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Letter to the Editor

Biofortification-enabled strategies to mitigate the challenges of malnutrition

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Scientific and technological intervention have significantly contributed to global food security, especially due to the enabling technologies during the so-called Green-revolution era. However, ending all kinds of hunger poses a daunting challenge to fulfill the food and nutritional demands of the ever-growing human population. Hidden hunger also referred as malnutrition is very common problem in the developing countries in Sub-Sahara Africa and South Asia. Consistent with malnutrition, an associated challenge is to improve the health-benefits of food crops to overcome the problems of obesity, type II diabetes, cardiovascular diseases, and some types of cancer by developing functional foods. Biofortification of food crops, especially staple crops like rice, wheat and maize by using innovative genomics and breeding technologies should be given priority to overcome this formidable challenge.

Globally more than two billion people suffer from malnutrition deficiency, which has serious consequences by increasing the economic burden on the health providing facilities. Both iron (Fe) and zinc (Zn) are important cofactors of major enzymes, that are essential for normal growth and metabolism of the human body. The dietary deficiency of iron contributes to anemia in approximately 25% of the global population. Similarly, zinc deficiency undermines immune system development and causes stunted growth in women of reproductive age (WRA) and children under 5 years of age. According to an estimate ~17% of world population is affected by Zn deficiency. Most African as well as developing nations like Bangladesh, Pakistan, and India have significant rates of malnutrition. For instance, in Pakistan, a significant proportion of WRA and children under 5 years age suffer from zinc (22.1% and 18.6%) and iron (18.2% and 28.6%) deficiencies.

The elevation of hidden hunger in developing countries has urged the need to understand the underlying mechanisms of mineral concentration and increasing micronutrient levels of cereal crops by sustainable approaches. Numerous techniques, including dietary and mineral supplementation, post-harvest fortification, and biofortification, can be used to increase the mineral concentration of cereals. Among these, biofortification is the most sustainable approach that increases the mineral levels in edible parts of crops by applying genomic, biotechnology and breeding techniques. However, a detailed knowledge of complex homeostatic mechanisms and genetic networks involved in regulation of Fe and zinc homeostasis in wheat is required for successful biofortification of wheat through genomic resources. Over the years, several genes with major effects on biofortification traits have been discovered, however their deployment in breeding is still lagging. A classic example is the

Gpc-B1 genes discovered in 2006 and the ability to increase grain protein, iron, and zinc by 30% in bread wheat. However, this gene was introgressed from *Triticum dicoccoides* and have serious yield penalties which hinder its deployment in the breeding programs. Recently, a NAC transcription factor that regulates iron content in the maize kernels was identified. A sequence structural variation in the promoter region of the NAC78 significantly correlated with the expression of NAC78 in the endosperm transfer cells and increased the iron contents in the maize kernels by two-folds. These approaches have substantial contribution and demonstrate the enabling technologies available to fortify the cereals to combat the problems of malnutrition deficiency.

Another area of immediate attention is the improvement of bioactive compounds in cereal grains to develop nutritional foods with health-benefits. Based on epidemiological evidence from last 30 years based on both observational and interventional studies, there is no doubt that increased whole grain consumption may bring various health benefits such as reduced risk of obesity, type II diabetes, cardiovascular diseases, and some types of cancer. The health benefits of whole grains have been partially attributed to its dietary fiber and unique phytochemical profiles. A broad family of beneficial phytonutrients known as phenolic chemicals provide several health benefits in addition to enhancing the wheat's color, taste, and nutritional content, and are 15-18-fold higher concentrated in the bran and aleurone layers of the wheat grain. However, there is no major gene discovered so far which can be used in the development of functional cereals for improved health benefits. We argue that despite significant discoveries at the scientific front, the application of these technologies for breeding to improve nutritional quality is slow. The International Maize and Wheat Improvement Center (CIMMYT) in collaboration with harvest Plus is actively involved in developing and disseminating high-yielding Zn biofortified cereals to South Asian countries including India and Pakistan, and most of the varieties developed and deployed by harvest Plus are the product of conventional breeding technologies. A rapid transit is needed to harness the benefits of new breeding technologies for nutritional security and health benefits.