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BIOFORTIFICATION-A SUSTAINABLE AGRICULTURAL STRATEGY FOR REDUCING MICRONUTRIENT MALNUTRITION

PARKASH MEGHWAR[1*], NIZAMUDIN CHANIHO[1] AND TAJAMUL ISLAM[2]

[1]Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam-70060, Pakistan.
[2]Department of Botany, University of Kashmir, Srinagar-190006, Jammu and Kashmir, India.

AUTHOR'S CONTRIBUTIONS

This work was carried out in collaboration among all authors. Author PM wrote the first draft of manuscript. Author NC managed the literature searches. Author TI designed the final manuscript. All the authors read and approved the final manuscript.

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ABSTRACT

Malnutrition is of great public health significance in several parts of the world, especially the developing and underdeveloped countries. Micronutrient deficiencies in humans can be mitigated through the process biofortification. It is the strategy of increasing the nutrient content in the edible parts of staple food crops for better human nutrition. Staple crops such as maize, rice, and wheat provide most of the calories for low-income families around the globe. Biofortification includes the enhanced uptake of such minerals from soils, their transport to edible plant parts, and improving the bioavailability of these minerals to humans. In paper, crop biofortification and malnutrition of essential nutrient have been discussed.

Keywords: Biofortification; crop; malnutrition; micronutrients.

1. INTRODUCTION

Malnutrition is one of the world's leading causes of death, accounting for over 20 million individuals annually [1]. It is also a projective feature of rising infection, incapacity, and immature psychological and physical development [2]. An adequate self-possessed diet of fruits, vegetables, and animal foods is mandatory to meet the needs for micronutrients and energy. Nevertheless, for much of the global population, these goods are out of control. While micronutrients can be produced and collected by almost all plants, some staple crops contain scarce amounts of micronutrients, and vitamins [3].

Biofortification can be a relatively new interference in the development of human nutrition worldwide, with particular focus on poor and developing countries. The basic objective is to eliminate the micronutrient malnutrition related fatality rates and improve the food security in developing nations. Biofortification of staple food is the main target to eliminate the malnutrition in the poor nations. Although the ability to biofortify is not like food supplements, it can help to decrease the gap in essential nutrient consumption and escalate the regular consumption of nutrients. This could have a notable effect on health by decreasing malnutrition [4]. Ample micronutrient quality and quantity in staple crops have significantly enhanced the nutrient levels in humans [5, 6]. Biofortification of orange sweet potato for vitamin A

**Corresponding author: Email: parkashmeghwarifstsau@gmail.com;*

has significantly altered the consumption of vitamin A by lactating mothers and children [7]. Biofortification of staple food crops has thus been designed as a latent method to tackle malnutrition offenders over the production of selected food crops to reduce the gap in human and animal micronutrient digestion [8]. Micronutrient deficiency is rising because of increasing world population. Deficiency of minerals such as Fe and Zn can cause various severe health issues [9]. Malnutrition not only raises the burden of disease, but also worsens welfare and economic performance globally [10]. Currently, the emergence of malnutrition with Fe and Zinc deficiency is now distressing 3 billion people worldwide and has severe health consequences. The WHO estimated that anemia is practiced universally by 25 percent of the world population. Globally there are 17.3 percent of people at risk of Zinc deficiency [11].

2. SCIENTIFIC METHODS/APPROACHES

Biofortification is also agronomic and/or genetic. In order to improve micronutrient levels in edible plant sections, genetic biofortification is often achieved either by traditional breeding or by gene splicing. Deficiencies of minerals in food crops may also be caused by different factors, such as soils deficient in one or more minerals, reduced availability of minerals to plants due to dynamic variables, such as edaphic factors, reduction in distribution/translocation of minerals, and accumulation of minerals nutrients in nonfood parts of food crops. Therefore, to expand the mineral levels inside the consumable parts of the crop plants. Henceforth, it is key step to deal with these issues.

3. DECREASING MALNUTRITION THROUGH BIOFORTIFICATION

Malnutrition can be a problem on the earth anywhere, and 60%, 30%, and 15% of the total population on earth have been assessed as deficient in minerals like Zn, Fe, or iodine (I), respectively [12]. Biofortification is an innovative technique to improve the nutritional quality of food crops, improving both their mineral quantity and the accessibility of minerals within the edible sections of crops and perhaps through agronomic mediation, plant growth and processing, and the use of hereditary characteristics. In order to tackle micronutrient deprivation, cultivating crops that are rich in vitamins and minerals can be a cost effective, relatively easy and straightforward solution. Deficiencies of Zinc, Iron, vitamin A, Iodine and a few other important minerals and proteins may also be alleviated by the effective use of traditional breeding methods and thus the use of bioengineering to enhance the micronutrient nutrient value of staple crops. In addition, mineral enriched plants under certain conditions are occasionally more resistant to external stresses (biotic and abiotic) [13] and can produce higher yields.

