Breeding Crops for Better Nutrition

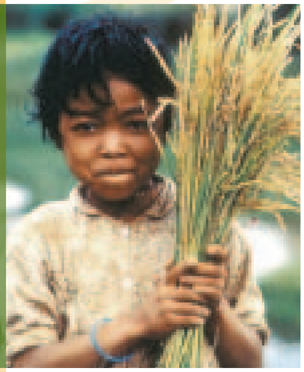
"**Imagine** a new breed of nourishing crops capable of alleviating undernutrition in even the hardest-to-reach populations—crops such as rice with more iron, wheat packed with zinc, and maize strengthened with vitamin A. These staples could be grown on family farms throughout the developing world."

photo: D. Marchand, IDRC

HarvestPlus

Harnessing Agricultural Micronutrient

A Hidden Hunger


Complements of IRRI

More than 840 million people do not have enough food to meet their basic daily energy needs. Far more—an estimated three billion—suffer the insidious effects of micronutrient deficiencies because they lack money to buy enough meat, poultry, fish, fruits, legumes, and vegetables. Women and children in Sub-Saharan Africa, South and Southeast Asia, and Latin America and the Caribbean are especially at risk for disease, premature death, and impaired cognitive abilities because of diets poor in crucial micronutrients—particularly iron, vitamin A, iodine, and zinc.

Current efforts to combat micronutrient malnutrition in the developing world focus on providing vitamin and mineral supplements for pregnant women and young children and on fortifying foods with these nutrients through postharvest processing. These approaches have accomplished much. In regions with adequate infrastructure and well-established markets for delivering processed foods such as salt, sugar, and cereal flours, food fortification can greatly improve the micronutrient intake of vulnerable populations.

But there are limits to commercial fortification and supplementation. Fortified foods may not reach a large number of the people most in need because of weak market infrastructures. Supplementation likewise depends on a highly functional health infrastructure, a condition that is often absent in developing countries. Thus, new approaches are needed to complement existing interventions.

Biofortification℠

A New Paradigm for Agriculture and a Tool for Improving Human Health

The introduction of biofortified crops—varieties bred for increased mineral and vitamin content—will complement existing nutrition interventions and provide a sustainable and low-cost way of reaching people with poor access to formal markets or health care systems. Once the investment is made in developing nutritionally improved varieties at central research locations, seeds can be adapted to growing conditions in numerous countries. Biofortified varieties have the potential to provide ongoing benefits year after year throughout the developing world at a lower recurring cost than either supplementation or postproduction fortification.

The biofortification approach is backed by sound science. Research funded by the Danish International Development Assistance (Danida) and coordinated by the International Food Policy Research Institute (IFPRI) has examined the feasibility of a plant breeding approach for improving the micronutrient content of staple crops and found that:

- substantial, useful genetic variation exists in key staple crops;
- breeding programs can readily manage nutritional quality traits, which for some crops are highly heritable and simple to screen for;
- desired traits are sufficiently stable across a wide range of growing environments; and
- traits for high nutrient content can be combined with superior agronomic characteristics and high yields.


Complements of IRRI

HarvestPlus

Technology *to* IMPROVE Deficiencies

Winning Acceptance of Biofortified Crops

The crops included in the HarvestPlus program are already widely produced and consumed by poor households in the developing world, meaning that farmers and consumers do not have to change their diet to benefit from biofortification. Moreover, breeding to improve the mineral content will not necessarily alter the appearance, taste, texture, or cooking qualities of the food made from the crop.

Where scientists can combine high micronutrient content with high yield, farmer adoption and market success of nutritionally improved varieties is virtually guaranteed. In fact, research showing that high levels of minerals in seeds also aid plant nutrition has fueled expectations of increased productivity in biofortified strains.

One way to ensure that farmers will like the new varieties is to give them a say in what traits are bred into the plants. Participatory plant breeding, in which scientists take farmers' perspectives and preferences into account during the breeding process, can be more cost-effective than confining breeding to research stations.

Distributing the New Varieties

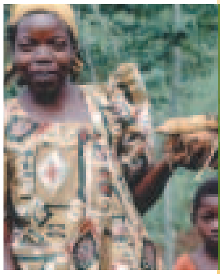
A common problem in many developing countries is the lack of delivery systems to get products—be they health or agronomic inputs—to the poorest people. HarvestPlus is overcoming this constraint through the seed-based technologies inherent in the biofortification approach. When households grow micronutrient-rich crops, the delivery system for micronutrients is built into the existing food production and marketing process. Little intervention or investment is needed once farmers have adopted the new seed. Moreover, micronutrient-rich seed can easily be saved and shared by even the poorest households.

