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Scaling up Biofortification: Better Crops, Better Nutrition

Audio Transcript

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PRESENTERS

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PRESENTATION

Laura Ostenso: Welcome, everyone. I'm Laura Ostenso, knowledge management specialist here at Agrilinks. We are happy to have HarvestPlus with us today. And before I turn it over we're just gonna go over a couple of process notes, the first one being that please go ahead and post questions to the presenters throughout their presentation, and we'll go ahead and facilitate those questions during the Q&A session at the end. And if you have any tech issues please start a private chat with the Agrilinks KDAD AV tech who will go ahead and help you. Just start a private chat by hovering over their name and clicking on "Start Private Chat."

Now I'm gonna go ahead and it right over to Diane De Bernardo, the nutrition advisor with USAID's bureau for food security, to get us kicked off.

Diane De Bernardo: Good morning, everybody. HarvestPlus is a nonprofit agriculture research program coordinated by the International Food Policy Research Institute and the International Center for Tropical Agriculture. HarvestPlus is based in Washington, DC and has country offices in Africa, South Asia, and research partnerships throughout the world. Biofortification has progressed from the research to the delivery phase with USAID's support. USAID has been an important partner since the organization's earliest years, and HarvestPlus today receives USAID funding for its vitamin A orange sweet potato program in Uganda, and vitamin A maize in Zambia. Currently ten million people in rural households in Africa, Asia, and Latin America are growing and eating these and other biofortified foods. HarvestPlus's goal is to scale up worldwide, working with a broad array of partners globally.

Dr. Howarth "Howdy" Bouis has been the director of HarvestPlus since its founding in 2003. He advocates widely for improving nutrition through food-based approaches, and has worked with India, China, and Brazil to promote national biofortification programs. Dr. Bouis holds at joint appointment at IFPRI in Washington DC and at the International Center for Tropical Agriculture in Columbia. He received his BA in economics from Stanford University and his MA and PhD from Stanford's Food Research Institute. He joined IFPRI in 1982 as a postdoctoral fellow in the food consumption and nutrition division, where he

later held positions as a research fellow and senior research fellow. His research has focused on how economic factors affect food demand and nutrition outcomes, particularly in Asia.

Dr. Anna-Marie Ball is a native of Canada but grew up in Zambia and has spent much of her career in Africa, working on projects involving behavior change, demand creation, community health, agriculture, and nutrition. Dr. Ball received her PhD from the University of Manitoba in community health sciences, her masters in international rural development planning from the University of Guelph, and bachelors of science in biology from Queens University Canada. She joined HarvestPlus in 2006 to lead the groundbreaking Research End Users project which piloted the delivery and evaluation of high vitamin A orange sweet potato in Uganda and Mozambique. This project, supported by USAID and other donors, demonstrated that farmers were willing to adopt orange sweet potato, and the additional vitamin A had clear nutritional benefits for women and children. Dr. Ball then served as manager of HarvestPlus's country program in Uganda, and now leads HarvestPlus's advocacy and partnership efforts throughout Africa. During today's presentation she will discuss biofortification at the country level.

Dr. Howarth Bouis: Okay, thank you, Diane, and we're very appreciative of USAID hosting this webinar today, and thank you to everyone in the audience for taking the time to learn about biofortification, to discuss biofortification.

So let me start with the evidence that we've generated. I think my message here today is that biofortification works. HarvestPlus got started in 2003. We're now 12 years into the program. In 2003 we didn't know biofortification would work, but now we have the evidence.

The first issue that we needed to deal with was to breed high levels of minerals and vitamins into high-yielding backgrounds. We knew that farmers would not adopt crops that were lower yielding, that had lower profits just because they were more nutritious. So one of the central tenets of the biofortification strategy of HarvestPlus is that our crops have to be just as high-yielding, just as profitable as other crops that farmers are growing. Then the value proposition that we offer to farmers is you get the same yields, but you also get the higher levels of minerals and vitamins, which I'll be discussing later.

So we – in slides that I'll show after this we have now releases of high-yielding crops in many countries around the world. So we've proven that we can breed mineral and vitamin density into high-yielding crops. That's the first very important piece of evidence that we've generated under HarvestPlus.

The next issue is the nutritional efficacy. Once we've bred the minerals and vitamins into the crops we have to show that when people who are deficient consume them that their mineral and vitamin status improves. So HarvestPlus

has commissioned 14 efficacy trials for various crops around the world, and now most of that evidence is in.

