Vol. 3 Issue-4, December 2022 (e-ISSN: 2582-8223)

Bio Fortification Strategies to Improve Nutritional Status of Cereals and Pulses

Anju Bala[*], Eshanee[1], Akashdeep Singh[2] and Akshita Awasthi[3]
*Department of Agronomy, Punjab Agricultural University Ludhiana, Punjab 141004
[1]Department of Vegetable Sciences, Punjab Agricultural University Ludhiana, Punjab 141004
[2]Department of Agronomy, CSK HPKV Palampur, Himachal Pradesh, India 176062
[3]Department of Plant Breeding and Genetics, Punjab Agricultural University Ludhiana, Punjab 141004

ARTICLE ID: 05

Introduction

Access to a healthy diet is a fundamental right of all human beings. A large fraction of the world's population, particularly in developing countries, suffers from vitamin and mineral deficiencies. According to the United Nations Food and Agriculture Organization, around 792.5 million people worldwide are malnourished, out of which 780 million people live in developing countries. Apart from this, around two billion people in the world suffer from "hidden hunger," which is caused by an inadequate intake of necessary micronutrients in the daily diet. So far, our agricultural system only focuses on increasing crop yield and crop productivity rather than nutritional security. This approach has led to a rapid rise in micronutrient deficiency in food grains and among consumers. The gradual transition from producing more food crops to producing nutrient-rich crops will aid in fighting "hidden hunger" or "micronutrient malnutrition", especially in poor and developing countries, where diets are dominated by micronutrient-poor staple food crops.

Traditionally, nutrient supplementation programs have been organized for providing vitamins and minerals to the people, but these programs are unable to meet the targets set by international health organizations since they exclusively rely on funding. Other limitations include the lack of knowledge about the long-term health advantages of these nutritional supplements, lack of purchasing power, and access to markets and healthcare systems. Therefore, the biofortification of different crop varieties is the key to providing micronutrient-rich food to people. The process of enhancing the concentration of vitamins and minerals in a crop by plant breeding, transgenic technology, or agronomic approaches is known as biofortification. The biofortified crops with higher bioavailable concentrations of essential micronutrients are delivered to consumers and provide an effective means of reaching undernourished and low-income group families with limited access to a variety of diets, supplements, and fortified foods. The primary objective of the biofortification strategy is to decrease the mortality and morbidity rates associated with micronutrient deficiency and to improve the quality of life, productivity, and nutritional security of the underprivileged populations of developing nations.

Need to biofortify cereals and pulses

Rice, wheat, maize, sorghum, barley, millets, and oats are the commonly cultivated cereal crops. Rice is a leading cause of hidden hunger in rice-eating areas because it is deficient in iron (Fe), zinc (Zn), and pro-vitamin A. Wheat requires biofortification to ensure adequate provision of zinc, iron, selenium, pro-vitamin A, grain yellow pigment contents (GYPC), grain anthocyanins, and essential amino acids. Maize lacks vitamin E as well as important antioxidants, vitamin C, vitamin A, anti-nutrient components, and quality protein. To improve the nutritional quality of vital zein proteins, tryptophan and lysine content should be increased.

About 1,000 pulses are known to humans but only 20 of them are cultivated for human consumption. Pulses are deficient in iron and zinc contents like the major cereal crops. They are also deficient in dietary fibres, selenium, and sulphur-containing amino acids including cysteine and methionine. Although pulses are a rich source of proteins and micronutrients, some anti-nutrients limit protein and nutrient bioavailability, such as lectins, phytic acid, saponins, lathyrogens, protease inhibitors, amylase inhibitors, and tannins, which also restrict the absorption of iron, zinc, calcium, magnesium, and other essential nutrients. There is a need to understand the metabolic pathway involved in the synthesis of these compounds and the disruption of key genes involved in their production.

Approaches of biofortification

Agronomic approach:

Agronomic biofortification is the application of fertilizers containing mineral elements deficient in the diet to raise their concentrations in crops by soil or foliar application. The efficiency of agronomic biofortification is highly dependent on the bioavailability of micronutrients throughout the entire pathway from soil to plant, food, and into the human body. This approach is simple and economical, but it requires specific consideration in terms of nutrient supply, application method, and environmental impacts. When micronutrient-enriched fertilizers are applied in appropriate amounts then they generally improve soil fertility and crop productivity and prevent the serious negative effect on the environment.

