

## CHAPTER 12

### INTEGRATING BIOFORTIFIED CROPS INTO COMMUNITY DEVELOPMENT PROGRAMS

MacDonald C<sup>1\*</sup>, Hilton B<sup>2</sup> and R Dove<sup>3</sup>

\*Corresponding author email: [carolyn\\_macdonald@worldvision.ca](mailto:carolyn_macdonald@worldvision.ca)

<sup>1</sup>World Vision International, Toronto, Canada

<sup>2</sup>World Vision Australia, Melbourne, Australia

<sup>3</sup>World Vision UK, London, UK



## ABSTRACT

Extensive research has demonstrated the effectiveness and acceptability of biofortification. There is now a need to establish effective, sustainable delivery systems for biofortified crops in countries with a high burden of micronutrient malnutrition. This requires country-level partnerships between national governments, non-governmental organizations (NGOs), the private sector and research institutions. World Vision (WV) is an international NGO with experience integrating biofortified crops as an agriculture-for-nutrition intervention within rural development projects, most extensively in Mozambique, Burundi, and Uganda. In WV's experience, successful integration and uptake of biofortified crops within broader community development programs is reliant on key elements of both the enabling environment and the program design. The optimal mix and intensity of interventions is not yet known; implementation science research is needed to enhance understanding of the critical elements of successful adoption, intensification, scale-up and sustainability of biofortified crops, and the human, technical and financial resources required to achieve this and to contribute to the sustainable reduction of micronutrient malnutrition.

**Key words:** nutrition, agriculture, biofortification, integration, multi-sectoral, nutrition-sensitive, nutrition policy, micronutrients, diet diversification



## INTRODUCTION

Biofortification is an innovative, food-based approach to improving micronutrient intakes in vulnerable populations. Extensive research by HarvestPlus and its partners has led to the release of micronutrient-rich varieties of several staple crops, including orange sweet potato (OSP) and iron beans [1]. Studies in Mozambique demonstrated that promotion of OSP within a food-based approach to improving nutrition resulted in significantly greater vitamin A intakes and serum retinol status among mothers and children [2, 3]. Studies in several countries have found biofortified varieties of staple crops to be acceptable or preferred by consumers [4]. Having demonstrated effectiveness and acceptability, the challenge now is to establish effective, sustainable delivery systems for biofortified crops [5, 6].

National governments ideally lead the roll-out of delivery systems, working in partnership with: 1) non-governmental organizations (NGOs) to reach farmers at the community level; 2) private sector entities for seed multiplication and marketing; and 3) research institutions for the propagation of new crop varieties and evaluation of implementation effectiveness. In practice, the roll-out of delivery systems for biofortified crops is often led by in-country partners. As NGOs are one critical partner, this paper focuses on lessons learned from World Vision's experience integrating biofortified crops into community development programming.

World Vision (WV) is well positioned to partner on biofortification delivery systems, as a large international non-governmental organization dedicated to transformational development that is community-based and sustainable, focused on the well-being of children. World Vision partners with communities and local governments in geographically defined areas to increase child well-being through long-term (10-15 year), multi-sectoral programs. Improvement of child health and nutrition is one of WV's four highest-level organizational priorities. World Vision applies a multi-sectoral approach to addressing malnutrition, with a particular emphasis on integrating interventions from the health and agriculture sectors.

World Vision has partnered effectively with several agencies to introduce biofortified crops, including orange sweet potato and iron beans. This began in Mozambique, where WV partnered with the National Institute of Agriculture Research on developing OSP varieties (1997-2000), and then with the Ministry of Agriculture to include OSP in their response to severe flooding (2000-2004). Collaborative research projects with HarvestPlus and other partners followed, and as the evidence base for biofortified crops continues to be built, WV is expanding implementation to integrated community development programs in an increasing number of countries.

This paper draws information and lessons from WV's experience in integrating biofortified crops as an agriculture-for-nutrition intervention within rural development projects, primarily in Mozambique, Burundi, and Uganda. The integration of biofortified crops within existing programs is an emerging area of experience, with a paucity of peer-reviewed implementation studies. As no fully integrated (that is, non-research) projects have yet been completed within WV, comprehensive evaluation data is not available.



