

NUTRIENT MANAGEMENT IN SOIL AND PLANTS THROUGH BIO-FORTIFICATION

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ABSTRACT

The method of production which protects the soil, environment and people is the organic farming. The fertility of the soil is raised by means of recycling waste, vermicomposting, using manures, and green manuring. The application of organic nutrients to satisfy demand from agriculture is the primary challenge in organic farming. Biofertilizers and cover crops, which might help in recycling the soil's nutrients, might also be employed to manage the nutrients. Utilizing an array of sources, like compost, manure, and biofertilizers, maintain the nutrients in organic management. The plant's nutrition impacts not only its higher yield but additionally its nutritional requirements, which involve proteins, vitamins, and minerals. Different nutrients have their own restrictions which results from a range of factors such as temperature, changes in climatic patterns, time of application, crop tolerance etc. A small number of micronutrients plays an important role in nutrition of the food which makes them easier to assess in the parts that are edible by the way that are used. In applications to crop that generates nutritional value for human, biofortification is found to be significantly more economical than related interventions such as supplementation and fortification.

Keywords: *Nutrient management, Biofortification, Micronutrients, Supplementation*

INTRODUCTION

The primary supplier of essential minerals for the plant growth and for the long-time agricultural output is soil. The gaps in the term of nutrient input and output in soil is the indicator of the soil fertility which is additionally useful to determine that how effectively the nutrients are used in the agricultural system (Cobo et al., 2010). The broad spectrum of complex factors can be utilized to identify the proper concentration of the elements which are found in the soil. The decreased amount in fertility of the soil in the dry climate area might be due to a variety of causes, such as low precipitation, elevated temperatures, cultivating, crop waste removal, and synthetic fertilizer use (Alvarenga et al., 2017).

The decrease of nutrients in soil can be attributed to an array of variables, such as chemical, biological, and physical components. The soil's density, nutritional status of soil microorganisms, and ground capacity for holding water constitute a few of the major factors causing organic matter in the soil to decrease (Zhang et al., 2014). Furthermore, adverse conditions of the soil influence the development of plants and the final yield of crops. As consequence, the fertility of the soil can be maintained, and food production turns vital to enhancing and preserving the soil's organic matter by means of the recycling of different organic substances (Sánchez et al., 2019).

Organic farming preserves the well-being of humans, the environment, as well as the agricultural system. It is dependent on the environment, biological activities, and processes which have been modified by surroundings and minimizes its negative contribution. The history, innovations, science all is integrated in organic farming in order to enhance the ecosystem and develop a relationship (Faux et al., 2022). In the organic farming the management of the nutrient must be preserved for enhancing the productivity of soil without leading to the excess loss of the nutrient in addition to the effectively satisfying the nutritional requirements and avoiding the exhaustion of the soil nutrient. Farmers employ various techniques to

minimize the chemical and physical constraints of the soil for the productive growth (Thompson et al., 2021).

According to Bouis *et al.* (2010), biological fortification constitutes a cultivation process which improves the nutritional value of crop residue and is an environmentally friendly means to combat nutritional deficiencies and improve overall health. The bio fortification of nutrition, is improving the nutritional quality of crops, which could enhance future food security (Msungu *et al.*, 2022). It highlights the crucial role of nutrient-dense vegetables in health, particularly those high in vitamins, minerals, and dietary fiber. But individuals, particularly those who live in developed countries, might suffer from deficiencies in nutrients as an outcome from the lack of a balanced and varied diet. Bio fortification offers an effective and beneficial approach to combating the lack of nutrients by improving the nutrient content of the soil as well as the plants (Avnee *et al.*, 2023).

By means of the use of novel biotechnological methods or traditional breeding methods, various biofortification strategies may increase the levels of essential minerals and vitamins such as iron, zinc, vitamin A, and vitamin C (Kumar *et al.*, 2019). Thus, taking into account the growing emphasis on environmentally friendly farming and nutritionally appropriate approaches, biofortification emerges out as an exciting avenue in the fight towards hunger and the nutritional difficulties resulting from it (Wakeel *et al.*, 2018).

