Biofortified Wheat

In developing countries, particularly in South and West Asia, about half a billion people are iron deficient. In many of these same regions, wheat is considered a major staple food. The main objective of biofortifying wheat is to develop nutritionally enhanced wheat to increase people's intake of iron and zinc. The International Center for Wheat and Maize (CIMMYT) is leading the HarvestPlus research effort in collaboration with national agricultural research and extension systems in South and West Asia, as well as with other advanced research institutes.

Given that spring wheat varieties developed by CIMMYT and its partners are used in 80 percent of the global spring wheat area, the potential impact of iron-enhanced wheat could be dramatic.

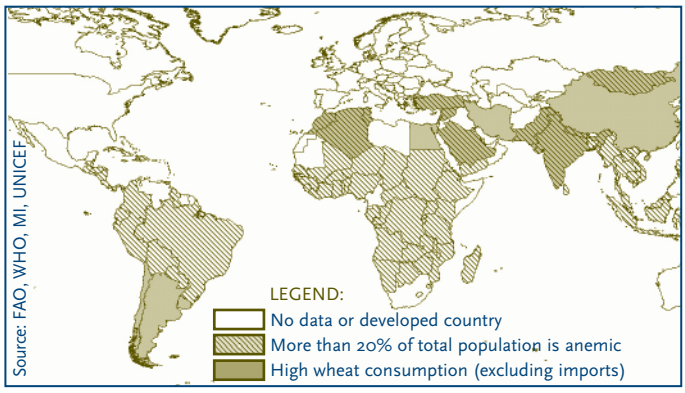
Strategy

The initial target countries for improving micronutrient content in wheat will be Pakistan and India, in the area around the Indo-Gangetic plains, a region with high population densities and high micronutrient malnutrition. As more resources become available, other countries will be included in this project.

The strategy is to improve iron and zinc levels of high-yielding, disease-resistant varieties being developed by the national research institutes of India and Pakistan and by international agricultural research centers.

The highest levels of iron and zinc in wheat grain come from landraces and wild relatives of wheat such as *Triticum dicoccon and Aegilops taushii*. In the search for better sources of high iron and zinc levels within CIMMYT genebanks, emphasis will center on screening wild relatives.

Because the best sources derive from wild relatives of wheat that cannot be crossed directly with modern wheat, researchers facilitated the cross between a high-micronutrient wild relative of wheat (*Aegilops taushii*) and a high-micronutrient primitive wheat (*Triticum dicoccon*) to develop a variety of hexaploid wheat that can be crossed directly with current modern varieties of wheat and have 40 to 50 percent higher levels of iron and zinc in the grain compared to modern wheat.



Researchers are using hexaploid wheat to support breeding efforts in India and Pakistan for the development of high-yielding, disease-resistant biofortified wheat. The first biofortified lines will be delivered to the target region by 2005. These initial advanced materials represent broadly adapted, high-yielding, disease-resistant wheat lines that demonstrate potential under Indian and Pakistani conditions.

If these advanced lines perform well, they could be approved for release after three years of testing or simply used by local breeders as improved sources of iron and zinc in their crossing programs. The development of high-micronutrient versions of other adapted varieties is under way, and the first high-yielding lines with confirmed high iron and zinc levels in the grain should be available for regional deployment by mid-2007.

Researchers will be exploring the introduction of the ferritin gene in wheat and will establish the feasibility of increasing the concentration of iron and zinc in the grain using advanced biotechnology approaches in addition to conventional plant breeding. Molecular markers for the iron and zinc genes that control concentration in the grain are being identified to facilitate their transfer.

In 2004, researchers will initiate studies of iron and zinc loss in milling and cooking. Chapatis, a type of bread commonly eaten by the poor in certain regions of India and Pakistan, use whole wheat grain, which means that losses due to processing and cooking are expected to be relatively small. Scientists will also undertake studies on bioavailability to determine the extent to which iron and zinc status in animal and human subjects is improved when biofortified varieties are consumed on a daily basis over several months.

While the development of varieties containing higher levels of zinc and iron is progressing, scientists continue to search genebanks for sources of high–vitamin A wheat. In the meantime, researchers are using a genetic engineering approach to introduce genes for vitamin A from other species.

Transgenic materials will not be deployed in developing countries without high biosafety standards and not until individual countries have resolved their internal debates on the deployment of transgenic crops.

HarvestPlus Wheat Alliance

Country	Category	Institute	Responsibility
Australia	University	Adelaide University School of Agriculture, Waite Campus	Nutrition Research
India	NARES	Indian Agricultural Research Institute	Plant Breeding
	University	Banaras Hindu University	Plant Breeding
Pakistan	NARES	National Agricultural Research Council	Plant Breeding
Switzerland	Private Sector	Syngenta	Biotechnology
Turkey	University	Sabanci University–Istanbul	Biotechnology
	CGIAR	CIMMYT–Ankara	Plant Breeding
	University	Cukurova University–Adana	Plant Breeding/Biotech.
	NARES	NAR-Konya	Plant Breeding
United States	CGIAR	International Food Policy Research Institute (IFPRI)	Economic & Policy Research
	University	Cornell University Division of Nutritional Sciences	Nutrition Research
		Cornell University U.S. Plant, Soil & Nutrition Laboratory	Nutrition Research
		Nutrition Research Center, Michigan State University	Nutritional Genomics

Selected Publications

Calderini, D.F., and **I. Ortiz-Monasterio**. 2003. Are synthetic hexaploids a means of increasing grain element concentrations in wheat? *Euphytica* 134:169–178.

Calderini, D.F. and **I. Ortiz-Monasterio**. 2003. Grain position affects macro and micronutrient grain concentration in cultivars and synthetic hexaploid wheats. *Crop Science* 43: 141-152.

Long, J., **I. Ortiz-Monasterio**, and **M. Banziger.** 2003. Improving the nutritional quality of maize and wheat for human consumption. *In* I. **Cakmak** and **R. Welch**, eds., *Impacts of Agriculture on Human Health and Nutrition*. Encyclopedia of Life Support Systems. Oxford: UNESCO-EOLSS.

Monasterio, I., and **R.D. Graham**. 2000. Breeding for trace minerals in wheat. *Food and Nutrition Bulletin* 21(4):392–396.

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