This paper, therefore, presents observations gleaned from internal WV project reports, external unpublished documentation, and the reflections of key individuals who have given leadership to WV's work in biofortification. We highlight lessons learned and call for a greater focus on rigorous implementation science to provide the evidence critically needed to guide effective scale-up of biofortified crops.

## LESSONS LEARNED

In WV's experience, successful integration and uptake of biofortified crops within broader community development programs is reliant on key elements of both the enabling environment and the program design.

### Enabling Environment

**Global enablers** Historically, most nutrition policies and strategies resided either in the national agriculture or health sectors, with limited support for linking agriculture for nutrition in either sectors. However, as the vital role of non-health sectors in implementing nutrition-sensitive actions has become evident [7], the Scaling Up Nutrition (SUN) Movement<sup>1</sup> and other global initiatives have effectively promoted and supported the development of multi-sectoral and multi-stakeholder national nutrition policies with supporting implementation strategies. More specific to integrating biofortification, the Global Panel on Agriculture and Food Systems for Nutrition has made six recommendations for policy makers to promote an enabling environment for the sustainable integration of biofortified crops at scale [8].

World Vision is active in contributing to the global enabling environment through multiple initiatives, but the examples cited below focus on these six recommendations by the Global Panel on Agriculture and Food Systems. The Panel's first recommendation is to "*identify national opportunities for improving micronutrient provision and determine whether biofortified crops can make a valuable contribution, in concert with other interventions*". Starting in 2012, World Vision and HarvestPlus developed a formal partnership, which included regular joint reviews to identify priority countries with national opportunities for integrating and scaling biofortified crops. As a result, WV progressively increased the number of countries with programs integrating biofortified crops. In 2012, WV had integrated biofortified crops in four countries' programs (Kenya, Mozambique, Papua New Guinea, and Uganda). In 2014, nine countries (including Bolivia, Burundi, India, South Sudan, and Zambia) and by 2016, seventeen WV country programs (adding Afghanistan, Bangladesh, DRC, Ghana, Lesotho, Pakistan, Rwanda, Zimbabwe) had integrated biofortified crops.

The Panel's second recommendation is to "*Invest in national agricultural research to generate or adapt crop varieties to have high content of essential vitamins and minerals while, at the same time, providing higher yields that will be attractive to producers. Opportunities for conventional breeding approaches should be identified and governments may wish to consider as well the pros and cons of transgenic approaches*". World Vision invests in national agriculture research on a number of levels including

<sup>1</sup> [www.scalingupnutrition.org](http://www.scalingupnutrition.org)



educating on biofortification, collaborating on research, and advocating for increased investment in research. Not all breeders recognize the importance of biofortification. Where breeders do not embrace biofortification, WV facilitates connections with organizations such as HarvestPlus or Consultative Group on International Agriculture (CGIAR) centers where breeders can learn more about biofortification in their countries, as well as supporting breeders to attend international conferences on biofortification. World Vision has also partnered with CGIAR centers or national scientists in conducting trials on biofortified crops in Mozambique, Afghanistan, and Burundi.

Thirdly, the Panel recommends to *“facilitate the registration, certification and production of biofortified seeds or cuttings to allow for private and public sector multiplication and distribution.”* World Vision works primarily at local levels promoting the production of seed and vines by local seed producers and decentralized vine producers. Where there are commercial seed systems in place, World Vision promotes certified seed production. In countries with poor seed systems, World Vision may promote quality declared seed. A recent example is Burundi, where WV received 19 metric tons (MT) of iron beans (Mac44) from Rwanda in 2013 at program start-up. As a result of WV’s facilitation of seed multiplication, in 2016, 108 MT of certified seed were produced and sold to other NGOs in Burundi, above the quantity of iron beans consumed and the 88 MT of iron beans marketed.