2. Biofortification as an instrument to combat micronutrient deficiency

The deficiency of the micronutrient also referred to as “Hidden hunger” since they are not always evident which means that the individuals might experience them without realizing it. Iron, vitamin A, iodine, and zinc deficiencies are serious health risks that contribute to diseases worldwide. Over two million people suffer from a lack of these important micronutrients (Mayer *et al.*, 2008).

Minerals are essential for plant growth, with enriched plants showing increased disease resistance and higher yields, especially in micronutrient-deficient soil. Bio-fortification is a key economic strategy for nutrient management in soil and plants. When new varieties are produced, a lot of bio-fortification resources are used. Once farmers begin growing and cultivating bio-fortified plants, the seeds can be propagated and sold to people in need at low costs to maintain high nutrient quality (Bouis *et al.*, 2010). Compared to other methods that require more money each year, bio-fortification can help those in need over time without requiring extra spending.

3. Approaches for limiting Micronutrient Deficiency in Plants

3.1 Breeding Techniques:

Another effective method for fortifying management of nutrients in the soil and plants is the conventional breeding method. Employing this approach, plant containing higher levels of nutrients are selected then crossed. The cultivars use this approach to develop variants that have enhanced nutritious qualities. Selecting and cultivating wheat varieties that have higher iron and zinc concentrations provides a prime instance (Yadav *et al.*, 2023). Since this approach requires screening across generations to come through the introduction of specific characteristics that are important to specific plants (Strobbe *et al.*, 2018). Marker-based breeding techniques can enhance crop yield by utilizing molecular genotyping markers such as RFLPs, AFLPs, RAPDs, SSRs, DArTs, and SNPs. Among these, SNPs are the most prevalent markers used in plant breeding due to their high genomic frequency (Jiang *et al.*, 2013).

3.2 Agronomic Biofortification:

By improving the agricultural practices which includes the nutrient management of the soil, irrigation techniques, application of the fertilizer, this approach intends to increase content of the nutrients in the plants. The nutritional value of the crops that are grown can be enhanced by modifying the development and giving the plants the nutrients, they require (Moharana *et al.*, 2017).

3.3 Genetic Engineering:

There are certain genes that participate in the synthesis of the nutrients in the plants in order to enhance their production via genetic engineering methods. To improve the nutritional value of the plant’s researches may introduce the genes from various organisms. To combat Vitamin A deficiency where rice is a major

crop the genetically modified varieties of rice have been developed to generate increase amount of Vitamin A (Kumar et al.,2023). The approval of the public for the cultivation of the transgenic crops has decreased because of its high costs and time consumption. Since genetic engineering and various breeding techniques have been developed it now becomes possible to increase the desired traits in the plants (Eckerstorfer *et al.*, 2019).