4. CLIMATE CHANGE IMPACTS

Climate change may have a negative effect on food security, affecting many crops and regions, with the most extreme impact predicted for South Asia and Southern Africa [14]. It is clear that rising temperatures and shifting patterns of precipitation will have a negative effect on crop yields worldwide [15, 16], so biofortification efforts due to the season will be adversely affected by such variations. On 96 percent of all arable land, agriculture is used [17]. Small holder farmers who believe that rainfed agriculture is dependent on rain and its timing for their livelihood, and intra seasonal precipitation patterns may determine the success or failure of their crops, especially in Sub-Saharan Africa, where 96 percent of all arable land is used for rain-fed farming [17]. By 2050, the decline in calorie accessibility is projected to increase child malnutrition by 20 percent worldwide without & with global climate change, the levels of child malnutrition could be even higher. Plant growth and development are temperature-related, and high temperatures can adversely affect crop yields in combination with low rainfall [18]. When crops are grown at high CO2 concentrations, protein and micronutrient levels are reduced [19]. Increased mortality and morbidity rates, reduced worker efficiency, hunger, and decreased cognitive capacity in children with lower educational potential born to mothers with micronutrient deficiencies are staggering implications for human health, satisfaction, livelihoods, and national growth [20, 21, 22]. In several countries, existing intervention initiatives (food fortification and supplementation programs) to mitigate the problem have not been shown to be successful or sustainable [23].

4.1 Biofortification of Staple Food Crops

Genetic engineering of food crops in their edible portions to cause substantial increases in bio available micronutrients when they are consumed holds much promise as a viable approach to malnutrition of micronutrients [24, 25, 13].

4.2 The Bioavailability Determinant

The challenge of bioavailability is one of the most contentious points in convincing the nutrition sector that biofortification should be used as a primary instrument to tackle micronutrient malnutrition [26]. Fortification (of four with iron,

Table 1. Micronutrient deficiencies in humans living world-wide and their effect on human health

Micronutrients	Deficiency	Deficient no. of people (in billions)
Fe	Anemia, impaired motor and cognitive development	~1.6
Zn	Weakened immunity	~1.2
I	Neuron damage in newborns and reduced mental capacity, goiter	~1.8
Vit. A	Ailments like visual impairment, blindness	0.209 preschool going children and pregnant women

Source: Karumbunathan and Zimmermann 2012)

for example) and supplementation are public health measures to deal with micronutrient deficiency (twice-yearly vitamin A capsules for pre-school children). Nonetheless, few governments have the funds to finance such initiatives on an uninterrupted basis. A modern complementary approach is biofortification, which uses plant breeding techniques to reinforce the micronutrient quality of staple foods.

Biofortification aims to improve the micronutrient quality of staple food crops by means of plant breeding techniques, leading to higher intakes of micronutrients. In comparison to commercial fortification, which involves the procurement of one fortified food, biofortification is primarily aimed at rural areas where food production remains within the community, and thus either on-farm or local food is consumed. In addition, repeat purchases are not required; a one-time investment in the dissemination of sorts with the nutrient-dense feature becomes self-sustaining for many crops. Research has shown that it is feasible to breed staple food crops to produce micro-enhanced cultivars.

4.3 The Burden of Iron Deficiency

Iron deficiency results in reduced physical activity and impaired mental growth (in all age groups) (in children under 6 years of age). In addition, it is estimated that iron deficiency is responsible for fifty of all maternal deaths. The death of a mother in turn suggests a stillborn child and the deaths of her older children due to the absence of breastfeeding and therefore the treatment that the mother would have provided if she had lived (Stein et al., 2005).

4.4 The Burden of Deficiency Disease

In adverse functional outcomes related to diarrhea, pneumonia, and stunting in infants, there is evidence from meta-analysis implicating deficiency disease. Some cases of diarrhea and pneumonia are frequently fatal. Accordingly, nearly 20% of diarrhea, nearly 40% of pneumonia, and 4% of mortality among young people under the age of 6 years are often due to deficiency disease. The information in Table 1 indicates that 0.1% of the population of the Philippines and 0.3-0.4% of the population of South Asia annually buffer deficiency disease outcomes [22].

4.5 Importance of Zinc in Human Health

Within the immune response, zinc plays an important role [27]. Alterations in zinc homeostasis can result in the development of diseases. Signs of zinc deficiency documented in animal studies, for example, include growth failure, hair loss, testicular atrophy, and epidermis thickening and hyper keratinization. One of the main causes of malnutrition today is zinc deficiency. Zinc deficiency is among the top five leading causes of loss of healthy years of life in developing countries [28].

5. CONCLUSION

Biofortification of crops is being introduced in many countries as a strategy to eradicate micronutrient deficiencies and thus improve human health. Enhanced fertilization with micronutrients, conventional plant breeding, and genetic engineering are used to develop biofortified cultivars. To date maize, rice, wheat, beans, pearl millet, sweet potato, and cassava have been biofortified with increased concentrations of Fe, Zn, and provitamin A. To increase micronutrient concentrations in edible crops, future research should focus on (i) integration of agronomic and genetic strategies to increase mineral transport to phloem-fed tissues and (ii) identification of the mechanisms effecting mineral-homeostasis in plant cells. Confidently, using a combination of strategies (e.g., enhancing efficiency of crops to take up mineral nutrients and/or enhanced production of vitamins/proteins using conventional breeding and genetic engineering tools) followed by enhanced fertilization of targeted nutrients should be considered.

6. RECOMMENDATIONS

The below noted actions are recommended when genetic engineering are used to improve the micronutrient levels in staple food crops:

- When attempting to eliminate anti-nutrients, caution should be used.
- Further research is required to understand micronutrient interactions about bioavailability issues, especially in regions with multiple micronutrient deficiencies.
- The effect of food constituents on the availability of micronutrients should be examined in much greater depth.
- It is important to investigate the effects of hindgut microorganisms on micronutrient bioavailability.
- More accurate models of bioavailability are utilized and the basic mechanisms underlying the bioavailability of micronutrients should be further analyzed.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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