We've conducted – for high iron, for iron deficiency we've conducted studies for high iron beans, for high iron pearl millet. Also there was one with high iron rice where we've shown improved iron status. And in fact our principle investigators from Cornell University have now done a meta-analysis of the various studies which was presented Micronutrient Forum in Addis last June showing that the iron biofortified crops are efficacious. So we're pretty much finished with the iron.

The story is very similar for the vitamin A. We've had efficacy trials for orange sweet potato for many years that were published many years ago. Recently we now have study for high provitamin A maize, high provitamin cassava that are in the journals and we have the evidence. There are still two more trials out in the field and we haven't done a meta-analysis.

For the high zinc crops we've done bioavailability studies. The bioavailability is high, but the efficacy trials are still in the field. We have three studies that are ongoing in India with high zinc wheat, high zinc pearl millet, and a study will begin on the high zinc rice in Bangladesh later this year.

So we have a lot of evidence now on the nutritional efficacy of the biofortified crops. Then the next piece of evidence is scaling up. We have to show that farmers will adopt the crops, that people will eat them, and that we have a public health impact. We've started on the delivery. We've been working on the delivery now for three or four years. We have a lot of positive evidence. We have a lot of momentum for the scaling up. More than two million farm households have directly received the biofortified crops now, and I'll be discussing some of the evidence in later slides on the scaling up.

We know that biofortification is cost effective. The main power of biofortification is that we use agricultural research. You do the research in a central location. We develop the varieties. Those varieties are made available to agricultural research institutions around the world. They're adapted to local growing conditions and they're available in the food supply year after year after year. Most of your costs are in the original development, and then once they're in the food system you don't have recurrent costs as you do with other types of interventions. That's the power of biofortification. So that's a brief summary of the evidence that we've developed.

So I wanted to make a point that USAID has been involved with us, with HarvestPlus, with biofortification from the start. We actually got our first grant to look into the feasibility of undertaking biofortification in 1993 from USAID. We were able – with that funding we were able to identify a set of plant breeders within the CGIR system who were interested in pursuing the strategy. It did take

ten years to develop a critical amount of funding so that we could start down the plant breeding road, start developing the breeding pipelines, but we did that. We got that funding in 2003. USAID has been a significant supporter during that time. And then we got our first releases in 2011-2012.

And now the missions, the USAID missions in the countries where we're delivering the crops are supporting the delivery of biofortified crops. Our whole operation in Uganda with orange sweet potato and high iron beans is supported by the USAID mission. The USAID mission in Zambia is helping to support our dissemination of orange maize. And we're talking to other missions and we hope we have some other missions supporting us in the future.

These are the target countries where HarvestPlus is focused on scaling up, so let me go through the countries a bit and the crops that we're working on. So in Africa – let's start in Africa. You can see that Uganda, we're working on the high provitamin A sweet potato, and in addition high iron beans. In Rwanda we're focused on the dissemination of high iron beans. Let me emphasize that the beans in Rwanda are even higher yielding than the normal bean varieties that bean farmers are growing now in Rwanda. In Zambia I've mentioned the high provitamin A maize; that's our focus crop there. In DR Congo we're working on two crops: high provitamin A cassava and high iron beans. And in Nigeria we're focused on provitamin A cassava, but we've also released orange maize, high provitamin A maize, and they're starting a dissemination program on that as well.

So those are our target countries in Africa. We haven't colored Ethiopia green, but we're intending to open an office in Ethiopia later this year or at the beginning of next year. And our initial crop that we'll be working on in Ethiopia is the orange maize, high provitamin A maize.

Moving over to south Asia, in India we're working on high iron pearl millet. High iron pearl millet was released in 2012. High zinc wheat – the high zinc wheat is out in India, and the high zinc rice will be released next year in India. In Bangladesh we have high zinc wheat. It was released two years ago. We're starting the dissemination program. And in Pakistan we have high zinc wheat, and those varieties will be released this year in Pakistan.

So these are our target countries. We have country managers. We have dissemination strategies that we're implementing. We're raising funding to work with collaborators to realize the scale up in those countries. Then all of the other countries we consider as partnership countries, and how we're gonna get biofortified crops out in the partnership countries I'll be discussing in subsequent slides.

