

Role of Nutrients in Biofortification of Food Crops

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ABSTRACT

Nutrient-based biofortification is an emerging concept to enhance the nutritional value of food crops and combat micronutrient malnutrition or “hidden hunger.” Optimal use of macronutrients and micronutrients increases the efficiency of nutrient uptake, translocation, and accumulation in the edible plant parts like grains, fruits, and tubers. Macronutrients such as nitrogen, phosphorus, and potassium, and micronutrients such as iron, zinc, boron, copper, manganese, and selenium are important for enhancing crop productivity as well as food quality. Practices like soil test-based fertilisation, foliar nutrient spraying, integrated nutrient management, and the use of organic manures and beneficial microbes help increase the availability of nutrients and efficient nutrient use. Nutrient-based biofortification is a cost-effective, farmer-friendly, and environmentally safe approach that can be easily practiced in different agro-climatic zones. Therefore, it provides a long-term solution to enhance food and nutritional security. Eating biofortified crops regularly can help overcome micronutrient deficiencies in the vulnerable sections of society. Extension and policy support can further help in improving the adoption of nutrient-based biofortification practices.

INTRODUCTION

Micronutrient malnutrition or “hidden hunger” is an essential nutritional concern that affects a large percentage of people across developing countries (Sheoran *et al.*, 2022; Singh *et al.*, 2016). Malnutrition or deficiency of essential micronutrients like iron, zinc, and vitamins A and C arises due to the widespread prevalence of cereal-based diets (Singh *et al.*, 2016). Therefore, as cereals have emerged as an essential crop in modern agricultural practices, increasing their nutritional content has also emerged as an important aspect of modern crop breeding (Sheoran *et al.*, 2022). Biofortification of cereals and other important food crops is an important contributor to enhancing nutritional content (Singh *et al.*, 2016). The nutrient element contributes significantly to biofortification as it allows for nutrient acquisition or intake of essential micronutrients like nitrogen, phosphorus, potassium, and other essential plant micronutrients (Kumar *et al.*, 2016). Moreover, nutrient management not only optimizes crop productivity; it also optimizes crop quality (Kumar *et al.*, 2016). Therefore, it is important to consider nutrient biofortification as an essential nutrient and plant breeding strategy to ensure food security (Sheoran *et al.*, 2022).

Biofortification of Food Crops

Biofortification aims at enhancing the nutritional content of crops during their life cycle rather than after harvesting (Singh *et al.*, 2016). It aims at the effective utilization of soil and plant nutrients to improve their concentration in grains, fruits, and tubers (Kumar *et al.*, 2016). This method is well-integrated with the existing agricultural system and does not require modifications in food processing and consumer behaviour (Singh *et al.*, 2016). Biofortification also improves the

efficiency of nutrient use in crops and supports sustainable agriculture by associating soil health with human nutrition (Sheoran *et al.*, 2022). Therefore, it is regarded as a feasible method for overcoming micronutrient deficiencies in crops (Singh *et al.*, 2016). Nutrient management ensures effective uptake and translocation of minerals to the edible parts of plants (Kumar *et al.*, 2016). It also ensures the maintenance of crop yield while improving food quality (Kumar *et al.*, 2016). Nutrient addition biofortification can be used for various crops and agro-climatic zones (Sheoran *et al.*, 2022). Therefore, it has a very important role in enhancing food and nutritional security (Sheoran *et al.*, 2022).

Importance of Nutrients in Biofortification

Plant nutrients are very important in the process of nutrient uptake, translocation, and deposition in grains, fruits, and tubers (Kumar *et al.*, 2016). Balanced nutrition not only enhances crop production but also enhances the nutritional status of food crops (Kumar *et al.*, 2016). The unbalanced use of high-yielding varieties and fertilizers has resulted in micronutrient deficiencies in soils, which in turn has contributed to low crop productivity and poor food quality (Singh *et al.*, 2016; Kumar *et al.*, 2016). Nutrients also affect physiological functions like enzyme activity, photosynthesis, and protein synthesis, which in turn regulate the enrichment of nutrients in edible plant parts (Kumar *et al.*, 2016). Soil characteristics, organic matter, and nutrient interactions also affect the availability of nutrients to crops (Kumar *et al.*, 2016). Balanced nutrient use, therefore, is important for successful biofortification (Singh *et al.*, 2016). Balanced nutrient use can enhance soil fertility and the nutritional status of food crops (Kumar *et al.*, 2016).

Role of Macronutrients in Biofortification

Although biofortification is mainly focused on micronutrients, macronutrients have an indirect role in the enrichment of nutrients (Kumar *et al.*, 2016).

Nitrogen (N): It helps in protein production and improves iron and zinc bioavailability (Kumar *et al.*, 2016).

Phosphorus (P): It promotes root development and improves the efficiency of nutrient uptake (Kumar *et al.*, 2016).

Potassium (K): It assists in the transport of nutrients and enhances grain filling and quality (Kumar *et al.*, 2016).

Balanced fertilization of macronutrients provides a favourable condition for the uptake and accumulation of micronutrients in the edible portion of plants (Kumar *et al.*, 2016). Nitrogen fertilisation increases the protein content of grains, thereby enhancing micronutrient binding (Singh *et al.*, 2016). Phosphorus fertilization promotes root development, which in turn helps in effectively exploring the soil nutrients (Kumar *et al.*, 2016). Potassium fertilization helps in maintaining plant health and stress resistance, which in turn helps in efficient transport of nutrients in the plant (Kumar *et al.*, 2016). Biofortification of micronutrients is less effective in macronutrient-deficient plants (Kumar *et al.*, 2016).

