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Foliar Nutrition: An Important Agro-Technique for Bio-Fortification to Mitigate Malnutrition Problem under Global Climate Change

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SUMMARY

Bio-fortification is a practicable and cost-effective way of enriching nutritional component(s) in the edible parts of the plants would be as a part of a large portfolio of environmentally friendly is known to be a potential method for tackling malnutrition.The principalobjective of this review is to represent a general outlook on the importance of foliar nutrition in agronomic science that describes its potential role in mitigating global malnutrition problem. However, alterations in the climatic condition such as increasing the temperature, more frequency of drought, flooding, and changes in rainfall patterns, occurrence of COVID-19 pandemic have a major threat to fullfill the required qualityfood demand.Malnutritiondue todeficiencies of micronutrients affects around one third of the global population and this severelyjeopardizes the nutritional security of increasing population.Agronomic bio fortification through foliar nutrition is quite successful to combat with the malnutrition problem.So, it may be concluded that the implementation of foliar nutrition in crop production is widely adoptedto combat with global malnutrition problem by contributing production of nutritious food products..

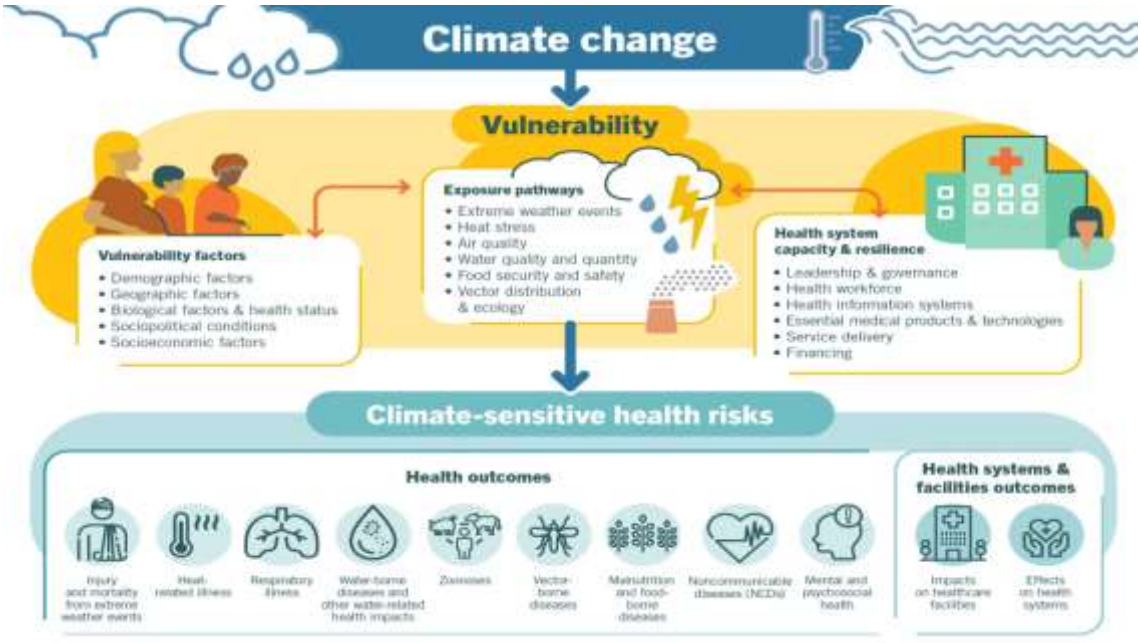
INTRODUCTION

The growing concerns about quality food production became noticeable with a rampant proliferation of population globally that are aggravated by the unforeseeable nature of climatic condition due to higher frequency and intensity of heat, drought, and flooding episodes have main determinants might cause variation in agricultural production(Anderson and Song, 2020;Murmu*et al.*, 2022).However, the alteration in climate condition has a continuous process on earth**,** but approximatelyover last 100 years or so**,** the occurrenceof this variation hasincreasedabundantly. Due to anthropogenic activitiesthe mean temperaturehas advancedby 0.9 °C throughout the world since nineteenthcentury, mainly due to emission of greenhouse gas (GHG) inthe atmosphere. Under such situation, achieving abundance food supply rich in nutrients to combat with the malnutrition challenges would be a major challenge.Malnutrition exacerbated by extreme climatic events are the most pernicious consequences of climate changeeffect the very large number of people worldwide.However, theoccurrenceof COVID-19 pandemic is estimated to increase the malnutrition risk causes the economic, food, and health systems disruption are expected to continue to exacerbate all forms of malnutrition and hence food consumption and consumer health have always been considered asone of the major concern in the new post-COVID-19 era. Bio-fortification is a practicable and economical method of this issuethe enriching nutritional component(s) in the edible parts of the plantswould be as a part of a large portfolio of environmentally friendly, food-based nutritional strategies.Agronomic bio fortification via foliar applicationisanopportunityforboosting the micronutrient content in edible food cropsand consumption ofsuch cropscould be more valuable option for overcoming malnutrition problem indeveloping nations.Foliar nutrition is a crucial strategy that defines as the utilizing the spray solution of essential nutrients directly applied on the plant foliage for