So this is a map of all the countries where biofortified crops have been released or are being tested, so you can see that it's a global program. We now have biofortified crops released in 25 countries, and we're doing multi-location testing

in 43 countries around the world. Just on a somewhat technical note, to get a crop released in a country we work with the national agricultural research institutes. Candidate varieties undergo multi-location testing so we can pick varieties that grow well in several different regions. Once those varieties are identified they're submitted to varietal release committees that test the agronomic properties of the crops, test that they meet certain minimum agronomic standards. And after usually two years of testing, once it's proven that they meet these agronomic standards, then they're released and we're allowed to multiply the seeds and sell them to farmers. So we've gone through that process now in 25 countries with biofortified crops, and there are 43 countries where they're in multi-location testing.

I want to point out three major countries where we want those countries with major scientific programs to get working on their own biofortified programs. So I think the prime example is Brazil. The Embrapa, which has a huge agricultural research system, has its own biofortification program that's supported by Embrapa. They're working on nine biofortified crops. I think they've released five different types of biofortified crops. And they're taking regional leadership in Latin America.

There's a HarvestPlus China program. I'll be in Beijing at the end of June, beginning of July. There's a conference on linking nutrition and agriculture that's sponsored by the central Chinese government. They're going to be announcing that biofortification will be part of their next five-year plan, and they're deciding now what the program will be and what their investments will be in biofortification.

Then the third major country that we want to take regional leadership is India, and we're working very closely with the Indian government on biofortification and have been working with them for the past ten years. So this is – again, this is a global program.

I'm trained as an economist, and one of the reasons that I've stayed focused on biofortification – I've worked on it for 20 years now – is that it is so cost effective. A group of economists called the Copenhagen Consensus which includes five Nobel Laureate winners in economics, they were asked to identify the 20 most productive investments that could be made in developing countries, and about four years ago they came out with a report. They identified – within the top five they identified three interventions that focused on micronutrient malnutrition: vitamin A supplements, iron fortification, and biofortification. Supplementation was the number one investment that could be made, fortification was the number three most productive investment that could be made, and biofortification was the fifth most productive investment that could be made.

So biofortification's niche is that we start in the rural areas. We start with the small holder farmers who grow part – who eat part of what they grow. As they produce surpluses of biofortified crops they make their ways into the marketing system and they reach into urban areas. Fortification, fortified foods primarily start in urban areas where people are buying their foods. As the economies develop the fortified foods make their ways into rural areas. So we feel that biofortification and fortification are highly complementary strategies. We need every – we need every type of intervention that we can to fight this problem of mineral and vitamin deficiencies. Biofortification is not a silver bullet, but it is a cost effective approach that we feel needs to be expanded in developing countries.

Okay? There we go. I'll talk a little bit about a program, a project that we implemented in Mozambique and Uganda to show that biofortification can be effective when it's implemented in a real world situation. So we targeted 24,000 households in Uganda and Mozambique. These were white sweet potato growing households. And we did extension with these 24,000 households and made the case with the mothers, with the fathers that if they would adopt and grow orange sweet potatoes, substituting one for one the orange sweet potato for the white sweet potato, that they could protect their families from vitamin A deficiency.

Well, we found that about 75 or 80 percent of the households adopted the orange sweet potato. They didn't completely convert all of their land from orange to white; maybe they converted about 50 percent of their land to the production of the orange sweet potato. And they consumed the orange sweet potato in their homes. This graph that's showing on the screen, the dark orange is the vitamin A intake in the villages where we did not intervene, where the households continued to grow just the white sweet potato. Those are the total vitamin A intakes. We had intervention villages; we had control villages. The dark orange was in the control villages. In the intervention villages where they converted part of their land, part of their sweet potato land to orange, vitamin A intakes were increased by the amount of the light orange bars on top of the dark orange bars. So they increased their vitamin A intakes by from 75 percent to 100 percent. And in Uganda we took blood samples and we measured an improvement in the serum retinol of the children in the intervention villages as compared with the control villages. So this was our first evidence that – in a real world situation that the introduction of biofortified crops could be effective in improving vitamin A status.

So that concludes my brief summary of HarvestPlus, of biofortification, the progress that we've made. And I'm now gonna turn it over to my colleague, Anna-Marie Ball, who's been very involved in the implementation on the ground in Africa and she'll talk about her experiences there.

Dr. Anna-Marie Ball: Thanks, Howdy. Hi to everybody that's listening. Howdy's given a really great overview from the global perspective, and so what I'd like to do in the next few minutes is just to talk to you a little bit about some of the lessons that we've learned from our country programs. And as you can imagine, with the number of years that we've been delivering the crops, we've got quite a few observations so this is by no means an exhaustive comment on things that we've learned. And you will find that I will draw my examples particularly about the orange sweet potato – I'm obviously a great fan of the sweet potato – but also about the high iron beans.