The fourth recommendation is to *“Invest in effective delivery strategies to provide poor smallholder producers, both women and men, knowledge of, and access to biofortified crops, and promote their adoption and in-home consumption”*. World Vision works primarily at the community and household levels, and targets small holder producers, both women and men, most often through farming groups and/or co-operatives to provide ‘hands-on’ experience with the biofortified crops. Seed at the year-end is distributed to members in a locally run scale-up programs. Importantly, WV integrates promotion of the biofortified crops into existing nutrition models to promote adoption and in-home consumption. For example, the Burundi program reached 3800 farmers, with a preferential focus on women farmers, women-led co-operatives and savings groups. The program integrated promotion of iron beans into existing nutrition models, with recipes in Positive Deviance Hearth programs reaching over 900 households; biofortified food served in 22 community-run crèches; and nutrition messaging through health and agriculture workers reaching all farmers. In addition, new nutrition approaches were developed, such as including iron beans in commercial production of complementary foods.

The fifth recommendation is to *“Promote uptake by farmers and consumption by targeting nutritionally-vulnerable populations through active social marketing, gender-sensitive extension guidance and potentially also via public sector procurement that supports institutional feeding programs (such as in school feeding)”*. World Vision agrees with and supports all of these activities, to assist with the adoption of biofortified crops. World Vision targets the nutritionally vulnerable, through program models and approaches which have undernutrition as a criterion for participation (for example, Positive Deviance/Hearth), and through the targeting of vulnerable communities with health models that use personal interactions and culturally appropriate approaches.



The final recommendation from the Panel is to “*Support the growing but critical evidence-base on costs and effectiveness of Biofortification strategies, and widely share success stories and best practices. Biofortification has the potential to reach large numbers of nutritionally vulnerable people, but measuring and tracking is important to understanding whether this potential is being achieved. Governments should invest in the data gathering and reporting systems to evaluate the effectiveness of all interventions aimed at improving agriculture, health and nutrition.*” World Vision assists in data gathering and evidenced based results, and advocates for increased government investment in tracking and reporting systems for nutrition outcomes and contributing factors. While there has been considerable investment in biofortification efficacy studies, there have been limited resources for evaluating the effectiveness and best processes for scaling-up. World Vision continues to advocate for increased resources for building the evidence-base on costs and effectiveness of biofortification strategies and to share success stories and best practices.

**National policy and coordination** There are now fifty-seven countries in the SUN Movement, with national multi-sectoral, multi-stakeholder plans to improve nutrition, providing an enabling environment for integrating biofortification. At least six countries (Bangladesh, Democratic Republic of Congo, Nigeria, Pakistan, Rwanda and Zambia<sup>2</sup>) have included biofortification specifically in national nutrition plans. Another fifteen African countries have included biofortification in their agriculture development plans [9]. This high-level political support for biofortification opens the way to integration of biofortified crops within existing programming [10].

In WV’s experience, introducing biofortified crops in Mozambique, Kenya, Zambia, and Rwanda has been greatly eased by the existing policy support. Key leaders across several government departments understand the value of biofortified staple crops, and high-level champions have supported initiatives, including two different presidents in Mozambique. In contrast, lack of policy support is likely a contributing factor to the challenges of importing OSP vines and implementing biofortification in Burundi and South Sudan, in addition to barriers created by conflict and isolation.

### **Organizational Priorities and Strategy**

As with country policies and strategies, non-governmental organizations (NGOs) that prioritize nutrition at the highest level and articulate a multi-sectoral, multi-stakeholder strategy for improving nutrition provide an enabling environment for the integration of biofortified crops into their development programs. This requires, first, recognizing the importance of good nutrition to multiple developmental goals so that nutrition is prioritized among many other competing development priorities. Secondly, an understanding of the linkages between food and nutrition make it easier to include biofortification as one intervention within a multi-sectoral approach. Conversely, the organization can use biofortified crops as well as the related nutrition messages, as a

<sup>2</sup> Project Completion Review - Top Sheet. 2016. DFID UK. [ONLINE] Available at: [http://iati.dfid.gov.uk/iati\\_documents/5198575.odt](http://iati.dfid.gov.uk/iati_documents/5198575.odt). [Accessed 23 September 2016].



means of communicating the linkages between food and nutrition, or agriculture and health.

The high-level prioritization of nutrition within WV's larger strategy has provided an enabling environment for integrating biofortified crops into agriculture, food security, and health programs. World Vision has a number of other enabling capacities: extensive global reach (operational in 97 countries); integrated, multi-sectoral programming platform at community level; national level advocacy initiatives with partners to influence policy change; robust experience in nutrition programming integrated with health, agriculture and food aid, microfinance/credit and water, sanitation and hygiene; local seed multiplication at the community level; marketing, behavior change and adult education; and lengthy experience partnering with a wide variety of collaborators to extend reach.