pursuing the higher productivity of crops for its a rapid, target-oriented, and ecologically compatible stimulating more vigorous growth and improving the yield potential of crop plants (Fernandez *et al*.,2021) and isregarded as an alternative of method fertilization in modern cultivation practicesfor its ability to mitigate the stresses, eliminating leaching loss by reducing the problems like fixation and immobilization of nutrients which enhances growth and yield of crop plants (Sarkar *et al*., 2021;Sarkar *et al*.,2022).Nevertheless, this article will highlight on the prospects of foliar nutrition to improvethefood and nutrition security with socioeconomic benefits under multifaceted agriculture challenge.

Impact of mineral micronutrients deficiencyon human health and nutrition

Globally majority of the population is under acute deficiency of nutrients due to poor quality food consumption.Undernutrition concerns around 821 millionpeople and ~2 billion people in the world are affected by one or more forms of micronutrient deficiency. Balanced daily nutrition should contain macronutrients,

including carbohydrates,proteins and fat, as well as micronutrients such as electrolytes, minerals and vitamins.The micronutrients are involved in the essential functions of the body such asmetabolism, cell growth, and immune reactions, and are required in minimal amounts.Therefore, the "malnutrition" includes protein/energy undernutrition andmicronutrient deficiencies, representing a major public health problem particularly insouthern Asia and sub-Saharan Africa.Current research on human health, specifically in the area of malnutrition, is driven towards identifying such crop production methodologies that results in boosting thenutritive value of produce without sacrificing high yieldssuffers from inadequacy ofessential micronutrients,especially Zn, Cu and Fe deficiencies thatare root causes of digestive problems, anaemia, highblood pressure, diabetes mellitus, hormone imbalance,loss of immunityagainst diseases (Gorji and Ghadiri., 2021).As per estimates, almost two billion people throughout the globe face acute deficiency of micronutrient mainly pregnant women, and children.Zinc, one of the many micronutrient elements essential for good health, is frequently low in the human diet. Zn deficiency can impair immunological function, restrict children's growth, and harm women's pregnancy outcomes (Hess and King, 2009). Similarly, a lack of Fe in the diet leads to a variety of physiological problems such as anemia and neurological illnesses argues that food security is just as crucial as food security.Iodine has been proposed as a potential treatment for COVID-19 infection and to lessen the side effects of vaccination. Iodine is used by the thyroid gland to make thyroid hormones. In addition to being a component of thyroid hormones, iodine serves as an antioxidant, anti-inflammatory, anti-proliferative, and differentiation agent. Iodine helps to maintain the health of organs that can absorb it by having effects that are mediated by a variety of various processes or pathways that have either direct or indirect activities.To overcome such problem, agronomic bio-fortification techniques are often used which is regarded a better option for enhancement of micronutrient density in edible portion food crop to combat with the malnutrition of micronutrients in humansimproving the quality nutritional value of agricultural produce which could be moreefficacious and long-term strategy to ensure food security.

