HarvestPlus
ABSTRACT No.10

How Cost-Effective is Biofortification in Combating Micronutrient Malnutrition? An *Ex ante* Assessment

J.V. Meenakshi, Nancy L. Johnson, Victor M. Manyong, Hugo Degroote, Josyline Javelosa, David Yanggen, Firdousi Naher, Carolina Gonzalez, James Garcia and Erika Meng

Biofortification is gaining increasing recognition as an effective means of combating micronutrient malnutrition, particularly amongst the rural poor. The viability of this intervention depends as much on its cost-effectiveness as the degree to which farmers and consumers accept biofortified staple crops. Using the Disability-Adjusted Life Years (DALY) framework to measure the burden of micronutrient deficiencies, this *ex ante* analysis concludes that developing and disseminating biofortified crops is a highly cost-effective means of reducing micronutrient malnutrition in the developing world.

The study analyzed the cost-effectiveness of a variety of staple crops biofortified with provitamin A, iron and zinc in 12 countries in Africa, Asia and Latin America. Studied crops included beans, cassava, maize, rice, sweet potato and wheat.

The Disability-Adjusted Life Years (DALYs) framework was used for the study to measure years of life lost to temporary illness, permanent conditions and premature death resulting from micronutrient deficiencies under both pessimistic and optimistic scenarios. By integrating morbidity and mortality outcomes into a single, easily-compared metric, the DALYs framework provides a more comprehensive means for measuring the burden of micronutrient malnutrition.

> "the majority of biofortified crops fall into the highly cost-effective category based on their cost per averted DALY..."

The study then measured the potential impact of biofortified staple crops in terms of averted DALYs. Due to the inherent uncertainties of an *ex ante* analysis, the study forecast both optimistic and pessimistic scenarios, taking into consideration a number of factors for each biofortified crop including: coverage rates, expected increases in micronutrient content, and processing losses.

Estimated coverage rates, or the proportion of biofortified staples in production and consumption, were based on the dissemination of other modern plant varieties in the given countries. Crops with visible traits, such as an orange coloration due to the presence of provitamin A, are expected to have lower coverage rates than crops with non-visible traits. Quicker dissemination is anticipated for crops in countries with well-developed seed systems. The optimistic and pessimistic scenarios for expected increases in micronutrient content were based on germplasm screening exercises conducted by plant breeders. The study also took into account the best- and worst-case scenarios for potential processing losses according to the preparation techniques typically used in each country, as various

processes can significantly degrade the micronutrients present in staple foods.

The impact was measured by the percent reduction in burden and the cost per DALY averted under pessimistic and optimistic circumstance. The cost per DALY averted was then calculated using the costs of developing and disseminating biofortified crops. The degree of cost-effectiveness was determined by comparing the results with recognized international benchmarks and the cost per DALY averted for other interventions targeting micronutrient malnutrition.

Impact on Vitamin A Deficiency (VAD)
The percentage reduction in the burden of vitamin A was greatest in the case of biofortified sweet potato varieties (between 38% and 64%) followed by cassava (3-32%) and maize (1-32%).

In an optimistic scenario, the burden of vitamin A deficiency could be reduced at a cost of less than $20 per DALY averted for all provitamin A rich crops and countries, with the exception of cassava in northeast Brazil. Under pessimistic circumstances, costs stay low in Africa ($30 for sweet potato, $124-137 for cassava and $113-289 for maize per DALY averted), while exceeding $1000 for cassava in northeast Brazil.

Impact on Iron Deficiency
The expected decrease in the burden of iron deficiency ranges between 16-36% for beans, 11-21% for rice and 27-39% for wheat under optimistic scenarios and 3-9% for all three crops under pessimistic scenarios.

Reducing the burden of iron deficiency with biofortified staple crops proves highly cost-effective under optimistic circumstances: $1-3 per DALY averted for wheat in South Asia, $3-5 for rice in South Asia, $55 for rice in the Philippines, and $20-66 for beans in Latin America. In a pessimistic scenario, wheat and rice remain extremely inexpensive in South Asia at $10-13 and $17-18 per averted DALY respectively. Rice in the Philippines would cost $234 per averted DALY. Beans range between $134-439 per DALY averted under pessimistic circumstances in Latin America.

Impact on Zinc Deficiency
The expected reduction of the DALY burden of zinc deficiency from biofortification ranged between 2-20% for beans in Latin America, 13-56% for rice in South Asia and 5-48% for wheat in South Asia in pessimistic and optimistic scenarios. These results translate into a highly cost-effective intervention for reducing the burden of zinc deficiency in optimistic scenarios: $1-2 per DALY averted for wheat and rice in South Asia and $12 for rice in the Philippines. Under pessimistic scenarios, results per DALY averted range from $11-18 for wheat and $6-55 for rice.

The results of the analysis are encouraging for biofortification as the majority of biofortified crops fall into the highly cost-effective category based on their cost per averted DALY. With lower costs, biofortification also demonstrates a comparative advantage in Africa and Asia, relative to alternative interventions. This is especially true in South Asia where well-functioning seed distribution systems would enable biofortified crops to benefit a large rural population. The study clearly demonstrates the value of integrating agriculture and public health strategies.

Source: Meenakshi, J.V., Nancy L. Johnson, Victor M. Manyong, Hugo Degroote, Josyline Javelosa, David Yanggen, Firdousi Naher, Carolina Gonzalez, James Garcia and Erika Meng "How Cost-Effective is Biofortification in Combating Micronutrient Malnutrition? An Ex ante Assessment." *World Development* 38.1 (2010): 64-75.