Through their ongoing work with seed systems and their contributions to disaster-response, CGIAR centers have gained valuable experience in building and promoting local seed-distribution systems. These established systems offer a natural route for disseminating biofortified seed. Local agricultural committees and small-farmer seed enterprises, in particular, will play a crucial role in getting micronutrient-rich varieties into the hands of growers.

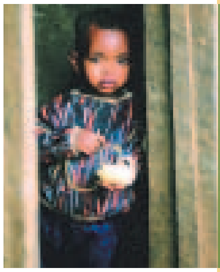
Complements of CIMMYT

Biofortification Makes Sense

The ultimate solution to eradicating undernutrition in developing countries is to substantially increase the consumption of meat, poultry, fish, fruits, legumes, and vegetables among the poor. Achieving this will take many decades and untold billions of dollars. Meanwhile, biofortification makes sense as part of an integrated food-systems approach to reducing undernutrition. It addresses the root causes of micronutrient malnutrition, targets the poorest people, uses built-in delivery mechanisms, is scientifically feasible and cost-effective, and complements other ongoing interventions to control micronutrient deficiencies. It is an essential first step in enabling rural households to improve family nutrition and health in a sustainable way.



Compelments of CIP



Complements of CIMMYT

HarvestPlus is a global alliance of research institutions and implementing agencies that have come together to breed and disseminate crops for better nutrition.It is coordinated by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). HarvestPlus is an initiative of the Consultative Group on International Agricultural Research (CGIAR).

The HarvestPlus international research coalition is bringing together an extraordinary range of knowledge and ability, including expertise in plant breeding, plant genomics, human nutrition, social behavior, and policy analysis.

The International Center for Tropical Agriculture (CIAT) and IFPRI are coordinating the plant breeding, human nutrition, crop dissemination, policy analysis, and impact activities that will be carried out at international agricultural research centers, national agricultural research and extension institutions, and departments of plant science and human nutrition at universities in both developing and developed countries. Nongovernmental organizations (NGOs) in developed and developing countries, farmer organizations, and public-private sector partnerships will strengthen the alliance and provide linkages to consumers. Initial biofortification efforts will focus on six staple crops for which prebreeding feasibility studies have been completed: beans, cassava, maize, rice, sweet potatoes, and wheat. The program will also examine the potential for nutrient enhancement in 10 additional crops that are important components in the diets of those with micronutrient deficiencies: bananas/plantains, barley, cowpeas, groundnuts, lentils, millet, pigeon peas, potatoes, sorghum, and yams.

Objectives:

Years

1 to 4

- Determine nutritionally optimal breeding objectives.
- Screen CGIAR germ plasm for high iron, zinc, and beta-carotene levels. Initiate crosses of high-yielding adapted germplasm for selected crops.
- Document cultural and food-processing practices, and determine their effect on micronutrient content and bioavailability.
- Discern the genetics of high micronutrient levels, and identify the markers available to facilitate the transfer of traits through conventional and novel breeding strategies.
- Carry out in vitro and animal studies to determine the bioavailability of the enhanced micronutrients in promising lines.
- Begin bioefficacy studies to determine the biological effect of the Biofortified crops on the micronutrient status of humans.
- Initiate studies to identify the trends—and factors driving these trends—in the quality of the diets of poor people.
- Conduct benefit-cost analyses of plant breeding and of other food-based interventions to control micronutrient malnutrition.

5 to 7

- Continue bioefficacy studies.
- Initiate farmer-participatory breeding.
- Adapt high-yielding, conventionally bred, micronutrient-dense lines to select regions.
- Release new conventionally bred biofortified varieties to farmers.
- Identify gene systems with potential for increasing nutritional value beyond traditional breeding methods.
- Produce transgenic lines at experimental level and screen for micronutrients. Test for compliance with biosafety regulations.
- Develop and implement a marketing strategy to promote the improved varieties.
- Begin production and distribution

8 to 10

- Scale up the production and distribution of the improved varieties.
- Determine the nutritional effectiveness of the program, and identify factors affecting the adoption of biofortified crops, the impact on household resources, and the health effects on individuals.

An International Consortium of Collaborative Partners

Collaborating CGIAR Research Centers: International Center for Tropical Agriculture (CIAT), International Maize and Wheat Improvement Center (CIMMYT), International Potato Center (CIP), International Center for Agricultural Research in the Dry Areas (ICARDA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA), International Rice Research Institute (IRRI).

Partner Collaborating Institutions: National agricultural research systems (NARS) in developing countries; departments of human nutrition at universities in developing and developed countries; NGOs; University of Adelaide; University of Freiburg; Michigan State University; Plant, Soil, and Nutrition Laboratory, U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS); Childrens' Nutrition Research Center, Baylor College of Medicine, USDA-ARS.

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