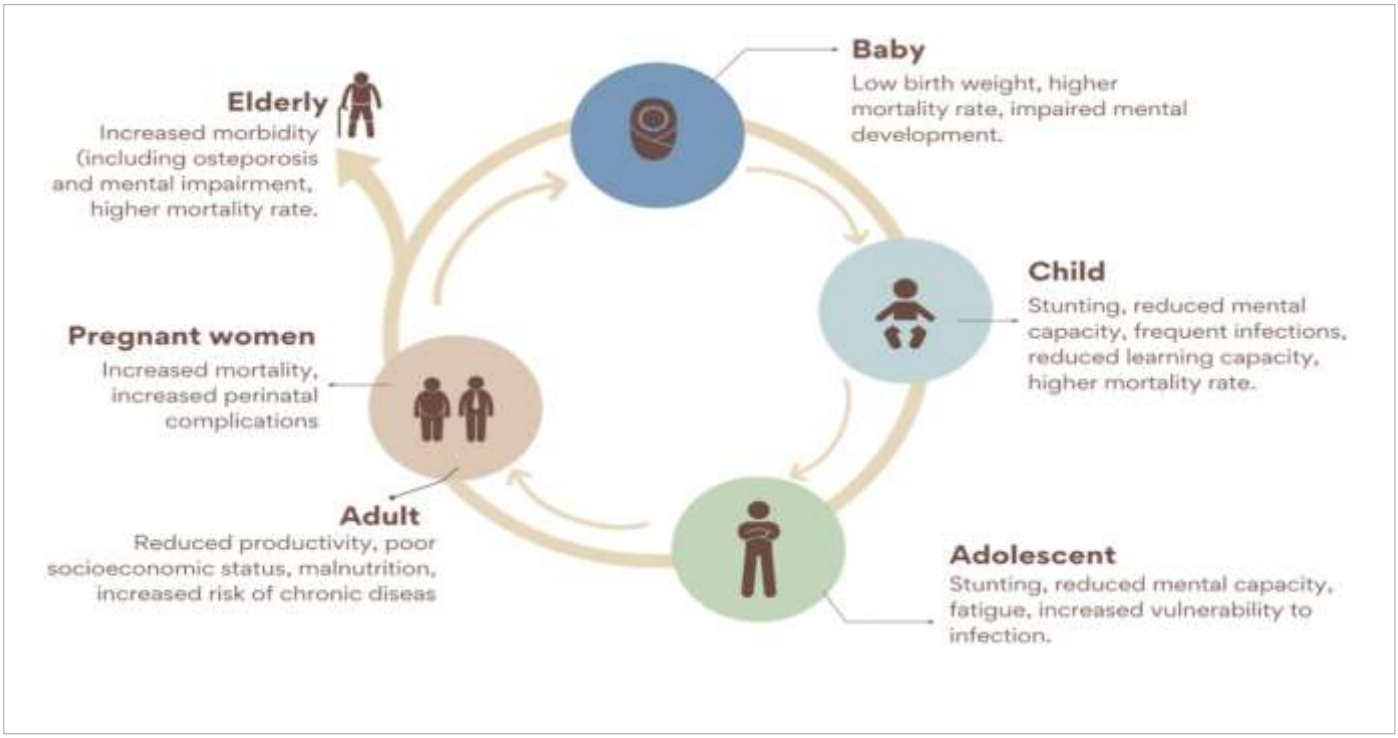


Impact on climate change on human health