***Investment and commitment*** WV was an operational partner in the initial pilot projects which demonstrated the effectiveness of OSP in Mozambique. While these pilots were successful in improving micronutrient intake and status [2, 3], they were highly resourced, stand-alone projects. Organizational champions and additional investment through grant projects with funding allocated to biofortification were needed to stimulate the integration of OSP within on-going programs in Mozambique and other African countries.

To further the organizational commitment and investment in biofortification, a global Institutional partnership between WV and HarvestPlus was developed in 2012, with a part-time staff position allocated to managing the partnership. This enabled a more intentional and concerted effort to communicate the importance of biofortified crops and integrate them within community development programs. Key WV nutrition and agricultural technical specialists in regional and national positions were engaged around the benefits of biofortification which increased the number of internal advocates. Prior to 2012, biofortified crops were integrated in WV programs in only three countries. In 2016, seventeen country programs are implementing biofortification. The inclusion of biofortified foods as a strategic approach in WV's global Resilience and Livelihoods strategy is anticipated to further facilitate integrative programming.

***Partnerships between government, NGOs and research institutions*** While government departments (for example, National Agricultural Research Centers) are necessarily responsible for the introduction of biofortified crops, they do not always have the presence at community levels, nor the capacity for monitoring and evaluating the scale-up. Partnerships with non-governmental agencies and research institutes (for example, HarvestPlus and International Potato Center) have been the basis for integrating biofortified crops. Non-governmental organizations (NGOs) such as WV have been necessary partners to provide the reach to communities, through organization of farmers' associations, technical support, and demand creation activities [11].

National policies often do not prioritize breeding programs for crops which could improve nutrition, rather focusing on commercial crops. In the case of Burundi only five crops were prioritized by the government, but orange sweet potato was not included.



Although sweet potato is an important staple in Burundi and has the potential to improve nutrition, the most recent new sweet potato variety released in Burundi was in 1988. Thus, the International Potato Center and WV jointly advocated to the government to add the orange sweet potato as a priority crop in their breeding program. As a result of the combined advocacy efforts, the Government of Burundi appointed a part-time orange sweet potato breeder in 2016. With this investment, the government is planning to release new orange sweet potato varieties in 2017.

### Program Design Elements

Integration of biofortified crops within community development programs requires intentional planning, decision-making and resource allocation at all stages of the program process.

**Rigorous assessment** When assessing the potential for the incorporation of biofortified crops into existing programming a useful tool to refer to is the Biofortification Prioritization Index (BPI) [12]. The BPI is calculated by combining sub-indices for production, consumption and micronutrient deficiency using country level secondary data. The BPI can be used for seven biofortified staple crops and covers 127 countries in Africa, Asia and Latin America and Caribbean. This tool was used when assessing the potential for the introduction of biofortified crops into WV programs. The BPI ranked Burundi second and fourth in the world for OSP and iron beans, respectively, indicating a high potential for using these crops to help address vitamin A and iron deficiencies. Rwanda, Tanzania, Uganda, and Kenya all ranked in the top ten BPI African countries for iron beans. Afghanistan is a country with high BPI rankings for zinc wheat and thus WV is testing new high zinc varieties with the International Maize and Wheat Improvement Center. Similarly, for other countries, such as India which is ranked high by the BPI for iron pearl millet, WV is collaborating on scaling up pearl millet, and in countries where orange sweet potatoes have high BPI (for example, Kenya, Mozambique, Tanzania and Ghana), WV is working to expand sweet potato growing areas to farmers with little experience growing sweet potatoes. In some cases the expansion to farmers is through introductions of new crops, and in some cases there are new varieties of existing crops.

However, high potential alone is not sufficient to move forward with their inclusion into programming. A number of other key considerations need to be assessed:

- Significant differences in micronutrient deficiencies, crop production or consumption between national averages and sub-national data for the targeted intervention areas, which may change the potential use of the biofortified crops. In Burundi micronutrient deficiencies were high in all areas, as were the production and consumption of sweet potato and beans.
- Suitability of biofortified varieties for the agro-ecological zone, including improved yields and alignment with traits desired by consumers. On-farm testing may be needed, which also enhances farmers' sense of ownership [11].
- Status of approval for the biofortified crop. In Burundi, although not released, authorization was given for high iron beans as they were in the regional variety testing scheme and also being grown in Rwanda.