When HarvestPlus in Uganda enters a community, the first person that arrives in is the agronomist. And his first message to the farmers is actually a nutrition message. So he would introduce the sweet potato as the vitamin A sweet potato, and the beans as rich in iron and we need iron to build strong blood. So as an agronomist he needs to talk about nutrition at a very basic level; otherwise why would a farmer even bother to plant a differently colored sweet potato, an orange one, when in fact they are used to white or cream colored ones?

So we want to give the reason right from the beginning. "So we're here with varieties that are better for your health than the ones that you're currently growing." So the message that our partners receive is that what we're doing is nutrition through agriculture, but we will in fact address both the agriculture and the nutrition.

As we go into communities and we talk to farmers and we do a fair amount of research, we find that extension is considered to be a preferred and trusted source of information for farmers. So – and this actually tends to be a primary source for many people, if there are extension workers around. But from our experience – from my experience of ten years working with the public and private extension services, my observation is that in fact while the extension workers can do the agronomy, they rarely talk about nutrition. So one of the things that we would do is to cross train so that extension workers can speak about nutrition at a basic level, that they know that the crops that they are bringing in are being brought in for the micronutrient that is present there. And that is bearing in mind, of course, that we are not interested in sacrificing on yield. In fact the varieties must match up in terms of yield to the varieties that people are currently growing and have disease and pest resistance as well. So the plus to the varieties will be on the nutrition, and extension workers have to know this so that they can give this information to the farmers that they're working with.

The other question that we talk about is who are we targeting when we're working with farmers. Are we looking at women because they are feeding their families? Are we targeting men because they're often seen to be the farmers? And our experience is of course that it's better to target households. So Sara here does feed her family, but she's also the family farmer. Julius is probably more

interested in the agronomic messages and the marketing messages, but in fact it's also in his best interest to get some of the nutrition messages. And the reason for that is obviously as someone who controls family resources – land and cash – he also needs to know that his children will be healthier with these crops, and that obviously is going to affect his pocket, because if he doesn't have to take his children to the clinic, he's not putting out money for that particular thing. So we want to provide the nutrition and the agronomic messages to both men and women in a household because it's the household that benefits.

Now particularly in Uganda we do see that linking nutrition to good growth and performance in school is actually really a poignant message, because education is so highly valued that when you are able to make that linkage for people, they can actually – they do get it.

Now another one of our interests in HarvestPlus is how do we get the biofortified crops out in the most cost effective way. And we currently have some interesting research going on in Uganda that looks at the diffusion from farmer to farmer. How do farmers do it? Who do they share with? And the question that we're asking is how much saturation in a community do you need to have for the biofortified crops to be anchored? So that if there was a drought, if there was a flood, would there be enough seed within the communities for it to be rooted there, anchored there?

Now both in Uganda and Mozambique we've played around a little bit with the idea of payback or pay forward, where farmers are encouraged, actively encouraged to share seed. Now of course with the propagated crops such as the sweet potato and also with cassava this works very well, because the seed is kept in your garden and you can easily share. Also with beans, because they're not hybrid, they are also easily shared. So in this slide what you see is Martha, who is the lead farmer in her farmers' group – she's working with the farmers. They've pooled their seed together with the intention that they will actually share with another farmers' group. But we know and we are tracking, in fact, farmers who share their seed with relatives and friends, and calculating up how cost effective this is in actually anchoring the seed within communities.

Those of you that work in agriculture know that quite possibly the first question that a farmer will ask you when you bring in a new variety is, "Can I sell this?" And we are convinced of course that addressing markets is key to long term sustainability. Crops may stay in a family garden for the nutrition, but we know that crops will stay in a garden – be maintained there if a farmer can sell the crops. And so we like to engage markets from the beginning. Recently we had some radio work, surveys going out, asking farmers, "Do you think the farmer should sell their crop or just keep it at home?" and it won't surprise any of you that farmers say at least the person should sell some of their crop, because that will allow them to deal with some of the issues in their household. But they don't

want – the farmers, they don't encourage their fellow farmers to sell everything. So for those of us working in biofortification and with these crops where you want to make an impact on family health, that's actually a really good thing. So people are consuming the crops but they're also taking the opportunity to sell.

In all of our countries that we're working in in Africa we have engaged the mass media to create demand, and that ranges from a radio mini-drama in Uganda with 30 episodes of a story of intrigue about a lady who has the orange sweet potato and a husband that wants to sell off her land and children that need some good nutrition, and how does she manage? We've also worked with Nollywood to produce some films about the yellow cassava, provitamin A cassava. And in Rwanda we've engaged popular singers who have put out a music video, which you can go to YouTube and listen to it when you're offline, and then the singers went around the country doing roadshows. And this creates tremendous demand for the crops, and it's a great thing.