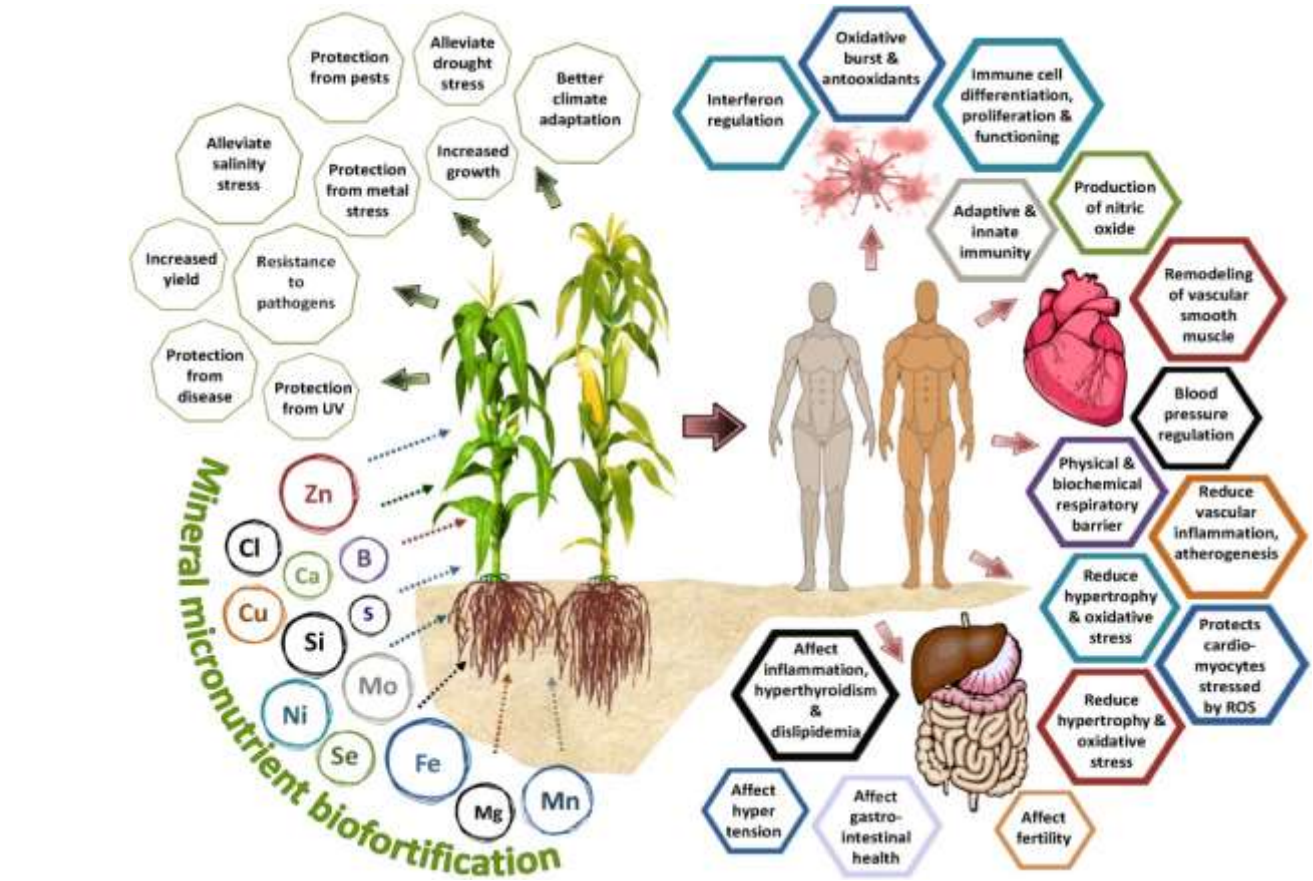
Foliar application and its role inbio-fortification

