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Popular Article

Biofortification of Pearl millet: A strategy to combat malnutrition

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Abstract

Biofortification is a cost-effective and sustainable agricultural solution to malnutrition. This is a multidisciplinary, cost-effective method that makes full use of crop development and nutrition science to address the persistent problem of micronutrient deficiency. A food-related issue known as micronutrient malnutrition is brought on by a dietary lack of certain vital elements such as iron (Fe), zinc (Zn), vitamin A, and others. Since many people who suffer from micronutrient deficiencies rely on staple crops to meet their nutritional needs, the cultivation of crop cultivars with higher concentrations of micronutrients in their edible parts is becoming more widely recognized as a sustainable choice. A key food crop of India and Africa, Nutri-cereal" Pearl millet with outstanding nutritional qualities and tolerance to climatic change is a good option for biofortification.

Introduction

Iron and zinc deficiency are major public health issues worldwide, notably in India and Africa. An economic and environmentally friendly agricultural solution to this issue is **Biofortification.** This is a multidisciplinary, sustainable, and economical strategy to address the ongoing issue of micronutrient malnutrition by utilizing the full capacity of crop development and nutrition science. Micronutrient malnutrition is a food-related health issue caused by dietary deficiencies of some essential minerals like iron (Fe) and zinc (Zn), as well as vitamin A, *etc*. Numerous health issues in developing nations are caused by deficiencies in vital micronutrients such as iron and zinc. In addition to neurological and behavioural abnormalities in children, deficiencies

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in iron and zinc are associated with cognitive abnormalities. Low iron and zinc deficiency cause the immune function to weaken. The production of crop cultivars with higher amounts of micronutrients in their edible sections is increasingly acknowledged as a sustainable option because many people who suffer from micronutrient deficiencies depend on staple crops to meet their nutritional requirements. Pearl Millet is a significant food crop in the dry and semi-dry tropical areas of Africa and Asia. The term "Nutri-cereal" has been given to Pearl millet and other millets because of its superior nutritional value and resistance to climatic change. Pearl millet is essential for food and nutritional security due to its capacity to mature early, tolerance to drought, and relatively low requirements.

When other food supplies are insufficient to address micronutrient deficiency, food fortification adopts an integrated strategy and offers assistance. The practice of adding micronutrients to processed foods is known as food fortification, and it has been used at varying levels and with different age groups. Nutritional supplements are aimed to provide nutrients that are sufficiently consumed by the diet but this have shown significant adverse effects. To overcome this, crop biofortification is an alternative method.

Pearl millet Biofortification -Breeding and Genomic Approaches

By utilizing the genetic variations across crops of the same species, biofortification through plant breeding tries to improve the concentration and bio accessibility of minerals in crops. There might not be enough genetic diversity among crops to allow for the biofortification of some crops through Plant breeding. As an alternative, the transgenic technique comprises locating and analysing the most appropriate genes that might be inserted into such crops to produce desired nutritional attributes. It is possible to produce biofortified Pearl millet with increased Zn and Fe levels using either traditional Plant breeding procedures or transgenic approaches (Bouis and Welch *et al.*, 2010). Drilling through the crop genomes to uncover intriguing genes and breeding those genes into new, improved varieties is a crucial component of biofortification. The advancement of genetic and genomic technologies paves the potential for the identification and transfer of genes and QTL linked to a better nutritional profile from the varied genetic resources of millets. This has made it easier to select and breed superior cultivars with high nutritional value.

By using the intra-population diversity within ICTP 8203, an early-maturing, large-seeded, disease-resistant, and high-yielding open-pollinated variety that has been grown in India since 1990, the

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world's first high-Fe pearl millet variety, "Dhanashakti," was created. The Central Variety Releasing Committee officially released and announced Dhanashakti in 2014 for cultivation in all Indian states that grow pearl millet Rai *et al.*, 2014. The present breeding initiatives in the public and private sectors are focused on hybrid creation, and ICRISAT is supporting these efforts by creating and disseminating a wide variety of enhanced breeding lines and hybrid parents through Pearl Millet Hybrid Parent Research Consortia (PMHPRC). The development of multiple high-yielding and high-Fe hybrids that are in various phases of testing was made possible by using identified high-Fe hybrid parents from among those who were initially not bred with high-Fe as a desired trait.

