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Agronomic Biofortification: An Inventive Tool to Combat Malnutrition

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ABSTRACT

Biofortification is a leading-edge strategy to boost the nutritional value of crops, thereby addressing global malnutrition challenges. It not only tackles food insecurity but also improves the economy of the country. Agronomic biofortification can be an important tool in combating malnutrition and achieving nutritional security. In recent hours its importance has increased because of limited access to nutritious foods and climate change-related issues. It is a means of increasing the bioavailability of nutrients in plants and plant products by use of befitted fertilizer form, application method, and time of application. The significance of agronomic biofortification for global nutrition and food security has been underscored by recent technical advancements and an increasing awareness of mineral micronutrient nutrition.

INTRODUCTION

Nutrient deficiency is a serious global challenge in many developing countries due to ever-increasing population and resource unavailability. In both developing as well as developed countries, hunger, poverty, and malnutrition are major threats. In terms of global public health, vitamin A, iodine, iron, and zinc deficiency represent a major menace to the health and development of the population. Micronutrient malnutrition is known to affect more than half of the world's population. Mainly due to low dietary intake of micronutrients, especially Zn and Fe, micronutrient malnutrition or hidden hunger is known to be common among women and preschool children all over the world. Along with the health of the population, it also impacts the economic prosperity of the country. There is an immediate need to address the worldwide problems of food insecurity, hunger, and malnutrition. Improving nutritional health is a great challenge for many countries. The most sustainable solution to nutrient deficiency is biofortification.

Biofortification is a powerful tool used to enhance the concentrations of essential elements like minerals, vitamins, and micronutrients in food crop plants through genetic selection, agronomic intervention, and typical breeding. It is a form of food fortification that increases the quantities and bio-accessibility of nutrients in food crops during their growth.

Approaches for biofortification

The ultimate goal of biofortification is to produce nutritious and safe foods, adequate and eco-friendly. Most of the food crops are biofortified by three main approaches namely transgenic, conventional breeding, and agronomic intervention by means of biotechnology, plant breeding, and mineral fertilization respectively. These approaches are currently in use to boost the nutritional value of crops.

Agronomic biofortification

A balanced diet that supplies the energy pathway and essential amino acids, vitamins, minerals, and folic acid is the most important contribution to human health. Micronutrient deficiency such as iron(Fe), boron (B), zinc (Zn), and deficiency of vitamins in soil as well as in plants eventually cause malnutrition. This results in impairments of human health and affects immunity, growth, development, etc. To meet the needs of the ever-increasing population, agricultural productivity production must be increased per unit available area.

Seventeen essential plant nutrients are required by plants for their proper growth and development viz, C, H, O, N, P, K, Ca, Mg, S, Zn, Mn, Cu, B, Cl, Fe, Mo, and Ni. Both macronutrients and micronutrients are equally important for plant growth.

Agronomic biofortification is the process of application of mineral fertilizers to the soil or crops to increase the concentration of nutrients, vitamins, and minerals. This can be done by adopting proper agronomic practices and can be considered an effective strategy. Previously, agronomic practices were done for the improvement of crop health and yield. However, solubilization and mobilization of minerals are of primary focus under agronomic biofortification.

Mineral fertilizers are either applied to the soil or directly sprayed on the leaves of the crops. The application of mineral fertilizers is mostly done by soil application. However, foliar application is more economical and applicable when nutrient deficiency symptoms are visible in crops. Foliar application tends to be more effective than soil applications because it increases micronutrient contents rather than just promoting yield.

Application techniques in agronomic biofortification

A variety of agronomic biofortification techniques are currently being tested for their effectiveness on a global scale. Key methods include applying micronutrient fertilizers directly to the soil to enhance nutrient uptake by plants, using diluted fertilizer sprays for foliar application, employing nutripriming, and implementing soilless cultivation.

- **Soil Application:** This traditional technique is effective in replenishing the soil's micronutrient content. It is particularly recommended for crops sensitive to micronutrient deficiency. However, it comes with drawbacks such as increased production costs, low micronutrient use efficiency, and soil pollution due to the buildup of unused micronutrients over time. Combining soil application with foliar application has been reported to be more effective in increasing grain production compared to using soil or foliar application alone.

- **Foliar Application:** Foliar application is a preferred option over soil application due to minimal loss of micronutrients and direct absorption by plant tissue. It is recognized as a vital strategy for addressing micronutrient deficiencies in crops, especially in arid and semi-arid climates with limited water availability for irrigation and soil-applied fertilizer solubilization. This technique offers higher fertilizer use efficiency and is easy to adopt.

- **Nutripriming:** Also known as seed-priming, nutripriming involves soaking seeds in a nutrient solution before planting. While originally used to enhance germination, root development, and seedling establishment, researchers have observed improved grain nutrient content due to nutripriming. For instance, zinc-nutripriming with $ZnSO_4$ (0.4%) increased grain Zn content by 29% in chickpeas (Harris et al., 2008), and 12% to 15% in wheat (Harris et al., 2008; Praharaj et al., 2019).

