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Biofortified Rice: A Strategy to Tackle Hidden Hunger

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ABSTRACT

Hidden hunger is a major and alarming risk for the modern world, with millions of people suffering from malnutrition. The world is seeking a solution by developing crops with rich nutritional profiles through a process called biofortification, and rice, as the main crop of interest, is a staple for billions and is low in many micronutrients, like zinc, iron, vitamins such as vitamin A, and more. Biofortification can be achieved through improved agronomic practices, conventional plant breeding, or biotechnology. Efforts to fortify rice are progressing positively, as many genetically modified varieties (like GR), hybridized varieties, and conventionally crossed varieties are being developed, with ongoing work to create even better options.

Keywords: hidden hunger, biofortification, Rice, zinc, Iron, Vitamin A

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Introduction

One of the biggest problems worldwide today is micronutrient malnutrition, also known as Hidden Hunger, which leads to low productivity and ultimately low income in an already poor household. In 2021, 828 million people were facing hidden hunger, so the UN added a healthy diet to 12 out of the 17 Sustainable Development Goals in 2022. According to the WHO, Iron (Fe) and Zinc (Zn) are two of the most important micronutrients, but they have very low availability in many diets. Approximately 31 percent of the earth's population faces the issue of Zinc deficiency, while 80 percent faces Iron deficiency. and 30 percent of them become anemic due to prolonged Iron deficiency, ultimately causing 0.8 million deaths each year [1].

Altering the food processing system and fortifying food with various chemical and biological additions are crucial to addressing these deficits. A sustainable substitute that can be very helpful for those with limited access to a variety of nutritional resources is biofortified (including bioengineered) staple food crops. Since half of the world's population depends on rice, genetically modified (GM) rice—which was created especially, to combat hidden hunger—has the greatest potential compared to any other staple crop. The most nutrient-dense type of processed rice is brown rice, which is made by removing the hull from field-harvested paddy. Important minerals like iron, zinc, copper, calcium, and phosphorus are found in unpolished brown rice, along with vitamins like thiamin(B1), riboflavin(B2), niacin(B3), pantothenic acid(B5), pyridoxine(B6), biotin(B7), folate(B9), and α-tocopherol [2].

For example, for Zinc biofortification, two techniques can be used: agronomic and genetic biofortification. Genetic biofortification includes the development of new crop cultivars that can accumulate important nutrients in higher quantities, like Zinc in grains. On the other hand, agronomic biofortification includes the application of Zn from a Competent source at the best application time and crop stage, for example maximum level of zinc can be achieved by application through soil treatment. Prior studies did not examine the combined effects of genetic and agronomic biofortification. Future studies must, however, assess how they interact with zinc intake and partitioning in rice crops. Biofortification in agronomy: Methods for applying zinc fertilizer. Applying zinc can be done by dipping seedlings into a fertilizer solution or by putting it in the soil, seeds, and leaves. When zinc is applied to rice, it is generally absorbed through the roots or leaves. Various strategies for overcoming dietary zinc deficiency [3]. This article deals with the idea of taking biofortification as a strategy against hidden hunger, the need for biofortification in rice, and ongoing work on rice biofortification.

Understanding Hidden Hunger

Hidden hunger refers to the subclinical deficiency of one or more of the 26 essential micronutrients required for optimal physiological functioning [4]. This condition is not confined to undernourished or underweight individuals—it can also be found among those who are overweight or obese. However, it disproportionately impacts populations experiencing extreme poverty. Although micronutrient deficiencies in children can hinder physical and cognitive development and act as early indicators of chronic non-communicable diseases in adulthood, hidden hunger poses a threat to all stages of life, from infancy to old age [5]. Zinc deficiency can affect different human organ systems, like the epidermal system, immune system, skeletal system, reproductive system, gastrointestinal system, and central nervous system [6]. Iron deficiency can lead to anemia, causing a reduction in the oxygen-carrying capacity of the blood, which further causes fatigue, weakness, and reduced work capacity, and in some cases, behavioural disturbance also occurs [7].

The need for biofortification in rice

Improving the nutritional profile of any crop by plant breeding and biotechnology is a very old concept, given decades ago as a strategy to combat nutritional shortcomings in an efficient way [8]. If we talk about rice and shortcomings in its nutritional profile, for instance, the required daily intake of Vitamin A is 600 micrograms, that of Iron and zinc is 15 milligrams, and for comparison, the most widely grown and consumed variety in India (Swarna) contains 0.78 milligrams of iron per 100g 2.28 milligrams of zinc per 100g brown rice, Even by taking 100 or 150 gram rice per day a person can have 20 percent of the recommended dose of iron and 50 percent of the recommended dose of the zinc [9].

Approaches for biofortification in Rice

Now, as we mentioned, the need for biofortification in rice, for example, we go for the fortification of iron. There are many approaches that we can go with, using plant breeding and biotechnology, like improving iron accumulation in rice seed by incorporating iron-storing protein, ferritin gene, SoyferH1, SoyferH2, or Pvferritin. The second approach includes improving iron transport inside the plant body through the overexpression of NAS. The third approach is by improving Fe absorption and Transfer by overexpressing the OsIRO2 gene, etc [10]. For zinc enrichment, we can use agronomic practices like using zinc fertilizer or by plant breeding or biotechnology practices like enhancing the zinc transporters and ligands within the rice plant [11]. For Vitamins like vitamin A, the recombinant DNA technology is the only option for fortification, as none of the known cultivars accumulated β-carotene in their endosperm [12].

Efforts towards biofortified Rice

If we dive deep inside today's world, work on biofortification. In Indonesia, 4 rice biofortified varieties have been released, which are fortified for zinc content. The first rice variety that was released had zinc contents up to 34.51 ppm and was introduced by IRRI (International Rice Research Institute) by the name of Inpari IR Nutrizinc [13]. In India, during an experiment conducted by the Indian Institute of Rice Research (IIRR) to check the zinc levels in the most cultivated varieties, population from 16 crosses made between the varieties were grown, the lowest zinc content was observed in the population from the cross of IR64 with the variety named Jalpriya that was around 18.6 mg per kg and as for the highest zinc content, it was recorded in a cross between RPBio226 and the same Jalpriya variety from the previous cross among the 16 crosses populations that were grown, These results demonstrate the genetic diversity that can be used to increase the zinc content of rice and offer useful information for biofortification breeding initiatives that seek to create high-Zn rice cultivars [14]. Golden Rice is a transgenic Rice that gives significantly high values of Vitamin A.

For the development of Golden Rice (GR), many approaches are used, as developing and growing generations of breeding lines through the technique of double haploids via another or pollen culture method, which gives rapid and stable GR lines [2]. In Bangladesh, efforts on biofortified varieties like IR102481-BK-BK-ACI28-3-1 are going on, and pre-existing varieties like Dhna62 and BRRI are also available [15].

Conclusion

Biofortification in Rice is essential without any delay, as rice is a staple food for more than 3.5 billion people today, and keeping in view that its nutritional profile is deficient in many micronutrients like zinc and Iron, as mentioned in the writing. And has great potential for biofortification, also biofortification of rice will greatly help tackle the rising issue of hidden hunger and malnutrition. There are multiple ways to achieve this goal using multiple agricultural disciplines, like agronomy, soil science, biotechnology, and plant breeding. The ongoing work, like Inpari IR Nutrizinc in Indonesia, varieties like in Pakistan, Vital Super Basmati, a variety enriched in zinc and Iron, for vitamin A transgenes like golden rice, and the development of high zinc-containing lines in India through conventional plant breeding, all of these are showing that efforts for having a nutritionally rich Rice Variety are going in positive direction.

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