

BIOFORTIFICATION: EVIDENCE AND LESSONS LEARNED FROM AN AGRICULTURE-NUTRITION PROGRAM

Howarth Bouis, Sherry Tanumihardjo, Margaret McEwan, Jan Low

Synopsis

For biofortification to be successful, three broad questions must be addressed:

- Can breeding increase the micronutrient density in food staples to reach target levels that will have a measurable and significant impact on nutritional status?
- When consumed under controlled conditions, will the extra nutrients bred into the food staples be bioavailable and absorbed at sufficient levels to improve micronutrient status?
- Will farmers grow the biofortified varieties and will consumers buy and eat them in sufficient quantities?

Conventional breeding research has thoroughly demonstrated that micronutrient density can be increased in food staples without negatively effects on other farmer-preferred traits. Progress to date in breeding and delivering biofortified crops:

- Varieties of biofortified orange-fleshed sweetpotato were introduced in Mozambique and Uganda in 2002 and 2007, respectively, and are now being introduced in many parts of Africa and South America. CIP's Sweetpotato for Profit and Health Initiative seeks to deliver OFSP to 10 million households in Africa by 2020.
- Provitamin A maize varieties that can provide up to 25 percent of the EAR for adult women and preschool children were released in Zambia and Nigeria in 2013. Large-scale delivery will begin in 2013. Varieties that can provide up to 50 percent of the EAR are in testing.
- Provitamin A cassava varieties with sufficient provitamin A to provide 25 percent of the EAR for women and preschool children have been released in DRC and Nigeria. Following intensive stem-multiplication efforts in Nigeria and DRC, biofortified varieties were disseminated to 125,000 households in 2013.
- High iron pearl millet was commercialized as truthfully labeled seed in India in 2012 and officially released in 2013. The biofortified variety is a version of the most popular open pollinated variety in Maharashtra, ICTP-820, and contains up to 50 percent of the iron EAR for women and preschool children. Hybrid varieties are in the development pipeline.
- High iron beans have been released in Rwanda and DRC; varieties that can provide an additional 30 percent of the iron EAR for women and preschool children are being disseminated to 250,000 households.
- High zinc rice is in varietal release testing in Bangladesh and India. Candidate varieties would provide 25 percent of the zinc EAR for women and preschool children.
- High zinc wheat is being testing in multilocation trials in both India and Pakistan and the first release is expected in India in 2013.

Biofortified crops developed through transgenic breeding, including golden and high-iron rice, cassava with increased levels of provitamin A and iron, bananas biofortified with provitamin A, and sorghum with increased provitamin A, decreased phytates, and an improved protein profile, are several years from the expected first releases.

Nutrition evidence increasingly shows that controlled conditions, extra nutrients bred into the food staples are bioavailable and absorbed at sufficient levels to improve micronutrient status. The evidence on bioavailability and efficacy is growing. Human studies have included a variety of technologies, including stable isotope methods, which are among the most powerful to measure bioavailability and efficacy.

- Both efficacy and effectiveness studies are available for orange-fleshed sweetpotato, and show that consuming OFSP can improve vitamin A status in certain populations.
- Full evidence is not yet available for biofortified maize, cassava, or golden rice but initial bioavailability results are promising. A large efficacy trial with 6-8 year old children evaluating the effect of orange maize consumption on serum retinol, vitamin A deficiency prevalence and dark adaptation is also underway in Zambia, and a similar trial is planned for biofortified cassava.
- Efficacy trials have been completed for iron crops, beans and pearl millet, and show that iron biofortified crops can improve iron status. For example, a completed recently efficacy trial with school children in rural India demonstrated that biofortified pearl millet is efficacious in improving iron status with 64% of the iron deficiency at baseline being resolved in the intervention group after 3 months of daily pearl millet consumption.
- Evidence for zinc biofortification is still developing; unlike iron and vitamin A, zinc does not have a measurable body store, which complicates efficacy research.