- Gender-based division of agricultural labor; impact on women's workload and cultivable area [11].
- Limitations of the value chain including marketing options and demand creation needs, particularly if the biofortified crop has visible traits that differ from traditional varieties [1, 11].
- Farmers' access to seed or planting material for the identified crop(s). It is important to work closely with the Ministry of Agriculture and the National Agricultural Research Stations to facilitate access to seeds and planting material. In Burundi, license was granted to import high iron beans seed but not OSP vines, which stalled that element of the project.

Following rigorous assessment along these dimensions, WV has integrated biofortified crops into programming in many countries.

***Harmonize demand creation and seed supply*** The pathway between agricultural interventions and child nutrition outcomes is complex, and the various objectives and components need to run in parallel. If a demand is created for biofortified crops but the seed systems are not there to supply the demands, then results will be limited [1].

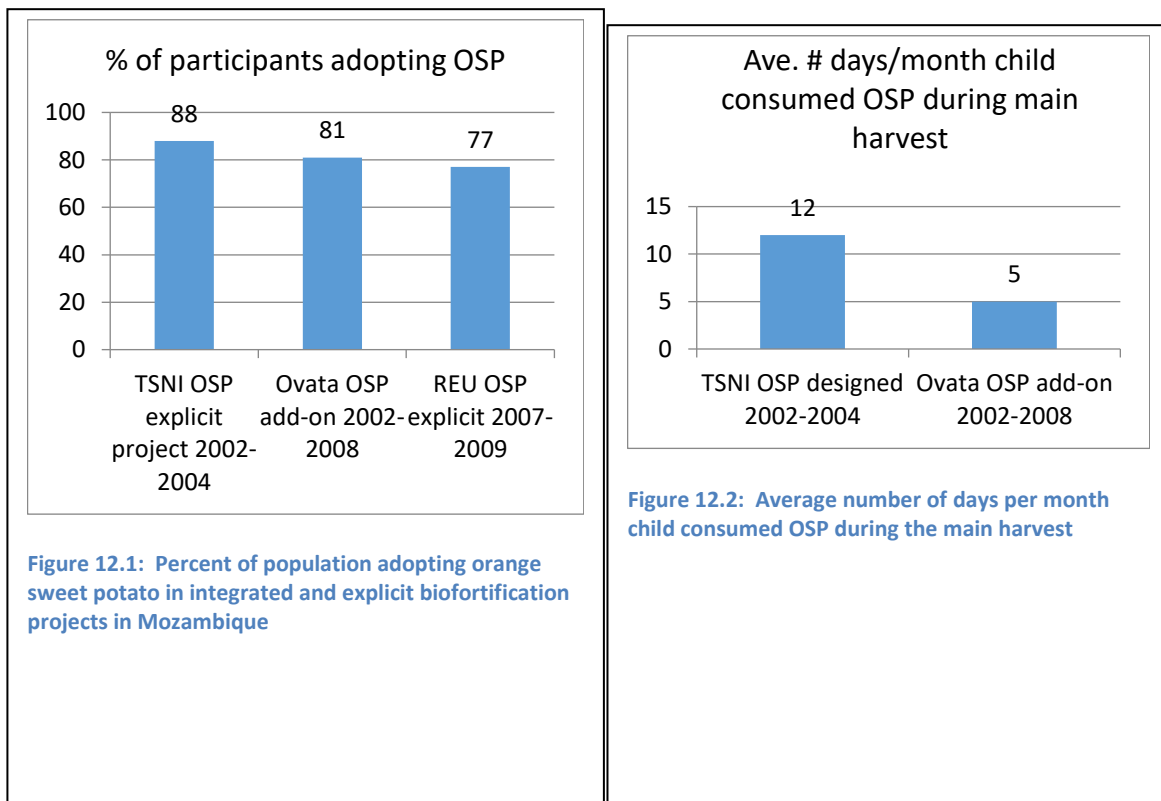
In many cases sufficient seed and planting material will not be available for an immediate start either from seed companies or local producers. In Burundi the national bean breeder was only able to offer 20 kgs of foundation seed for introducing high iron beans in 2013. It would have taken two years of multiplying beans just to start the program for a few thousand farmers. Fortunately, the same variety existed in Rwanda and WV was able to broker the import of 19 MT to rapidly jump start the integrated agriculture-nutrition project that same year.