Table 1: Biofortified released variety of Pearl Millet

Sr. No.	Variety	Year	Area	Salient features
1	Dhan shakti	2013	Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Rajasthan, Haryana, M.P., Gujarat, U.P., Punjab	Early maturing variety, High iron, resistant to down mildew
2	HHB299	2018	Rajasthan, Haryana Maharashtra, Delhi, Gujarat, Tamil Nadu, Punjab	Medium maturing, resistant to major disease and pest
3	AHB 1200 Fe	2018	Maharashtra, Andhra Pradesh, Tamil Nadu, Rajasthan, Haryana, Gujarat, Punjab, Delhi, and Telangana	Medium Maturing, high Fe content, resistant to downy mildew, highly responsible for fertilizers
4	AHB 1269 Fe	2019	Rajasthan, Haryana, Maharashtra, Delhi, Gujarat, Tamil Nadu, Punjab	Medium maturing, High Fe
5	RHB234	2019	Rajasthan, Haryana, Maharashtra, Delhi, Gujarat, Tamil Nadu, Punjab	Medium Maturing, resistant to insects and pests
6	RHB 233	2019	Rajasthan, Haryana, Maharashtra, Delhi, Gujarat, Tamil Nadu, Punjab	Medium maturing. Complete excretion, resistant to insects and pests
7	HHB 311	2020	Rajasthan, Haryana, M.P., Maharashtra, Delhi, Gujarat, Tamil Nadu, Punjab	Medium maturing, highly resistant to downy mildew and other diseases.

Agronomic Biofortification

By adding mineral fertilizers to soil or crops, agronomic biofortification aims to boost the concentration and bio accessibility of nutrients in the crops. Agronomic techniques have been

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developed to enhance the nutritional properties of crops, nevertheless, the significance of nutrition has become more widely recognized over time. An indication of the need to enhance and broaden agronomic practices to include enhancing the nutritional attributes of crops is the quick loss of soil nutrients and changes in climate conditions. Increasing the solubilization and mobilization of minerals is the main goal of agronomic biofortification. Identified high-Fe hybrid parents and populations help to generate high-Fe cultivars for quick delivery in the short- and medium-term aims.

Human trials of biofortified pearl millet

The literature lists numerous research that has used biofortified crops successfully. For instance, 20 African women from Benin participated in a field trial to assess the potential of Fe-biofortified pearl millet as a source of extra bioavailable Fe in a study by Cercamondi *et al*. 2013. The total amount of Fe absorbed from Fe-biofortified pearl millet was up to three times higher than that from conventional pearl millet, according to the results, after consumption of two meals per day of Fe-biofortified pearl millet for five days. This implies that pearl millet biofortification is a beneficial strategy for boosting bioavailable iron for persons residing in millet-eating communities with limited access to standard post-harvest fortified diets (Cercamondi *et al*., 2013). These results are consistent with those of another recent study carried out in Karnataka, India. In this study, Pearl millet was biofortified with both Zn and Fe and fed to forty Fe-deficient children (aged 2 years). Results showed that the amount of Fe and Zn absorbed from the biofortified pearl millet test meals exceeded the minimum physiological requirements for children aged 2 years, which are 0.54 and 2.5 mg/d, respectively. This absorption was significantly higher than that from the non-biofortified pearl millet meals. These results indicate that biofortification has increased Zn and Fe concentrations in pearl millet, which are more than enough to meet young children's physiological minimum Zn and Fe requirements. Biofortification has a huge potential to eradicate MNDs, especially in millet-eating communities in developing countries.

Future Challenges

Compared to other important crop species, pearl millet's nutritional biofortification study is now in a limited state. Given this, interdisciplinary efforts from the disciplines of agriculture, medicine, nutrition, and genetics are required to advance this study in a responsible and user-friendly manner. Fe and Zn routes in pearl millet must be better understood to aid this research. A deeper knowledge would improve the reliability and consumer friendliness of biotechnological and transgenic applications by increasing their safety. Research on the root rhizosphere, analysis of the intricate biological and ecological processes in the soil microbiome, clarification of the mechanisms underlying cation selectivity, and examination of potential drawbacks like enhanced accumulation of antinutrients and toxic metals could all contribute to a better understanding of the mechanisms underlying efficient Fe and Zn uptake for improved health and productivity. Any prospective technologies should also be tested in real-world settings because pearl millet is frequently grown in soils that are infertile and deficient in Fe and Zn. Transcriptomics and metabolomics may substantially assist in this.

There has not been much research done on pearl millet so far, even though nutritional upgrading of pearl millet grains by genetic engineering should be regarded as a significant topic of research for nutrition security. The utilization of in vitro culture systems, activation, and knockout mutants, and gene editing techniques like CRISPR have shown that genetic engineering technologies are nevertheless feasible when applied to model organisms and important grains. When the Zn and Fe routes in pearl millet are better understood, this study should be used while taking into account socioeconomic factors including customer acceptance and feasibility for small-holder farmers.

Conclusion

Deficits in Fe and Zn have been linked to serious health problems, which are well-documented. Many individuals now depend on food fortification, supplements, and agronomic practices as solutions because there is a scarcity of nutrient-dense food. These, however, have serious shortcomings and are not sustainable. The most sustainable way of intervention is the biofortification of staple crops, such as pearl millet, which is mostly made possible by conventional plant breeding and transgenic methods. Since pearl millet may be able to help with health-related problems, attempts are being made to target the genes that are involved in effective Zn and Fe uptake and breed them into superior cultivars. For many years, research on improving the productivity, sustainability, and nutritional quality of food production systems has been driven by genetics and functional genomic platforms. Today, it is possible to identify QTLs and candidate genes that merit further investigation to determine whether these are responsible for advantageous traits.

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