Breeding Crops for Better Nutrition

by Yassir Islam & Christine Hotz

IAEA-supported research partnerships zero in on "biofortification".

Millions of malnourished children in developing countries will never lead healthy, happy lives due to 'hidden hunger' caused by an insufficient amount of micronutrients in their diets. Micronutrients, such as vitamin A, zinc, and iron are more abundant in the diverse diets enjoyed by affluent populations—these micronutrients quietly do their work to help children grow, develop cognitive skills, and build their immune systems. Their presence, beneath the demeanour of a happy well-nourished child, goes unnoticed. However, the same cannot be said of their absence. During the accelerated growth phases from infancy through adolescence, micronutrient deficiencies can leave children ill, stunted, or even blind, and diminish their prospects for a healthy and productive adulthood.

Fortifying foods and providing supplements are the main strategies used to reduce hidden hunger. However, the reach of these interventions can be quite limited, especially in rural areas of developing countries where most of the poor live. Biofortification is a promising innovation that could help fight hidden hunger especially in rural areas.

Researchers know that the rural poor consume large amounts of staple food crops, such as rice, or sweet potato, foods that do not provide them with enough micronutrients. Through a process called biofortification, scientists are now breeding staple foods with higher micronutrient content.

HarvestPlus, a global leader in biofortification, is leveraging a worldwide network of scientists to breed and disseminate new biofortified varieties of staple food crops that are rich in vitamin A, zinc, or iron. By targeting staple food crops that are already important in people's diets, HarvestPlus believes it will be easier—and more cost-effective—to reduce hidden hunger in rural areas by integrating these new foods into the lives of the poor. Along with fortification, supplementation,

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Staple foods, such as rice, may fill a child's stomach, but provide few nutrients.

and other efforts to diversify diets, biofortification could be an effective tool in helping to prevent, or reduce, hidden hunger.

Plant breeders must taken into account several factors when they set nutrient target levels for staple food crops. Among these are:

- post-harvest nutrient loss from crops during storage, processing and cooking;
- micronutrient bioavailability (how much of the nutrient is absorbed when the food is eaten), and
- bioefficacy—how the increased intake of micronutrients increases nutrient stores in the body and prevents outcomes associated with micronutrient deficiency.

This data is lacking for many crops, but is essential if plant breeders are to breed sufficient amounts of micronutrients into food crops, so that consuming normal amounts of these foods will provide a substantial proportion of daily micronutrient requirements.

It is at this critical juncture, that the IAEA is helping HarvestPlus move towards its goal. While animal models may be useful for studying mechanisms of absorption and conversion, scientists' cannot directly extrapolate their results to humans. Ultimately, researchers will need to conduct complex human efficacy trials requiring large numbers of participants, longer consumption periods, and difficult logistics for monitoring consumption of the test foods to provide the burden of proof for the biofortification strategy. However, stable isotope tracer studies can provide direct estimates of the bioavailability of micronutrients in humans far more quickly and cheaply than long-term efficacy trials. Furthermore, they can be used to estimate the potential impact of biofortified foods in the dietary contexts typical of rural, developing country populations, as there are many dietary factors that can limit micronutrient bioavailability.

"Stable isotope tracer techniques constitute a useful intermediate step that can provide us with physiological data to help predict the impact of biofortification in the long-term on micronutrient status," says Dr. Erick Boy, nutrition coordinator at HarvestPlus, "and IAEA has considerable expertise in this field."

In 2004, HarvestPlus and IAEA launched their first research partnership, which analyzed the contribution of biofortified staple food crops to micronutrient status in adult women using stable isotope tracer techniques.

One of the first collaborative projects was on orange sweet potato, which is emerging as a biofortification success story. It has been demonstrated that orange sweet potato biofortified with provitamin A (hence the orange color) increases vitamin A intake and vitamin A status of deficient individuals, compared to traditional white varieties that are popular in Africa. This is encouraging news, given that thousands of children in Africa go blind every year from vitamin A deficiency. Fat is required to facilitate the absorption of vitamin A, but fat intakes tend to be lower in developing country populations than in more affluent populations, which may also contribute to inadequate vitamin A status among the rural poor. Stable isotope dilution techniques are being used to estimate total body stores of vitamin A before and after consumption of provitamin A rich foods, thus determining the efficacy of these foods to prevent vitamin A deficiency.

This research project will also shed light on the extent to which orange sweet potato prepared with added fat improves vitamin A status compared to orange sweet potato prepared without added fat. This will help researchers better understand the broader context in which orange sweet potato can improve the vitamin A status of populations, as many households cannot afford to cook with vegetable oil or other fats.

Wheat is the second most popular cereal in Asia, after rice. In South Asia, where zinc deficiency is widespread, wheat biofortified with zinc could provide more zinc to millions of zinc-deficient people. The only problem is that phytates, a phosphorus compound that is abundant in wheat and other cereal grains, can inhibit the absorption of minerals such as zinc and may even contribute to the high rates of zinc deficiency found in populations with high intakes of unrefined cereals. Many consumers around the world typically eat products made from refined wheat flour and yeast-leavened bread, both of which have low phytate content due to the processing methods used. However, among populations in rural India and Pakistan, unleavened bread is often prepared from whole-wheat products, and thus, the phytate content is maximal. In this dietary context, the benefits of increased zinc content in biofortified wheat could be rather limited.

A zinc stable isotope tracer study supported by HarvestPlus and IAEA confirmed, however, that a proportionate amount of zinc from biofortified wheat products provided a proportionately greater amount of absorbed zinc, regardless of whether the wheat was refined or unrefined. This result is encouraging for the prospects of zinc biofortification.

As a follow-up to this first round, a second set of collaborative projects launched in December 2008, will also examine zinc absorption, but this time, in children, who are the most vulnerable to the devastating consequences of hidden hunger. Relatively little information is available on zinc absorption in children, especially from cereal-based diets. These studies will look at zinc absorption from three biofortified crops: rice, pearl millet, and maize. For each of these crops, researchers will measure zinc absorption in children from Bangladesh, India, and Zambia, respectively, who are vulnerable to zinc deficiency. This is important because it is not yet known whether zinc absorption in children follows the same pattern as it does in adults.

The protocols and findings that emerge from these coordinated research projects should have broad applications in developing biofortified crops and increase our understanding of how humans, especially children, ingest and absorb nutrients from the food they eat. Ideally, the poor will eventually need to have better access to more diverse diets that could provide them with needed micronutrients, but rising food prices means this goal may remain elusive for quite a while longer.

Furthermore, millions of people in remote regions of the developing world also lack diversity in their diets simply due to their isolation, marginal agricultural conditions, and the seasonal availability of many foods. Biofortified staple food crops can help bridge the micronutrient gap, providing people with a larger proportion of their daily micronutrient requirements through the foods that they already grow and eat.

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About HarvestPlus

HarvestPlus is an international research program that seeks to reduce micronutrient malnutrition by breeding biofortified staple food crops that are rich in micronutrients. It is a Challenge Program of the Consultative Group for International Agricultural Research. It is co-convened by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI).

For further information visit: www.harvestplus.org

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