The caveat to this is if you do not have your seed system in place, if you don't have the source of seed sorted out before you create this demand, you will find yourself in hot water because people are very enthusiastic. I am constantly amazed by how farmers are so willing to try a new variety. So if you create the demand, make sure that you have the seed system in place, you've got the seed there, you can direct the farmers to where they can find the seed, because they are going to want to try it. And that's exactly what you want, so some preparation is definitely needed.

The other – the last point that I'll make and then I'll hand it over to Howdy is to say that farmers never, ever produce and consume within a vacuum, a political vacuum. They need the support of policymakers who know and understand the issues. And so in each country they – the country teams have engaged with policymakers to make sure that biofortification is on the agenda, on the national agenda, worked into the plans for agriculture and nutrition, for education. And what we are seeing right now – a good example is that the government of Uganda is actually taking up the biofortified crops in a World Bank project that will involve health, agriculture, and education, and they'll introduce at least two of the biofortified crops.

Dr. Howarth Bouis: Okay, now I'll finish up by talking about where we're headed next with HarvestPlus. Just continuing on this slide that we're on now, the minister of agriculture of Bangladesh endorsed biofortification at the Second International Conference on Nutrition which was held at FAO last year. The other three slides are from our Second Global Conference on Biofortification which HarvestPlus sponsored about a year ago in Kigali. Up in the upper right is Akin Adesina, the minister of agriculture of Nigeria, who has endorsed biofortification. The lower left hand is the minister of health from Rwanda who also was endorsing biofortification. And in the lower right hand corner is Rachel Kyte, vice

president at the World Bank, whose comment at the conference was, "Now we've kind of switched. Before people were asking, 'Should we do biofortification? Is it the right thing to do?' Now with the evidence that we have, the question now for policymakers is if you're not implementing biofortification, why aren't you implementing biofortification?"

So what's the road ahead? I pointed out our eight target countries, nine target countries as we add Ethiopia, but there are so many other countries where we want to start the implementation of biofortification. So there are so many different types of institutions that we want them to embrace biofortification and mainstream the use of biofortified crops within their day to day activities.

So the primary actor that we want to get engaged are private sector entities. So especially with the hybrid crops – the maizes are hybrids; the pearl millet in India is hybrids – we want seed companies to develop their own biofortified varieties and to be involved in the marketing of biofortified seed. We've done that with the Nirmal Seed Company in India with the pearl millet. Other companies are now getting involved. We've done that with three seed companies in Zambia with the orange maize, the three major actors. Those three companies in Zambia next year will be producing orange maize biofortified seed which will constitute five percent of the commercial market in Zambia, so we're making very good inroads there with private seed companies.

At the same time, the public agricultural research communities need to mainstream biofortification. We can't have some – one stream of high-yielding crops coming out that are drought resistant, climate smart, and another stream that are biofortified crops that don't have these agronomic properties. We have to combine the two. The climate smart crops have to also be biofortified. So we have to get the public agricultural research institutes to mainstream biofortification, and we're working very hard on that, first within our centers, the CGIAR centers, and then also with the national agricultural research institutes.

In addition we're working with international NGOs. We've signed an MOU with World Vision. They have agricultural programs in 90 countries around the world. They want to integrate their agricultural programs with their health programs, and they see biofortified crops as a perfect way to do that. So we're working with them in countries where we're releasing crops but we don't have programs. We're working with World Vision to develop the funding, to develop the technical expertise so that World Vision can take the lead in introducing biofortified crops in those countries, which we call partnership countries.

Multilateral institutions – the World Food Program has a purchase for progress where they're helping – a program where they're helping farmers develop their productivity, and then they buy their produce and store – they buy locally and store in World Food Program warehouse. Well, it's a simple step to substitute a biofortified crop for the regular crop, so in Rwanda they're substituting high iron

beans for regular beans in the purchase for progress program, and they've now purchased 77 tons of biofortified high iron beans to store in their warehouses.

The World Bank has recently announced a grant to the Ugandan government. It's a $27 million grant, and one of the key components is the dissemination, the scaling up of orange sweet potato and high iron beans. These are exactly the types of programs that we want the NGOs and multilateral programs to become engaged in. We want to spin this off to these institutions.

