High-iron and -zinc rice

Rice Science for a Better World
International Rice Research Institute

rice fact sheet

Why improve the nutritional value of rice?

Rice is the dominant cereal crop in many developing countries and is the staple food for more than half of the world's population. Currently, polished rice contains an average of only 2 parts per million (ppm) iron (Fe) and 12 ppm of zinc (Zn). In many Asian countries, rice provides 50–80 percent of the energy intake of the poor but it does not provide enough essential micronutrients to eliminate "hidden hunger," in particular iron deficiency anemia (IDA) and zinc deficiency. In many of these same Asian countries, IDA affects nearly 60 percent of the population. Because of the high per capita consumption of rice in these countries, improving its nutritive value by increasing iron and zinc levels in the grain can have significant positive health outcomes for millions of people.

What is being done now?

Micronutrient-dense rice is being developed at the International Rice Research Institute (IRRI) and elsewhere using the best traditional breeding and modern biotechnology methods to achieve Fe and Zn levels that will bring measurable benefits to human nutrition. National institutions in Bangladesh, Indonesia, China, Vietnam, India, the Philippines, and elsewhere are screening their own germplasm to breed for high iron and zinc. A number of iron storage protein and iron transport genes from other food crops are also being evaluated in transgenic plants.

Breeding for iron and zinc

Developing rice with high iron and zinc through the process of "biofortification" aims to combine high mineral content with grain quality and agronomic characteristics, such as high yield and pest and disease resistance, to ensure acceptability by farmers and consumers. Breeding for high iron and zinc is guided by the breeding objectives of the HarvestPlus program, which require that

1. Crop productivity be maintained or increased to guarantee farmers' acceptance,
2. Micronutrient enrichment levels have a measurable impact on human nutritional status,
3. Micronutrient enrichment traits be relatively stable across various environments and climatic conditions,
4. Bioavailability of micronutrients in enriched lines be tested in humans to ensure the benefits to people preparing and eating them in traditional ways within normal conditions, and
5. Consumer acceptance be tested (taste and cooking qualities) and be acceptable to household members to assure maximum impact on nutritional health.

Initial germplasm screening and field evaluation for iron and zinc have included breeding lines from Korea, Bangladesh, Indonesia, India, and the Philippines. Thirty lines of rice with more than 5 ppm iron in the polished grain were initially selected and evaluated in multilocation trials in the wet and dry season in the Philippines to determine agronomic and nutritional performance, to assess genotype × environment interactions for iron and zinc, and to identify parent materials and candidates for fast-track breeding. Results show that iron content in polished rice can increase by a factor of 2–4, but with some environmental and climate effects. For zinc, concentrations of 20–25 ppm have been identified in several varieties, which suggest a high feasibility for developing high-zinc rice.

Proof of Concept

Iron-dense rice IR68144 is a cross between high-yielding variety IR72 and tall traditional variety Zawa Bonday with relatively high iron (4.1 ppm) in the grain. A human efficacy study used IR68144 to show that increasing micronutrient levels in the rice grain may help improve the Fe status of women with low iron stores. The study (www.nutrition.org/cgi/content/ full/135/12/2823) was able to prove that consumption of biofortified high-iron rice increased body iron by 20 percent. Improvement in iron stores was most evident among nonanemic subjects with the lowest baseline iron stores and highest consumption of the high-iron rice. This phase of the project was largely funded by the Asian Development Bank (www.adb.org/Documents/Periodicals/ADB_Review/2004/vol36_3/rice_power.asp).

What would be the cost to farmers and consumers?

It is not anticipated that high-iron and -zinc rice seeds will be more costly for farmers to buy or to use to produce the crop. Therefore, the price of biofortified rice for consumers should not be different from that of other rice.

For additional information on high-iron and -zinc rice, visit www.harvestplus.org/ or contact Gerard Barry, HarvestPlus Rice Crop Leader, at g.barry@cgiar.org.

IRRI International Rice Research Institute

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