Conventional breeding

Conventional plant breeding is the tool for enhancing the concentration of essential nutrients in the crops by improving the cultivars through conservative manipulation of plant genomes within their natural genetic boundaries. Biofortification through conventional breeding is a widely accepted way of biofortification. It provides a sustainable and cost-effective alternative to transgenic and agronomic techniques. For successful conventional breeding, sufficient genotypic variation in the trait of interest is required. In this, over several generations parent lines with rich nutrients are crossed with recipient lines with suitable agronomic qualities to generate plants with desired nutrient and agronomic traits. However, sometimes breeding strategies have to depend on the limited genetic variation present in the gene pool. In some cases, this can be addressed by crossing to distant relatives and thus moving the trait gradually into the commercial cultivars. Alternatively, the introduction of new traits into commercial varieties can be done with the help of mutagenesis.

Transgenic breeding:

The transgenic breeding method is used for biofortification when there is limited or no genetic variation in nutrient content among crop varieties. It is based on access to an infinite genetic pool for the transfer and expression of desirable genes from one species to another, regardless of evolutionary or taxonomic status. The development of transgenic crops depends on the ability to identify and characterize gene function and then utilize these genes to engineer plant metabolism. Transgenic techniques can also be employed for the simultaneous incorporation of genes associated with the improvement of micronutrient concentration, bioavailability, and the reduction of antinutrient concentrations, which limit nutrient bioavailability in plants. Furthermore, genetic modifications can be used to redistribute micronutrients among tissues, increase the concentration of micronutrients in edible regions of commercial crops, improve the efficiency of biochemical pathways in edible tissues, or even reconstruct of selected pathways. Transgenic development, unlike nutrition-based organizational and agronomic biofortification programs, requires significant

JUST AGRICULTURE
multidisciplinary e-Newsletter

expenditures, efforts, and commitment during the research and development stage, but in the long term, it is a cost-effective and sustainable method. The first transgenic biofortified crop to be developed was golden rice.

In addition to the transgenic approach, targeted gene editing tools, such as synthetic nucleases, ZFNs, TALENs, and CRISPR/Cas9, have made it feasible to accurately manipulate the target gene and, as a result, show considerable potential for genetic crop improvement. Out of these techniques CRISPR/Cas9 is extensively popular in crops.

Conclusion:

The green revolution made us self-sufficient in food grain production but now we need to have such food grains which make us free from hidden hunger. We need to move towards the quality enhancement of the staple food crops. The familiarity of dietary diversity must be followed up to mitigate micronutrient malnutrition. A promising agricultural-based method for enhancing the nutritional status of undernourished people across the world is bio fortification. Bio fortification is the process of enhancing the nutritional value of vegetables utilising a variety of techniques, such as conventional breeding, genetic engineering, and agronomic management methods. Agronomists, plant breeders, and molecular biologists working together is essential to attaining these objectives. The lengthy and expensive regulatory approval process is the main barrier to the commercialization of GM crops. Finally, major funds should be allocated to bio fortification initiatives. If these challenges could be overcome then bio fortified crops can have a great role in alleviating micronutrient deficiency problems in people especially in the developing countries. Bio fortification can be a great initiative to achieve “Zero Hunger”.

References

Gulave, C.M. and Kshirsagar, A.V. (2020). Biofortified varieties: Way to build nutritional immunity to fight against Covid-19 pandemic- A review. *Journal of Pharmacognosy and Phytochemistry*. **9**(4): 219-221

Khush, G.S., Lee, S., Cho, J. and Jeon, J.S. (2012). Biofortification of crops for reducing malnutrition. *Plant Biotechnology Reports*. **6**:195–202

Shahzad, R., Jamil, S., Ahmad, S., Nisar, A., Khan, S., Amina, Z., Kanwal, S., Aslam, H.M.U., Gill, R.A. and Zhou, W. (2021). Biofortification of Cereals and Pulses Using

New Breeding Techniques: Current and Future Perspectives. *Frontiers in Nutrition*. https://doi.org/10.3389/fnut.2021.721728