We've just talked in the previous slide about the advocacy and the support by national governments and regional organizations. You know, we're engaged with CAADP in Africa. I was just at – Anna-Marie and I were just at the African Union two weeks ago, and a press release came out by the commission for rural economy and agriculture endorsing the biofortification strategy.

We need to create consumer demand. That's the ultimate sustainability of biofortification, if consumers demand the biofortified crops. Anna-Marie talked about our using the media. The private sector marketing – we're talking to food processing companies, millers to use biofortified crops. We're developing new products that involve the use of biofortified crops that are processed. This creates demand. The farmers are able to sell the biofortified crops in the markets, and this is something that the farmers want to do. They need to sell part of what they produce.

And then of course we're generating evidence across the world, documenting what the reach of biofortified crops is, what the public health benefit is, what works in the dissemination of crops, what doesn't work, what's most cost effective. And then HarvestPlus is collecting this evidence and then sharing it with others so that they can implement the biofortification strategy.

So in a nutshell that's what HarvestPlus is working on and looking forward, the road ahead for HarvestPlus. So that ends our formal remarks, and we're very happy to take questions now. And thank you again for taking the time to participate in this session with us.

Laura Ostenso: Great – thank you so much. Sounds like a lot has been done and a lot more is in the pipeline to happen. It's really exciting, and we have broad array of participants right now in the webinar who have been asking quite a few questions throughout.

We're gonna go ahead and start with some of the more, as I like to think, science-y questions, but really what is the progress on amino acid fortified varieties in crops?

Dr. Howarth Bouis: Yeah, the first biofortification program in our system actually started back in the 1970s. The name of the program was what they called quality protein maize, a high lysine maize. QPM is the acronym. Back in the 1970s the nutrition community identified protein as a public health problem, quality protein as a public health problem. They identified a maize that was high in lysine but it was low yielding, and it had terrible consumer characteristics. But a breeding program was started at our center in Mexico, the International Center for Maize and Wheat Improvement. They started developing QPMs. They had difficulty getting the high lysine in high yielding backgrounds. But over a number of years they did manage to get them into high yielding backgrounds.

A problem is that there was a – basically a short timeframe during which the international nutrition community identified protein – they basically came out and said in the late 1970s, "We made a mistake. It's not a limiting public health problem." But the breeding program continued, and there are varieties that are available that are high yielding.

But let me contrast the difference between what HarvestPlus is doing and what happened with the quality protein maize program. I don't want to put down the quality protein maize, but we started from the beginning – we knew that the nutrition community identified vitamin A, iron, and zinc, as well as iodine as major public health problems. We started with that. We quickly determined that we could not address the iodine problem through plant breeding, but we could vitamin A, iron, and zinc. Iodine is well-address through salt fortification.

Then we – as I've already emphasized, we bred them in high yielding backgrounds. It wasn't nearly as difficult to breed high minerals and vitamins in high yielding backgrounds as it was the quality protein maize.

Then we did the efficacy trials. It was very important for us to generate the evidence on the efficacy trials and give that evidence, show that evidence to the nutrition community so that they would support the biofortification strategy. To the best of my knowledge I don't believe that there have been efficacy trials done in human subjects that have been published in major human nutrition journals.

And now with the dissemination of the biofortified crops, the vitamin A, the iron, and the zinc, we are raising the resources, developing the strategies to have programs in our target countries to get those varieties out. There are small amounts of funding and there is interest in getting the QPMs out, but I don't think there's a major program and major backing for the dissemination of those crops.

So we do as we travel around the African countries – I just spent – I just visited five African countries on a two-week trip. In each country that we went to we were asked about QPMs. And I tell that story, and you know, it's just – it's not part of HarvestPlus. It may be a very good intervention. You know, we wish

QPMs well, but that's the status of the QPMs. Maybe I went on longer than I should have –

Q&A

Laura Ostenso: Great, thank you for that. In terms of HarvestPlus initiatives, can you expand a little bit in terms of iodine?

Dr. Howarth Bouis: Yeah, yeah. We're not working on iodine. Basically the amount of iodine that gets into crops is totally dependent on the amount of iodine in soils, and so it's not genetically controlled; it's not something that you can breed for. So we don't work on iodine in the biofortification strategy.

Laura Ostenso: Good thing to keep in mind for the international year of soils, how these two things can connect.

Dr. Howarth Bouis: Yeah. I'll mention a very interesting study that was done in China. There was an area – this is how agriculture and nutrition can be linked. There was an area in China where iodine deficiency in humans was a very big problem, and there was a professor from Duke University whose name I don't remember now – he ran an experiment. He dripped iodine in the irrigation water. The iodine – through the irrigation water the iodine got in the soil, it got into the crops, and it solved the iodine deficiency problem in the villages where they dripped the iodine.

