



Advances and challenges in the use of Agronomic Biofortification of crops for mitigating environmental stress

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Abstract

Agronomic biofortification enhances the nutritional quality of plants and helps mitigate adverse climatic impacts such as droughts, salinity, and extreme temperatures. By using enriched fertilizers, foliar fertilization, and biological soil management, this technique increases the absorption of essential nutrients like zinc, iron, and selenium. In addition to strengthening food security, it makes agricultural systems more resilient. However, challenges such as cost, input availability, efficiency of the approach, and accessibility still limit its adoption. Despite these obstacles, its rapid implementation and compatibility with existing agricultural systems make it a promising strategy for addressing environmental and nutritional challenges.

Keywords: Sustainable Agriculture; Food Security; Mineral Fertilizers.

Currently, there is a global issue related to adverse climatic conditions such as prolonged droughts, intense rainfall, and extreme temperatures, which are causing various problems in global agriculture. These climatic changes lead to reduced crop yields, compromised food security, and increased phytosanitary issues. The use of techniques like agronomic biofortification is essential to minimize these impacts and ensure more resilient and sustainable agricultural systems.

Agronomic Biofortification: This strategy aims to increase the concentration of essential nutrients in plants through soil management and fertilizer application. Studies show that this approach not only improves the nutritional quality of food but also helps mitigate the impacts of environmental stresses such as drought, salinity, and nutrient deficiencies.

Agronomic biofortification involves the use of enriched fertilizers, foliar fertilization, and biological soil management. These methods can enhance plant tolerance to abiotic stresses and improve the absorption of essential elements such as zinc (Zn), iron (Fe), and selenium (Se).

Mechanisms for Mitigating Environmental Stresses:

- **Water Stress:** Biofortification with silicon (Si) improves water retention in plants and reduces water loss through transpiration. Studies have shown that selenium and silicon can enhance water retention in plants, decreasing transpiration rates and increasing water use efficiency. Zinc also helps stabilize cell membranes, reducing damage caused by water deficits.

- **Salinity:** Potassium (K) and calcium (Ca) help maintain osmotic balance and protect against damage caused by excessive salts. Supplementation with potassium (K) and silicon can also reduce sodium (Na) toxicity in saline soils, improving ionic homeostasis and promoting plant growth.

- **Nutrient Deficiency:** Supplementation with essential micronutrients supports plant metabolism and biomass production. For example, applying iron and zinc in nutrient-poor soils improves the availability of these crucial elements for plant metabolism. Selenium can also enhance antioxidant activity, reducing cellular damage and improving nutrient absorption.

- **Temperature Stress:** The use of silicon can mitigate the impacts of excessive heat by increasing the structural stability of leaves and stems. Magnesium (Mg) improves photosynthetic capacity under low-temperature conditions, reducing oxidative damage.

- **Heavy Metal Toxicity:** Elements such as selenium (Se) can reduce the absorption of toxic metals and minimize oxidative damage.

Perspectives on Agronomic Biofortification: Agronomic biofortification offers various advantages and

opportunities, including:- **Improved Food Security:** Increasing micronutrient levels in widely consumed crops helps reduce hidden hunger and malnutrition.

- **Rapid Implementation:** Compared to genetic biofortification, the application of enriched fertilizers can have an immediate impact on plant nutritional quality.
- **Economic Viability:** The cost-effectiveness of biofortified fertilizers can be advantageous, especially in agricultural regions with adequate infrastructure.
- **Compatibility with Existing Agricultural Systems:** The use of essential micronutrients can be integrated into soil fertility management programs.

Main Challenges: Despite its advantages, agronomic biofortification faces challenges that limit its adoption and effectiveness:

- **Availability and Cost of Inputs:** Access to micronutrient-enriched fertilizers is still limited in some regions, hindering widespread adoption.
- **Efficiency of Plant Absorption:** Various factors, such as soil type, pH, and interactions with other nutrients, can affect the bioavailability and uptake of micronutrients by crops.
- **Environmental Sustainability:** Excessive fertilizer use can lead to negative impacts such as soil and water contamination.
- **Acceptance by Farmers and Consumers:** Raising awareness about