Agreements with seed companies may need to be made to guarantee an agreed level of purchase of seed until sustainable demand is established in the markets. In the case of sweet potato and cassava, vines and cuttings will need to be multiplied (probably by the "project"; unless there are local producers already doing this). The need for irrigation support for vine multiplication has also been noted [10]. In Mozambique biofortification projects paid for irrigated fields as a temporary solution because locally produced vines were not supplying enough material for start-up [13]. This approach was eventually supplanted by decentralized sweet potato vine producers which were cheaper, more sustainable, and empowered the private sector. World Vision's experience suggests that once demand for biofortified crops has been established, private sector entities recognize opportunities in the biofortified seed and crop value chain.

***Avoid competition between biofortified and traditional varieties*** Crop breeding is a difficult job. Breeders are already breeding for high yield, pest and disease resistance, and myriad other special considerations such as taste, cooking qualities, and storage. Adding the further parameter of improved micronutrient content may not be welcomed, particularly if breeders perceive that it is not possible to achieve this without compromising other desirable traits. However, when improved biofortified and non-biofortified varieties are released together, they may compete for the same market. Where possible, improved micronutrient levels should be bred into all new varieties, as

agricultural research institutions have done with climbing and bush beans (Burundi) and sweet potatoes (Mozambique). Non-governmental organizations can have a voice in advocating for this practice.

When biofortified and non-biofortified varieties are released together, uptake of biofortified varieties may be more limited. For example, WV and the Australian Centre for International Agricultural Research worked in Papua New Guinea releasing both orange and white sweet potato varieties [14]. There was no particular nutrition messaging in this project and adoption of orange varieties was limited, which compromised the potential to reduce vitamin A deficiency.



**Plan for additional resources** Exclusive biofortification projects are expensive but they are effective, especially with the poorest of the poor. This was demonstrated through a series of OSP projects in Mozambique (Figure 12.1). The Towards Sustainable Nutrition Improvement (TSNI) project (2002-2004), a well-resourced, exclusive biofortification project reaching approximately 750 households, achieved high impact but conducted activities not normally included in integrated projects, such as home visits [15]. The Reaching End Users Project (REU) (2007-2009), another exclusive biofortification project, showed that a lower-cost intervention model (saving 30% with nutrition messages, but no home visits) can be similarly as effective as a more intensive, higher cost model [2].

Projects with a less intensive focus on biofortification, but integrating biofortified crops with other interventions can also have significant impacts despite much lower resources for biofortification and much less attention to seed systems, demand creation, and child feeding practices [16]. For example, the Ovata (2002-2008) integrated project directly



targeted approximately 10,000 households, with multiplying mechanisms to reach a population of 2 million in Zambezia province [17]. Ovata added OSP as one of its many interventions and achieved adoption rates similar to the two concurrent explicit biofortification projects during program implementation (Figure 12.1). But when does cutting cost compromise results? Households in Ovata did not get OSP as effectively into child meals during the project (Figure 12.2), and the OSP adoption rate declined precipitously (from 48% to 12%) in some districts after the project had finished [10, 15, 18].

In Mozambique an ex-post study undertaken in 2012, three years after the REU project finished, showed that mothers and children under 3 years of age continued to consume more vitamin A in the treatment clusters than in the control group, and that this increase was almost entirely due to the consumption of OSP [19]. This indicates lasting benefits of the REU project, as the children in the ex-post study were born after the project ended.

The sustained improvement in OSP consumption and vitamin A intake in the treatment group of the REU project was observed despite some beneficiary households ceasing to grow OSP as well as the fact that the control group were given vines after the end of the project in 2010. However, the control groups did not adopt the OSP en masse. This suggests that giving vines alone, without the additional nutritional components of the integrated project, is insufficient to translate into widespread nutritional benefits. There is need for rigorous research to determine factors contributing to sustainable uptake of biofortified crops.