Now what was very interesting was salt iodination is obviously an alternative for addressing the problem, but it turns out the animals were also iodine deficient because iodine was deficient in the soil. So they – actually dripping it in the irrigation system actually improved the animal productivity as well, solved the iodine deficiency problem in the animals.

So it's just an example. If you take more of a holistic approach, you look at how to solve these problems through the agricultural system, sometimes you can come up with very efficient approaches to solving the problem.

Laura Ostenso: That's an amazing example. I'm sure there's a lot of jaws dropping. Mine was. What about – while we're on this, what about selenium or calcium, while we're kind of on this topic?

Dr. Howarth Bouis: Selenium – the government of Finland had a selenium deficiency problem. They decided to try to address it by putting selenium in fertilizers, mandating that all fertilizers have selenium in them, a trace mineral. And it worked. It got into the soil, it got into the food system, and selenium deficiency in Finland was solved. They found that their initial – the initial amounts that they put into the fertilizers were too high, and they cut back on the amount that was put in the fertilizers. But eventually it was a very effective way of treating the problem.

So again, selenium is something that the problem can be addressed through adding that element to fertilizers, getting it into the soil, getting it into the food system, and it's not something that we're working on in HarvestPlus or with biofortification.

Laura Ostenso: Mm-hmm. Another question that has come up is in terms of, you know – when you're working with the biofortification is how do you ensure that it's absorbed in the body later? So how do we know that these nutrients and kind of make sure for that, that it is absorbed.

Dr. Howarth Bouis: Yeah. The – yeah, bioavailability was a huge issue when we discussed biofortification in the 1990s. There was a significant debate in the nutrition community about the percent of the trace minerals that would be absorbed when the biofortified crops were consumed. Staple foods have phytates. Phytates are known to bind the iron and the zinc. And some nutritionists argue that the bioavailability would be such a low percentage that it wouldn't make much difference at the levels that we could breed into the crops. Other nutritionists argue that people who are deficient would absorb the minerals at a higher rate because they were deficient. The body regulates. If you're deficient you're more efficient at absorbing what's in the diet; if you're replete in the nutrient you absorb a lower percentage.

Well, we've done the trials now. We've done the efficacy trials, and we've proven that the latter group was correct, that people who are deficient absorb the minerals at a high rate and were able to improve their iron status. We're still doing the zinc efficacy trials, but we've shown that the bioavailability is sufficiently high.

In the vitamin A crops we actually found that the efficient of conversion of the provitamin A to retinol was actually much better in food staples than it is from vegetables and fruits. They usually assume a conversion rate of 12:1 of provitamin A to retinol in vegetables and fruits. We've found – in the provitamin A cassava and the provitamin A maize we've conversion rates of 6:1 rather than 12:1, and even better than 6:1 in some examples.

Laura Ostenso: So so far the questions have really focused on the nutritional aspects and different pieces of that. Let's move a little bit into adoption. Different people are asking, you know, how have you promoted adoption, and you did speak earlier about this. A specific question is how does the color of the maize in Zambia impact the uptake of the product, especially given that the traditional color of this maize is white?

Dr. Howarth Bouis: Okay, I'll let Anna-Marie do some of the talking.

Dr. Anne-Marie Ball: That's actually a great question. It's the kind of question that we also faced in Uganda with the sweet potato, is will people in fact be willing to take up a crop

that looks different than the one that they are used to, which is white? Surprisingly I think this is less of an issue than we had expected, although it is something that has to be addressed. One of the things that we find is that you do have to tell people why there's a different color here, and that this is about a crop that has vitamin A in it. And because of the fairly high levels of knowledge about vitamin A that mothers have because they're told to bring their children to the clinics for immunization and vitamin A supplementation, they actually know that vitamin A is important for their children and so they get that message. But for those of you that have worked in the maize sector and in southern Africa, even east Africa, you will know that there is a history of yellow maize that has come into some of the countries as relief food, and that there are very strong, and I might say negative, emotions associated with yellow maize.

So for sure this is something that we've been extremely conscious of. When I was introduced you were told that I grew up in Zambia and I did, and I was there when the yellow maize was there, and I ate it. But – so you can't tell people that this is a silly issue. They take it really seriously. And it's one of the reasons that we like to show the pictures where you've got a white maize cob, a yellow one, and an orange one, because there really is a difference here. And people when they see that, that's an interesting thing for them. It's also interesting for them that the maize is grown in Zambia; it is not brought from outside.