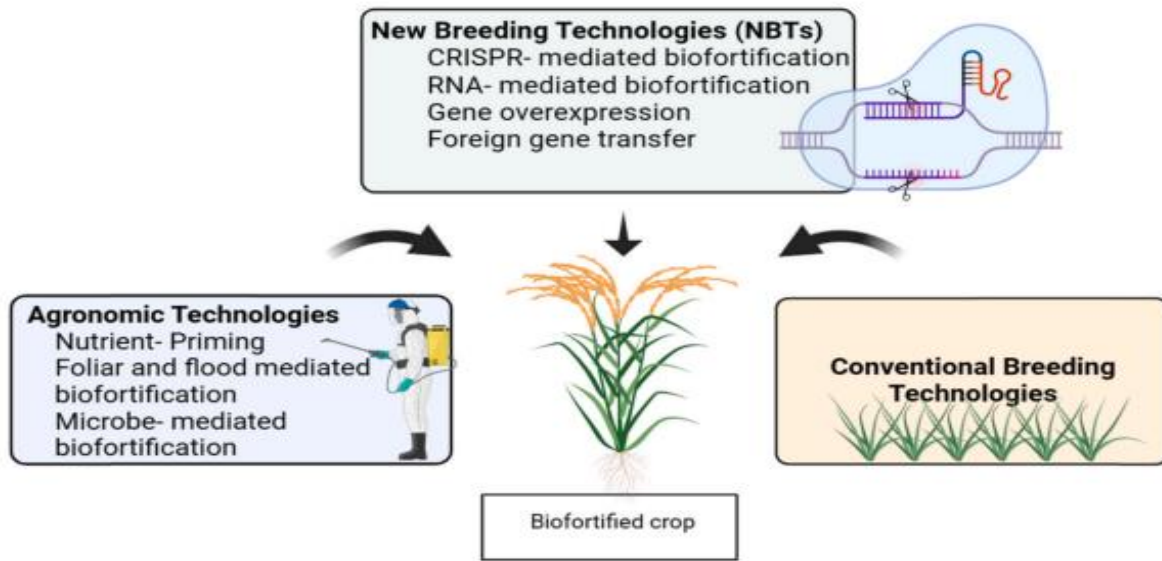


Figure 1: Advanced technologies used in bio fortification of plants. Sandhu *et al.*, 2023,



Figure 2: The benefits of biofortification and Challenges. Srivastav *et al.*, 2022

4. Compared Benefits of Bio-fortification

Biofortification provides various advantages over different techniques of improving human nutrition, as biofortification targets the entire human population through staple foods. Farmers with limited amount cannot afford these products, as these can be incorporated into their meals through alternatives like

Review Article

awareness of their nutritional importance, display of these products, and subsequent implementation. Once a crop is developed with a new genotype, this process can continue with minimal costs, as compared to different techniques of biofortification. These are present in their seeds and products, as fortified seed does not affect crop yield. Other benefits include disease-resistant plants and enhanced agricultural productivity, as shown in Figure 2. By improving the nutritional content of their meals, quality of the crop, and genetic diversity, biofortification can play an important role in solving issues of malnutrition (Nissar *et al.*, 2019).

5. Soil and Plant Nutrient Management via Bio-Fortification

Increasing the nutrient content in the plant needs effective management of the soil which includes various methods like soil enrichment which increases the fertility of the soil by the addition of organic matter. For effective fertilization, the right amount of nutrients should be given to the crops to guarantee the availability of the required nutrients for the growth of the crops. For example, the addition of fertilizers will enhance the concentration of the micronutrient in the crops. The nutrient content of the crops grown in the fields can be enhanced by using different soil management strategies which might include the regular testing of the soil (Meenakshi *et al.*, 2019). The nutritional content of the crops cultivated in the fields will be affected by the changes in the different crop management strategies. the crops enough area for growth, hence affects the nutrient content, the optimal density should be used. The water status of the crops will be maintained through the regular watering of the crops, hence reducing the nutrient leaching from the crops. The nutrient content of the crops will be enhanced through the precise nutrient management strategy which might include the amount of fertilizer to be used (Niranjana *et al.*, 2016).

6. Advancements and Outcomes

There are number of biofortified crops that are meant to increase micronutrient deficiencies in several regions of the world that have been developed and implemented, thus showing how far the field of biofortification has come. Some of the successes that have been achieved include:

Rice: One of the biggest successes that can be cited in biofortification is Golden Rice, which has been used for cultivation and consuming in different countries due to its substantial content of β -carotene, a precursor of vitamin A. Therefore, this shows that biofortification can increase vitamin A deficiency in areas where rice is a staple crop, as cited by Okunlola *et al.* (2016).

Wheat and Beans: Biofortified types of staple foods like wheat and beans have been introduced to areas where there is a high number of micronutrients such as iron and zinc. For example, iron-enriched beans have been introduced to countries where there is a high incidence of iron deficiency, which includes Rwanda and Uganda. Similarly, individuals where wheat is a staple food have benefited from a decrease in zinc deficiency in countries such as Pakistan and India, where amount of the quantity of the zinc in wheat has been introduced (Stein *et al.*, 2020). These examples show the power of conventional breeding in improving the nutritional content of staple food crops.

Sweet Potatoes: Various countries have succeeded in producing and making use of transgenic varieties of sweet potatoes, which are rich in beta-carotene. For countries where sweet potatoes are the main food source, it has been an effective strategy for dealing with Vitamin A Deficiency, considering the availability of Vitamin A from such crops. Genetic engineering has been successfully used to increase the nutritional value of commonly eaten foods by creating and using these crops (Saltzman *et al.*, 2017). This progress has shown great promise for improving nutritional standards and dealing with nutritional deficiencies (Haug *et al.*, 2019). Progress in the field of global nutrition and health relies up on the continued research and utilization of such crops, particularly for countries where food items are the primary source of sustenance.