## DISCUSSION

Biofortification is an effective strategy for improving nutrition among the poorest of the poor. Biofortified crops have been integrated with WV programs in multiple African and Asian countries. The prospects for integration, adoption, and scalability depend on the national and organizational enabling environments as well as several elements of the program design. There is significant scoping and preparation required before biofortified crops can be implemented. This is particularly evident in countries where the selected biofortified crop has not as yet been promoted [10].

The BPI index is a useful tool for prioritizing potential impact of biofortified crops, but some of the highest impact countries are poorly functional or in conflict zones. They may not have the national policy to support biofortification and almost certainly have poor seed systems which hinder scale up. High potential districts should be chosen to achieve quick impact.

In terms of program design, it is much more conducive to introducing biofortified crops when health, agriculture, or food security programs include a nutrition outcome or objective. However, mechanisms are also needed for multi-sectoral program designs, evaluations and coordination of nutrition messaging, to manage both the supply and demand sides. Adequate resources and collaboration between sectors on evaluations with adequate depth to determine both nutritional and agricultural outcomes and processes are required to evaluate the cost of and effectiveness of integrating biofortified crops into development programs.

The level of investment required for effective, sustained integration of biofortified crops is not well understood, but work on investment guidance has begun [10]. While encouraging evidence exists that less expensive models can be effective, it is unclear where the inflection point is or the extent of supportive programming that is necessary to facilitate high adoption and sustained cultivation of biofortified crops [20]. A survey of rural farmers in Mozambique who participated in a USAID-funded food security project (2001-2003) found that five factors were statistically significant and positively associated with adoption of OSP [11]. These were: participation in field days and demonstration activities; the number of OSP vines received; the number of times the farmer received vines; the household's sweet potato cultivated area, and the district where the respondent resided. In Rwanda it has been observed through project monitoring that the scale up of iron beans has quickly outpaced the nutrition program so that many farmers do not know that the beans have better nutrition. They just know that the yields are higher.

The lessons learned presented in this paper represent the reflections of key personnel involved in WV's biofortification projects, but it should be noted that a comprehensive analysis of implementation lessons has not been formally conducted. In addition, the reflections in this paper are limited by the early stage of experience integrating biofortified crops within broader programming, such that no integrated project has yet been evaluated.

## RECOMMENDATIONS

As experience with integration of biofortified crops continues to develop, implementation research is needed to better understand the elements contributing to sustained adoption of biofortified crops [5]. World Vision recommends the following research questions be prioritized:

- *To what extent is cultivation, marketing and consumption of biofortified crops sustained after project funding ends? What factors influence sustainability?*
- *What factors drive adoption (initial uptake), intensification (increased production in areas of adoption), scale-up (expansion to new areas) and sustainability of biofortified crop cultivation and consumption in various contexts?*
- *What are the minimum additional human, financial and technical resources required at community, district and national levels to achieve success in the various stages of mainstreaming biofortified crops?*
- *What changes in current programming structures of siloed sectoral programs are required to achieve effective integration of biofortified crops? How can this be achieved?*
- *How does inclusion of nutrition messaging in integrated programming influence uptake of biofortified staple crops?*
- *What are the population-level nutritional impacts of scaling up biofortified crops and what additional costs are required to achieve those impacts, in a program setting?*

## CONCLUSION

Integration of biofortified crops within community development programs is an emerging area of programming and evidence is limited. World Vision's experience in several African countries demonstrates that with a favorable policy environment and careful attention to formative assessment, harmonization of program activities and allocation of additional resources, biofortified crops can be successfully and sustainably integrated within broader programming initiatives. Benefits of OSP adoption continued to be realized three years after completion of the REU project in Mozambique, suggesting the high acceptability of biofortified crops and the potential for this food-based approach to sustainably improve micronutrient intakes in vulnerable populations. The factors that may have contributed to the sustainability in the REU project include the very intensive approach, the OSP demand creation, the vine production and distribution system, and inclusion of nutrition behavior change programs. However, a renewed focus on rigorous implementation science to build the evidence base on the integration and scale-up of biofortified crops is urgently needed.

