, New Delhi
Cauliflower	Pusa beta Kesari 1	Beta carotene	IARI, New Delhi
Potato	Bhu sona	Beta carotene	Central Tuber Crops Research Institute, Trivendrum
Pomegranate	Solapur lal	Iron, Zinc and Vitamin C	National Research on Pomegranate, Pune

Source: Yadava et al., (2018)

also as high as 61%, 53% and 35% for iron, zinc and pro-vitamin A biofortification.

More than 290 varieties of 12 biofortified crops, including key staples such as iron beans and pearl millet; vitamin A cassava, maize, and orange sweet potato (OSP); zinc maize, rice and wheat, have been officially released in over 30 countries (Bouis, Saltzman and Birol, 2019). The deliberate efforts by Indian Council of Agricultural Research (ICAR) to harness this process resulted in the release of several biofortified crop varieties in India with the active support from HarvestPlus (Table 1). The trajectory of biofortified crops in India started with the release of iron-rich ICTP 8203 pearl millet variety by the ICRISAT in 2012 followed by several hybrids like Dhanshakti, ICMH1201 with 65-74 ppm iron. These are commercialized by different private companies under license from public developers and some of them were included in the Nutri-Farm pilot program of government of India

HarvestPlus and its partners have developed wheat lines that can achieve zinc concentration of 60-70 ppm to add 20-25 ppm in daily diet of children and reproductive age women (Sazawal et al., 2018). Similarly, high zinc and high protein varieties are released in rice for cultivation in several states of India. While high zinc rice- Dhan 45 is being cultivated, protein rich CR Dhan 310 is diffusing faster in Odisha due to its popular base Naveen. Ex ante studies at the Directorate of Rice Research, Hyderabad showed that iron zinc can reduce zinc deficiency upto 35% and quite cost effective with as low as three dollars for each life year saved. They also find that the agronomic performance of Dhan 45 is similar to the local check with lower cost of production. Several multi-nutrient rich cultivators are also released to simultaneously address deficiency of several nutrients as shown in Table 1.

Value chain development

Value chain development for biofortified foods necessitates action at all nodes of the value chain across consumers, food retailers, wholesalers, processors, aggregators, farmers, seed developers and breeders, besides engaging with the policy makers and enablers like NGOs. Studies in several countries have found biofortified varieties of staple crops to be acceptable or preferred by consumers. However, consumers do not prefer to trade off nutrition attributes with consumption attributes as evidenced in case of iron beans in Rwanda. Most studies indicate that there is a need for segmented and targeted communication strategies due to the preference heterogeneity of respondents. Short messages are as effective as longer ones and to be preferred on cost considerations.

Experiences with diffusion of high-iron pearl millet varieties in India reveal that invisibility of the trait, lack of segregation of grains, poor shelf life and lack of suitable varieties for Rabi crop are some of the problems. They also note that it is crucial to link these crops with value-addition industries to ensure sustainability in the longer run. Small and medium size companies can play a role in creating demand for biofortified grain and food even before supplies reach scale, while the interest of multinational companies is slower to develop. The availability of infrastructure in the form of effective seed markets that can spread technology is crucial and countries like India are well placed in this regard. While private sector participation is essential in creating sustainable markets for biofortified seed and foods, NGOs remain important in delivering this nutrition information to vulnerable households. The existing partnership between World Vision and HarvestPlus is an example of this.

Global experiences

The experiences so far, mostly in African countries, indicate that the unique feature of development of these value chains is the centrality of behavioral change communication (BCC), alien to other agricultural programmes and common in health related interventions. As already mentioned, short and brief messages customized to local culture and context will have maximum impact in creation of demand for cultivation and consumption. Preliminary findings from field trials in Uttar Pradesh by the Tata-Cornell Institute for Agriculture and Nutrition (TCI) indicate that new crops with micronutrient dense crops can be introduced and foods can be popularized using social marketing techniques. Demonstration plots with these crops and product development using the biofortified crop varieties will go a long way too. Positive response was reported in case of music concerts on healthy eating, movies, radio programs, jingles and advertisements, competitions, engagement with extension workers, monitoring visits, broadcasting in convenient time, radio DJs with loyal following, customizing dramas to local context and language.

The trajectory so far centered on coaxing producers and this indicates the insipient nature of biofortified crop value chain development. Market research by HarvestPlus indicates that consumers are wary of mixing of non-biofortified with biofortified foods as they cannot be physically differentiated. Therefore, brand building assumes significance. Promoting their consumption requires nuanced approach to attract different age groups. Despite a general contagion effect, social learning does not help in diffusing their cultivation, as studies found farmers to stifle information so that their first mover advantage continues. Vibrancy of seed markets determines the strategy for diffusing among growers. Where seed markets are fully functional like in India and Zambia, biofortified crop varieties can be licensed to companies. The general approach, in most country contexts, is a mix of engaging with public and private sectors. As Wolfgang Pfeiffer, Director of HarvestPlus breeding programs informs superior agronomic traits of biofortified crop varieties possess better adoptability and related characteristics and find favor with growers in most cases. For example, shorter duration and submergence tolerance of zinc rice made it popular in Bangladesh. Improving shelf-life and extending cultivation to cool season in case of pearl millet is expected to improve high-iron pearl millet reach in both cultivation and food products. There is a need at this stage to engage with food processors and retailers that are armed with methods of detection of nutrients and certification.

Ways forward

Biofortification has the potential to ameliorate malnutrition and its adverse consequences, as a part of comprehensive approach with other interventions. However, dietary diversification is the way forward for nutritional security in the long run. It needs to be underlined that biofortification has just progressed beyond orange fleshed sweet potato with large number of varieties in several crops. This will be increasingly cost effective as biofortification needs investment only at the breeding stage. The major challenges are mainstreaming the nutrient traits and establishing criteria for minimum micronutrient levels for crop varieties. The ministries of agriculture and health need to collaborate, for communication issues, with other governmental organizations and stakeholders. Two other important requisites for value chain development are product labeling for biofortified grains and processed foods and detection kits for easily and cheaply determining the levels of micronutrients in food products

Several food products are developed from high iron pearl millet and zinc wheat and demand generation is the key through processors and private retailers as well as by including in mid-day meal scheme and pubic distribution. Scaling up would also require development of niches by elevated research into the kind of food products with appropriate labels to attract urban consumers. The current studies on consumer acceptance and willingness depend on the scanty data of only few crops like sweet potato and cassava. Consumption of multiple biofortified crops together is an area that needs further research to understand the interactions and impact on nutrient intake, nutrition and health. Robust new trials might be undertaken to test the efficacy of these crops for a wider range of age and gender groups, including infants and over longer time period.

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