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BIOFORTIFICATION THE KEY TO ADDRESS MALNUTRITION

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Malnutrition affects more than two billion individuals, Africa and Asia being the most affected regions Grew *et al.*, (2018). “Biofortification” is defined as the production of nutritionally enhanced food crops using modern biotechnological techniques, conventional plant breeding, and agronomic practices Garg *et al*., (2018). Traditionally the prime focus of our agricultural system is increasing grain yield and crop productivity, leading to the rapid rise in micronutrient deficiency in food grains followed by among the consumers. Recent trends shows a shift in the focus to the production of nutrient-rich food crops in sufficient quantity Khush *et al*., (2012).

Need For Biofortification Research

The primary source of nutrients is agricultural products, especially for those living in developing countries Graham *et al*., (2001). The diet includes rice, wheat, maize, cassava which are insufficient in nutrients like vitamin A, iron, zinc, calcium, copper, magnesium etc. These nutrient deficiencies cannot support a healthy life, thus resulting in poor health, stunted growth, reduced socio-economic development Chizuru *et al*., (2003). Globally, 38% of pregnant women and 43% of pre-school children are affected by malnutrition. Biofortification can enhance the desired nutrition in the edible portion of the crop plant and help in lowering the statistics. Moreover, biofortifying the crops consumed by the poor population around the world can be a targeted approach for improving the amount of nutrient consumed by the population Brinch *et al.*, (2007).

Transgenic Approach For Biofortification

Transgenic methods are useful where there is limited or no genetic variation among the plant varieties related to nutrient content Brinch *et al*., (2007). Hence, when a particular nutrient is not present naturally in the crop, the transgenic approach is the only way to fortify this crop with the nutrient Perez *et al*., (2013). The transgenic approach helps in the incorporation of the genes that help in increasing micronutrient level, reduce the presence of antinutrient elements. The development of crops through these approaches need a substantial amount of time, investment, effort, but it is a cost-effective and sustainable approach Das *et al*., (2013). In wheat, provitamin A content is enhanced by expressing bacterial PSY and carotene desaturase genes [CrtB, CrtI] Wang *et al*., (2014). Iron content enhanced by expression of ferritin gene from soybean Xiaoyan *et al*., (2012) and wheat [TaFer1-A] Borg *et al*., (2012). Protein content enhanced by using Amaranthus albumin gene [ama1] Tamas *et al*., (2009).

Agronomic Approach for Biofortification

The agronomic method needs the physical application of nutrients for improving temporarily the nutritional and health status of crops followed by the nutritional status of consumers Cakmak *et al*., (2017). Micronutrients like iron, zinc, copper, magnesium etc., are found in different proportion in edible parts of the plant, which are generally absorbed from the soil. Thus, increasing the soil nutrient status can lead to reduced malnutrition in the population Cakmak *et al*., (2008). This approach is simple and inexpensive but requires extra attention to application methods, source of nutrients and environmental effect. Soil microorganisms like *Azotobacter*, *Bacillus, Rhizobium*, *Pseudomonas,* etc., can also be used to increase the Phyto-availability of nutrients Smith *et al*., (2007). Foliar application of urea with iron inclusion has a positive correlation with high iron accumulation Aciksoz *et al*., (2011). Foliar application of zinc reduces the amount of antinutrient element (phytic acid) and reduce zinc deficiency in the consumer population Yang *et al*., (2011). Moreover, mycorrhizal fungi, along with fertilizers, are used extensively for biofortification Nooria*et al*., (2014). zinc biofortification was also achieved by using *Bacillus aryabhattai* Ramesh *et al*., (2014).

Conventional Breeding Approach for Biofortification

This is the most acceptable approach for biofortification and is a sustainable, cost effective alternative to the transgenic and agronomic approach. Sufficient genotypic variation is needed to make this approach feasible. Here, the parent lines with high nutrient contents are crossed with the lines with desirable agronomic traits for many generations to obtain plants with desired nutrient and agronomic traits. Sometimes distant relatives can also be used in the crosses. Mutagenesis can be an alternative method to introduce variation Garg *et al*., (2018). Closely related wild relatives of wheat with wide variation in grain iron and zinc concentration can be used for exploitation of modern elite cultivars Monasterio*et al*., (2000). Six high zinc wheat varieties released in India (2014)- BHU 1, BHU 3, BHU 5, BHU 6, BHU 7, and BHU 18. In Pakistan (2015)-NR 419, 42, 421, and Zincol. WB2 is high in iron and zinc content developed by the Indian Institute of Wheat and Barley Research. High provitamin A durum wheat variety (HI 8627) has been released by the Indian Agricultural Research Institute (IARI), India, in 2005. Black grain wheat in China rich in protein and selenium Li *et al*., (2006). The purple wheat cultivar (Indigo) released in Austria in 2006 Eticha *et al*., (2011).

Limitations

Agronomic approach- The success rates are highly variable due to difference in mineral mobility, soil composition in specific geographical areas, mineral accumulation in plant species Ismail *et al*., (2007). It is less cost effective and labour intensive, demands continuous input of micronutrients on a regular basis. Many times it's not possible to target the edible portion of the plant for nutrient accumulation. For example- in Turkey, the cereals absorbed a high amount of zinc from the soil, but the accumulation of the zinc was not in the grain Cakmak *et al*., (1999).Accumulation of antinutrient elements (phytic acid) is one of the limitations Frossard *et al*., (2000). Moreover, the accumulation of such fertilizers in soil and water also posses a setback Waters *et al*., (2011).

Conventional breeding approach- The major limitation is the availability of genetic variation. It is a time taking process. Sometimes it may be impossible to breed for specific traits by conventional means. Example- improving Se concentration in wheat grains Lyons *et al*., (2005).

Transgenic approach- The major limitation is the low acceptance among the masses. Another major limitation is different countries have adopted different regulatory processes for the acceptance and commercialization of these transgenic crops Inaba *et al*., (2004). The regulatory process is very expensive and time-consuming Watanabe *et al*., (2005)—example- the case of Bt-brinjal.

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Conclusion

Biofortification is a promising, cost effective strategy for combating malnutrition in the population throughout the world. The generation of biofortified crops with enhanced nutrition especially increased content of iron, zinc, provitamin A etc., can provide a sufficient level of these and other micronutrients that are frequently lacking in the diets of developing and developed countries. Many international initiatives, like Harvest Plus programs and national programs, act as a pillar to achieve the target. Traditional breeding approaches are widely accepted rather than transgenic approach. Transgenically fortified crop plants have to face difficulties due to acceptance constraints among consumers and different expensive and time-consuming regulatory approval processes adopted by different countries. Biofortified crops have a bright future and have the capacity to reduce malnutrition cases in developing countries.

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