## REFERENCES

1. **Bouis H, Low J, McEwan M and S Tanumihardjo** Biofortification: Evidence and lessons learned linking agriculture and nutrition. Rome: Food and Agriculture Organization (FAO), 2013.
2. **Hotz C, Loechl C, de Brauw A, Eozenou P, Gilligan D, Moursi M, Munhaua B, van Jaarsveld P, Carriquiry A and JV Meenakshi** A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. *Br J Nutr* 2012; **108**:163–76.
3. **Low JW, Arimond M, Osman N, Cunguara B, Zano F and D Tschirley** A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *J Nutr.* 2007; **137**(5): 1320-7.
4. **Birol E, Meenakshi JV, Oparinde A, Perez S and K Tomlins** Developing country consumers' acceptance of biofortified foods: a synthesis. *Food Security* 2015; **7**(3): 555-568.
5. **Jenkins M, Shanks CB and B Houghtaling** Orange-Fleshed Sweet Potato: Successes and Remaining Challenges of the Introduction of a Nutritionally Superior Staple Crop in Mozambique. *Food Nutr Bull*, 2015; **36**(3): 327-53.
6. **De Moura FF, Palmer AC, Finkelstein JL, Haas JD, Murray-Kolb LE, Wenger MJ, Birol E, Boy E and JP Pena Rosas** Are Biofortified Staple Food Crops Improving Vitamin A and Iron Status in Women and Children? New Evidence from Efficacy Trials. *Advances in Nutrition* 2014; **5**(5): 568-570.
7. **Ruel MT and H Alderman, Maternal Child Nutrition Study Group** Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *Lancet* 2013; **382**: 536–51.
8. **Global Panel on Agriculture and Food Systems for Nutrition** Biofortification: An agricultural investment for nutrition. Policy Brief No. 1. London, UK: Global Panel on Agriculture and Food Systems for Nutrition, 2015.
9. **Saltzman A**, *Personal communication*. 2015.
10. **Mbabu A, Munyua H, Mulongo G, David S and M Brendin** Learning the smart way: Lessons learned by the Reaching Agents of Change Project. Nairobi, Kenya: International Potato Center, 2015.
11. **Mazuze FM** Analysis of adoption and production of orange-fleshed sweet potatoes: the caes study of Gaza province in Mozambique. Food Security Collaborative Working Paper 55868. Lansing, Michigan: Michigan State University, 2007.

12. **Asare-Marfo D, Birol E, Gonzalez C, Moursi M, Perez S, Schwarz J and M Zeller** Prioritizing countries for biofortification interventions using country-level data. HarvestPlus Working Paper No. 11. Washington, DC: International Food Policy Research Institute (IFPRI), 2013.
13. **HarvestPlus** Reaching and Engaging End Users (REU) with Orange-Fleshed Sweet Potato in Eastern and Southern Africa: Final Report. 2010.
14. **Grant I, Guaf E and F Yagama** Farmer evaluation and multiplication of sweet potato varieties on the north coast of Papua New Guinea. Adoption Study Report. Australian Centre for International Agricultural Research, 2012.
15. **Low JW, Arimond M, Osman N, Osei AK, Zano F, Cunguara B, Selemane MDL, Abdullah D and D Tschirley** Towards Sustainable Nutrition Improvement in Rural Mozambique: Addressing Macro- And Micro-Nutrient Malnutrition Through New Cultivars And New Behaviors: Key Findings. Donor Report, Michigan State University, 2005.
16. **World Vision** Biofortification programming experience and lessons learned. World Vision East Africa Region, 2015.
17. **van Straaten L** Agricultural and natural resources management project (DAP II): End of project survey report. World Vision Mozambique, 2006.
18. **Fote I, Hilton B and D Brown** OCLUVELA Multi-Year Assistance Program baseline survey report. World Vision Mozambique, 2009.
19. **De Brauw A, Moursi M, Munhaua B and C Qiu** Vitamin A intakes remain higher among target groups three years after a biofortification intervention in Mozambique. Conference presentation, London, UK: Leverhulme Centre for Integrated Research in Agriculture and Health 5th Annual Research Conference, 2015.
20. **Kim SS, Rogers BL, Coates J, Gilligan DO and E Sarriot** Building evidence for sustainability of food and nutrition intervention programs in developing countries. *Adv Nutr*, 2013; 4(5): 524-526.