Human nutrition is greatly rely upon plant kingdom and so the plants deficit in micronutrient can also lead to micronutrient deficiency in people who consume those plants and their processed products as a source of nutrition. Bio-fortification is generally a process that relies on methods of fertilizer application,solubilisation of mineral element, and mobilization of nutrientfrom source to sink (consumable parts of a plant). Foliar feeding is among the technologies that provides a practical way to increaseyield with balanced nutrients, particularly micronutrients, is discussed in the prospects for bio-fortificationprovidesediblefoods withhigher amount of bioavailable minerals (Fe, Cu, Zn, Ca, Se, I**,** etc.), thiamine or vitamine B1, vitamin B6 provitamin A and vitamin E (Cakmak andKutman, 2017). Bio fortification of rice crops by foliar spray of iron and zinc proves an efficient way to promote a successful agronomic strategy for increasing iron and zinc concentration

and its bioavailability in rice grains (Garg et al., 2018).The Selenium concentrationin grains after application of both selenite and selenite formduring the full heading stage of rice was 2.9–3.5 times greater than at the late tillering stage. Field pea's enrichment for zinc has been obtained with foliar zinc applications alone or in combination with soil zinc applications(Poblaciones and Rengel, 2016).Zinc foliar spray at reproductive growth stage is the most crucial strategy for biofortification of soybeanwhen Zn availability in the soil is less.



Consequences of micronutrient deficiency through the life cycle



Influence of mineral micronutrient biofortification on the plant physiological processes and its relation to human health and immunity

Zinc is involved in the starch formation, growth promotingsubstance like auxin, seed maturation and production that indirectly increases grain and stoveryield is attributed for its role in variousenzymatic reactions, hormone productionand protein synthesis and also in translocation ofphotosynthates to seeds (Read *et al.*, 2019). The nodulesplant^{-1}, root length, uptake of nutrients in cowpea wereconsiderably increased by adding Mo to the soil combined withfoliar applications of $FeSO_4.7H_2O$ (0.5%) and $ZnSO_4.7H_2O$(0.5%) to address the shortage of micronutrient (Dhaliwal *et al*.,2022).The Zn concentration on mungbean seedafter application of 1.0% of zinc sulfate was almost 1.8 times greater than soil Zn application at aconcentrationof 10 mg kg^{-1} soil (Haider *et al*.,2018).The foliar application of Selenium boosts the concentration of Selenium two times in durum wheat grain in comparing with soil application (Mahmoud *et al*., 2022).Iron fortification in pearl millets and beans improve the health status of the children and available to the targeted population (Hass et al., 2005).The response of potato plants to iron fertilizer will help to understand the mechanism of iron plantations in potatoes boosts the chlorophyll and carotenoid content of potato leaves (Singh *et al.*,2021). Under waterlogged situations,soil Zn fertilization becomes less effective in boosting Zn concentration in grain due to its fixation associated with reduced redoxpotential; therefore, the foliar application was proved to improve grain Zn.One more additional complementary approach for agronomic bio-fortification with Fe or Zn is enhancing the N nutritional status of plants and positive synergistic effects on their concentration.Nowdays, a cocktail solution with I, Zn, Se and Fe when foliar sprayed in wheat recorded an average increase nutritionalvalue can be a promising strategy for grain biofortification that can be the best option to reduce the multiple deficiencies of micronutrients. (Prom-u-thai*et al*.,2020).Thus, bio-fortification efforts of stable crops should be augmented to respond to foliar method of nutrition,considered a promising strategy to alleviate multiple deficiencies of micronutrient by supplying healthy diets to combat with the double burden of malnutrition statuswhile focusing on maintaining ecological sustainability.

CONCLUSION

The global health crisis witnessed under the global climate change situation, occurrences corona Pandemic has turned the focus of the global population towards the nutritional quality of food, especially micronutrients that play a crucial role in developing body immunity.Nutrient application via foliar applicationhave been widely known to improve micronutrient biofortification, and suitsbetter micronutrient use efficiency. The efficacy of biofortificationthrough agronomicapproach in enrichingconsumable parts of plants with intended micronutrients can be suitable option in combating malnutrition globally.

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