Role of Micronutrients in Biofortification

Micronutrients require low amounts but have significant physiological functions in plants and immense importance in human nutrition (Kumar *et al.*, 2016; Singh *et al.*, 2016). Micronutrients affect the activity of enzymes, metabolism, and the concentration of minerals in the edible parts of plants (Kumar *et al.*, 2016). It is therefore important that there be

micronutrients in adequate quantities in the soil to ensure the success of biofortification of food crops (Kumar *et al.*, 2016).

Iron (Fe): Iron is required for the production of chlorophyll and the function of enzymes in plants (Kumar *et al.*, 2016). Iron biofortification is essential as it assists in the prevention of iron deficiency anaemia, which is prevalent among women and children (Singh *et al.*, 2016; Sheoran *et al.*, 2022). Iron is also essential for optimal plant growth and productivity (Kumar *et al.*, 2016).

Zinc (Zn): Zinc is an essential element in enzyme activation, synthesis of protein and growth regulation (Kumar *et al.*, 2016). Zinc-supplemented cereal and pulse grains are beneficial for enhancing the immune system, growth, and overall human health (Sheoran *et al.*, 2022). Zinc treatment also improves the quality of grains and crop productivity (Kumar *et al.*, 2016).

Boron (B): Boron has a very crucial role in cell wall development, pollen viability, and seed production (Kumar *et al.*, 2016). Boron treatment is important as it improves the quality of grains and fruits, hence contributing to the enrichment of nutrients in crops (Kumar *et al.*, 2016).

Copper (Cu): Copper is an important element in photosynthesis, enzyme action, and protein metabolism (Kumar *et al.*, 2016). Copper supplementation is beneficial in promoting plant growth and quality (Kumar *et al.*, 2016).

Manganese (Mn): Manganese is an important element in photosynthesis and nitrogen metabolism because of its role in the activation of various enzymes (Kumar *et al.*, 2016). Proper manganese nutrition is beneficial in promoting plant growth and nutrient utilization (Kumar *et al.*, 2016).

Selenium (Se): Selenium has antioxidant properties and helps to improve plant

resistance to various stresses (Kumar *et al.*, 2016). Selenium-enriched foods help to promote human health by boosting the immune system and fighting oxidative stress (Singh *et al.*, 2016; Sheoran *et al.*, 2022). Agronomic selenium application helps to enhance its concentration in food crops (Kumar *et al.*, 2016).

Agronomic Approaches for Nutrient-Based Biofortification

Biofortification through nutrient approaches can be efficiently carried out by the following simple agronomic practices (Kumar *et al.*, 2016; Singh *et al.*, 2016):

- Soil test-based fertilizer application
- Application of micronutrient-fortified fertilizers
- Foliar application of Fe, Zn, and Se
- Integrated nutrient management (INM)
- Application of organic manures and biofertilizers
- Utilisation of beneficial soil microbes

These practices increase the availability of nutrients in soil and increase the concentration of nutrients in edible plant parts (Kumar *et al.*, 2016). Soil testing allows the correction of particular nutrient deficiencies and prevents the overuse of fertilizers (Kumar *et al.*, 2016). Foliar application ensures rapid absorption of nutrients at crucial growth stages (Kumar *et al.*, 2016).

The use of organic manures and biofertilizers increases the fertility of the soil, hence the solubility of nutrients (Kumar *et al.*, 2016). Combining different agronomic practices makes biofortification a more sustainable approach (Sheoran *et al.*, 2022).

Benefits of Nutrient-Based Biofortification

- Improves the nutritional value of commonly grown staple food crops (Singh *et al.*, 2016; Sheoran *et al.*, 2022)
- Assists in the reduction of micronutrient malnutrition and micronutrient “hidden hunger” (Singh *et al.*, 2016; Sheoran *et al.*, 2022)
- Serves as a cost-effective and farmer-friendly technique (Singh *et al.*, 2016)
- Assists in the promotion of sustainable and environmentally safe agricultural methods (Sheoran *et al.*, 2022)
- Improves crop productivity and food quality simultaneously (Kumar *et al.*, 2016)
- Assists in the improvement of overall food and nutritional security (Sheoran *et al.*, 2022)

Through the fortification of staple food crops with higher levels of nutrients, nutrient-based biofortification is able to target micronutrient deficiencies in the population (Singh *et al.*, 2016; Sheoran *et al.*, 2022). This technique does not require any significant modifications to the existing agricultural practices of farmers, making it very convenient for them (Singh *et al.*, 2016). Furthermore, this approach improves crop productivity as well as produce quality, thereby ensuring better economic benefits to farmers (Kumar *et al.*, 2016). It also serves as a sustainable, long-term solution for enhancing food and nutritional security (Sheoran *et al.*, 2022).

CONCLUSION

Nutrient management is an important component of the biofortification of food crops, as it helps to improve crop productivity and nutritional quality. Balanced use of macronutrients and micronutrients through agronomic approaches provides a feasible and

sustainable method to overcome hidden hunger. The application of nutrient-based biofortification approaches can greatly help in improving human health and ensuring nutritional security in India. Better availability of nutrients in soil helps to ensure improved uptake and accumulation of key elements in the edible parts of plants. Soil testing, organic manures, and micronutrient fertilizers can help to improve the efficiency of biofortification programs. The application of nutrient-based biofortification programs can be easily implemented in different agro-climatic zones and cropping systems. This approach helps to ensure sustainable agriculture by improving soil health and nutrient use efficiency. Continuous consumption of biofortified crops helps to overcome micronutrient deficiencies in target groups. Assistance from extension programs and government policies can further help to promote the adoption of this approach. Therefore, nutrient-based biofortification is a long-term and inclusive approach to ensure food and nutritional security.

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