The experience of delivering OFSP suggests that farmers will grow the biofortified varieties and consumers will buy and eat them; however, many lessons learned through the delivery of OFSP (by projects including Towards Sustainable Nutrition Improvement in Rural Mozambique, the HarvestPlus Reaching End Users project in Mozambique and Uganda, and Mama SASHA) are applicable to the delivery of other biofortified crops and agriculture-nutrition interventions more broadly.

- For orange-fleshed sweetpotato (OFSP), two issues requiring integration into behavior change strategies orientated towards increasing its production and consumption were its visible orange trait and its image as a lowly food security crop. Efforts were made to transform the orange color into a selling point and to change the way that sweetpotato was marketed and utilized.
- Delivery systems for biofortified crops require strong partnerships and effective partnering practices.
- As agriculture-nutrition programs move to scale, they face the issue of capacity at multiple levels; there is a dearth of community-level personnel trained in basic nutritional knowledge, and health workers may not be able to take on an additional task. Public sector investment in agriculture and health extension services in many countries is low; donors have shifted to NGO or private sector service provision. Working with a range of NGO, CBO, and government partners is complicated by each organization's mode of operation and institutional vision, and implementing new cross-sectoral working methods and common monitoring systems is difficult.
- In the OFSP cases discussed, regular face-to-face review and planning meetings at the field level were key to ensuring cross-sectoral cooperation. Process review was found to be just as important as technical review.
- Partnerships around nutrition sensitive agricultural interventions must be clear about their objectives (e.g. advocacy, information sharing, implementation) and what types of capacity strengthening are needed to make that agriculture-nutrition partnership work. Due to the high transaction costs associated with cross-sectoral partnerships, incentives to partnering and the added value of multi-stakeholder partners to both the common goal of the partnership and individual organizational objectives must be fully analyzed.

Policy recommendations

Policies to support cross-sectoral implementation at all levels, as well as increasing the evidence base, will contribute to ensuring that biofortification is a cost-effective investment in community nutrition. Specific recommendations for participants in the ICN2 conference include:

- Make the mineral and vitamin content of the edible portions of new crop varieties core breeding objectives at agricultural research centers, in addition to yield and other agronomic characteristics
- Invest in developing cultivars with multiple micronutrients to capitalize on the synergistic effects between micronutrients
- Develop further efficacy trial evidence for biofortified crops, in particular with respect to the nutritional status of mothers going into pregnancy and for young children less than 24 months.
- Through effectiveness studies and other evidence, demonstrate that deployment of biofortified crops can be scaled up cost-effectively in selected target countries
- Identify and engage private sector entities, such as seed and food companies, to incorporate biofortified crops into their core business activities
- Integrate biofortification into selected global frameworks that heavily influence national governments, including *Codex Alimentarius*, the Scaling Up Nutrition framework (SUN), and the Comprehensive Africa Agriculture Development Program (CAADP).
- Incorporate biofortification into WHO evidence-based guidelines for nutrition interventions in its e-Library of Evidence for Nutrition Actions (eLENA)
- Identify opportunities to integrate biofortification within existing funding mechanisms and platforms, such as the Global Agriculture and Food Security Program (GAFSP), Global Donor Platform for Rural Development (GDPRD), Global Alliance for Improved Nutrition (GAIN), AgResults, the World Bank and regional development banks, and others.
- Expand the number of nutrition and health professionals within multilateral institutions, including the CGIAR and FAO, and invest in and reward efforts to work collaborative across disciplinary divisions
- Engage health and agricultural ministries to achieve a joint understanding of how agricultural policies can hinder or help achieve nutrition and health goals
- Consider dietary quality in economic policy analysis related to food security, not just energy intake
- Invest at higher rates in sustained productivity increases for a range of non-staple foods as well as biofortified foods

Biofortification is yet to be fully scaled-up in a single country, but much evidence and experience has been assembled to support its eventual effectiveness. As evidence continues to mount, it should be included in the policy framework to address today's major nutrition challenges and considered a priority area for enhanced international cooperation on nutrition.