7. Challenges

Biofortification has come a long way, but there are still some problems that keep biofortified crops from being widely used and working well. Some of these problems are:

Genetic Diversity: Genetic diversity in staple crops is limited, constraining biofortification efforts to enhance nutritional value. Addressing this issue requires advanced breeding techniques and exploring genetic resources from landraces and wild relatives, which can improve nutritional content and disease resistance (Chao *et al.*, 2018).

Environmental Factors: The soil and humidity significantly influence plants' nutrient absorption and storage. Factors such as soil fertility, acidity, pH, and humidity can greatly affect the efficiency of biofortification, while environmental variables can also impact plant growth and nutrient absorption capabilities. It is vital to develop varieties of crops capable of change to a variety of environmental circumstances with the aim to achieve constant nutritional enrichment. Knowing how plants interact within their developing environments as well as creating agricultural techniques which promote nutrient uptake are essential to solving these environmental issues (White *et al.*, 2019).

Consumer Approval: For people to accept crops they need to feel good about them. Some might be worried about GMOs. To help we should teach consumers about the health benefits of these crops. We should also let them be part of the development process. This way they will know that biofortified crops are safe and work well. We need to make plans to make resources, environmental factors and consumer awareness better. This will help people overcome their doubts about crops and accept them. Biofortified crops are the key and consumer approval are crucial. It is essential to educate consumers about crops. Consumer awareness, about crops will foster acceptance.

8. Future Perspectives

Further research in biofortification must concentrate on a number of important topics with the goal to optimize the effect of this approach on global nutrition and food security:

Integrative Techniques: In order to improve crop nutritional quantity and overall yield, it is necessary to combine genetic engineering, traditional breeding, and agricultural techniques. Using these methods might result in stronger and abundant in nutrients crops. As an example, traditional breeding may enhance qualities including productivity and resistance to disease, however genetic engineering can add precise nutritionally beneficial genes. Agricultural approaches may be employed thereafter to optimize nutrient intake and accumulation. A systematic strategy assures that every aspect of crop development is tackled, and results in more efficient and sustainable biofortification methods (Babu *et al.*, 2017).

Expansion: Efficient biofortification efforts need to be scaled to include regions and crops so as to address the worldwide micronutrients deficiencies. This implies expanding current initiatives to encompass larger populations as well as to creating new bio fortified varieties for an array of staple foods. Ensuring biofortified crops easily available to the most vulnerable individuals is important. Attempts should be made to adapt biofortification techniques to region agricultural and nutritional requirements in addition to developing infrastructures enabling the delivery and uptake of these crops (Anderson *et al.*, 2017).

Strategy and Teamwork: Governments, academic institutions, and the commercial sector should collaborate to strengthen policies with the goal to encourage biofortification initiatives. Effective strategies may promote funding for research, and utilization of biofortified crops. Collaboration amongst partners may improve the exchange information, resources, and technology in addition to enable the growth of effective programs. Farmers, scientists, politicians, and entrepreneurs will collaborate to support the viability and efficiency of biofortification projects, aiming to enhance global food security and address micronutrient deficiencies (Islam *et al.*, 2016).

Conclusion

To deal with micronutrient deficiencies biofortification makes conventional crops more nutritious. We can see this with things like Golden Rice, iron-rich beans and zinc-enriched wheat. These show that biofortification can work because of advances in breeding, genetic engineering and agronomy. However, there are some problems that stop these crops from being used. To make biofortification work well we need to think about things like limited genetic diversity, changing environmental conditions and whether people will accept these crops. We should do research to combine different farming and breeding techniques. Biofortification can help a lot of people because biofortification is good, for us. Biofortification can do this by dealing with these issues in a way that makes the world a safer and better place to live. By working on biofortification we can make a difference in global nutrition and food security and that is a great thing, for biofortification.

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