- **Soilless Cultivation:** Soilless cultivation, a contemporary approach to crop production, utilizes organic, inorganic, or liquid growing media with the desired concentration and form of nutrients. Various soilless systems, such as hydroponic, aeroponic, and vertical farming, are tailored to the specific needs and types of crops. This method is gaining traction in human nutrition, particularly in the cultivation of microgreens, where micronutrients are supplemented through nutrient-rich media (Rouphael and Kyriacou, 2018). Continuous root contact with the fertilizer solution enhances nutrient uptake, translocation, and accumulation, ensuring consistent results for nutritional quality (Wiesner-Reinhold *et al*., 2017; Rouphael and Kyriacou, 2018). Furthermore, soilless cultivation extends the crop cultivation cycle and enables year-round production while considering soil restrictions such as fertility and disease transmission. Additional benefits include the absence of weeds and simplified harvesting and processing.

Advantages

- It paves the way for overall health improvement of the people.
- This strategy seeks to put the micronutrient-dense trait in the highest-yielding and most profitable varieties targeted to farmers.
- Biofortified crops produce nutrient-rich products and better yields.
- Fortified seeds do not come with a yield penalty.
- Such crops are often resistant to diseases, pests, and environmental factors.
- Such crop products also act as alternatives to nutrient supplements, for example, Iron.
- Agronomic biofortification is the easiest, fastest, and widely accepted way to reach the poorest of the poor rural masses and make foods rich in micronutrients, folic acids, etc.

- It can be easily adopted by growers as it is simple to follow.
- It is cost-effective as it is a single-time capital investment.

Challenges

- Initial costs may pose a barrier to implementation for many people.
- Production on a large scale is more beneficial than on a small scale.
- A biofortified crop should be acceptable to both farmers and consumers.
- In the agronomic approach, the success rate is quite unpredictable due to the mobilization of minerals, varied composition of soil, and accumulation of minerals in plants.
- Agronomic biofortification is known to be less cost-effective and labor-intensive than other methods.
- The regulatory procedures for adopting and marketing the products are both time-consuming and costly.

Future perspective

The recent emphasis on biofortification—by enhancing plants' natural ability to absorb mineral micronutrients in their tissues through genetic and transgenic methods—has largely arisen from the low nutrient use efficiency and limited fortification potential observed with traditional soil application techniques in agronomic biofortification. The traditional soil application of mineral micronutrients was initially focused on improvement in crop yield rather than enhancing nutrient status in consumable parts. Agronomic biofortification is straightforward and can be readily embraced by growers. The effectiveness of agronomic biofortification has improved with the development of various fertilizers, such as nano-fertilizers, chelated fertilizers, biofertilizers, and water-soluble fertilizers. These innovations offer greater nutrient use efficiency by plants and enhance nutrient translocation to the edible parts of the plant. Several new techniques like foliar application, nutripriming, soilless culture, etc. have further increased the significance of agronomic biofortification. An integrated attempt by varietal improvement and nutrient incorporation seems highly relevant in times to come. It has the potential to be a crucial strategy in addressing malnutrition and global food insecurity.

CONCLUSION

With recent advancements today, plant nutrition can be enhanced with both genetic and non-genetic methods. Overshadow line. Biofortification, an advanced method for combating micronutrient deficiency in impoverished nations, can help. The agricultural practice of biofortification has been acknowledged for a considerable amount of time as a realistic and economically viable way to meet the nutritional requirements of undernourished people on a worldwide scale. People consuming plants or their products with low micronutrient availability are highly susceptible to micronutrient deficiency. As a result, micronutrient fertilization (agronomic biofortification) can be used to address both crop nutritional quality and human dietary micronutrient requirements. Overall, raising the levels of essential nutrients in cereals, vegetables, fruits, and other local foods can help address the negative impacts of climate change and other global crises**.** Fertilizers can help in crop improvement, and yield and even lessen hunger in many countries but they also have hidden dangers. Farmers must adopt biofortified crops, which have enhanced nutritional value when compared to conventional crops. The high initial cost of biofortification is a significant barrier; therefore, farmers should receive support through a guaranteed minimum price to encourage the cultivation of more biofortified crops. However, because of the introduction of biofortified food crops, individuals in these areas are now able to ensure that they are receiving the nutrients that they need. With adequate focus on factors like fertilizer type, application method, and timing, agronomic biofortification can be a straightforward and cost-effective solution. One of the only ways that these objectives may be accomplished is with the assistance of national and international initiatives such as the Harvest Plus program.To accomplish this goal, individuals with expertise in molecular biology, genetic engineering, nutrition, and plant breeding need to collaborate. Despite several challenges, biofortified crops are the wave of the future. They have the potential to eliminate micronutrient deficiency in developing countries and improve the lives of billions of people who are living in poverty.

SUMMARY

Agronomic biofortification is a cost-effective solution to combat hunger and malnutrition in the world. There are several approaches like the application of minerals through soil, foliar, nutripriming, and soilless cultivation. Although this approach is useful for addressing the mineral malnutrition problems worldwide, the efficacy of the biofortification program essentially relies on the farmer's and consumers' acceptance and future strategy interventions. With the right strategic research and effective policies, we can pave the way for the successful implementation of biofortification

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