But for those people who are not growing and consuming their own crops, so really the urban population, they're buying the maize-meal in the shops, and so what they see is a maize meal that is lighter in color, so not as orange. And that's why we really are very convinced that you have to have that vitamin A message attached to the packaging so that people can understand the reason behind having the color change.

And I think that when we've done taste tests in the field, what people will say is that they like the taste of the orange maize better than the white maize. Now we'd like to be really clever and say that we intended that, but actually that's an unintended benefit – and we're going to ride it all the way. We've had some nice stories off people saying, "Well, I cannot eat that colored nshima," using the orange maize, and when they taste it they say, "Oh, that's – that's really nice."

So for some people the color will be an issue, but I think that as people get the message about the vitamin A and as they taste it, I think those are more compelling reasons to adopt.

Laura Ostenso: And given HarvestPlus's experience, what has been the most effective way to get that message out? What has been your lesson learned in terms of increasing uptake of these biofortified foods?

Dr. Anne-Marie Ball: Well, you know, I think it depends on what stage you are at in disseminating your crops. At the beginning we had to make sure that we were using person to

person type of communication so that there was a credibility that built up. So again I refer to extension workers are trusted and preferred sources of information and an interactive source of information. So when people had their questions, they could put their question to a person.

Now as the crop is seen in the country, it becomes – is seen in different areas of the country, I think that using mass media is very effective. Many of the countries that we're working in have very good coverage in their mass media, and so with careful messaging you can get the word out to a lot of people.

I noticed that one of our participants on the webinar is actually one of our former extension workers, and I'm sure he would put in a few comments there. And he was right there at the beginning where it was very much word of mouth, here's the demonstration, here's how we go. And I think he would be pleasantly surprised to hear the mass media that's happening in Uganda and how many of the urban dwellers now actually do know about these crops.

Dr. Howarth Bouis: I'll add just a bit. This picture that I put up from the slide we took in Lusaka just two weeks ago. This is the orange maize meal being sold in Pick n Pay supermarkets. That isn't our – people who buy in supermarkets aren't our target audience, but it shows the Star Milling Company has found that there is a demand for the orange maize now. We visited their mill and their delivery trucks have their products on the side of the trucks, so they had their white maize but the central one was the orange maize. It was just exactly this package on the side of the trucks. And two – we saw two commercials that are being prepared to air on TV that I thought were quite good. They still need some editing, but when the harvest comes in in June and there's a much larger supply for the millers, those advertisements will go on TV.

The other point I'll make is that this is for the vitamin A crops. So people are used to eating white sweet potato, white maize, white cassava, so with the provitamin A we changed the color so we have to provide this information to get people to switch. And when we do provide the information, we do find that people are willing to switch. It's how can we get the cost down. But with the iron and the zinc, those are invisible, so you need a different strategy with the invisible nutrients. So the best strategy for those is to just piggyback on the best agronomic properties. So for example, our high iron beans in Rwanda yield I'm told a ton and a half, whereas normal beans yield a ton. We've released ten high iron bean varieties with these superior agronomic qualities, so I think that those bean varieties will take over a very high percentage of the total supply. So you don't really – anybody who goes to the market at that point, any bean that you buy in the market is a high iron bean. Farmers adopt the varieties because they're high yielding. They're more profitable. To me it's like a strategy of putting fluoride in the water system. We all know that there's fluoride in the water but

we don't think about it; we just consume it. So it's got that kind of strategy with the high iron, high zinc varieties.

Laura Ostenso: That's really interesting hearing about the visible versus the invisible in terms of adoption and getting information out that promotes adoption. So you mentioned person to person extension and also mass media. A couple of questions came in specifically about extension, so that one to one promotion. In the countries where you're working so far, how have you found the numbers or the ratios in terms of direct contact with extension workers? And how do you interact with extension offices depending on those numbers?

Dr. Anne-Marie Ball: So depending on the country that we're working in, we may engage with both the public extension system and the private extension – usually both actually – because yeah, you do not want to ignore the public system. Even if it's not working to its fully capacity it is a system in place. And when you're looking to ensure that the whole country gets access to the biofortified crops, you want to use all channels possible. So I know that actually in all of the countries that we're working in in Africa there's a good interaction with the public system using whoever is on the ground and their general ways of working with their farmers.

So I can't really say what the ratio would be because I think that differs from country to country. In the countries where we have research going on, and so I can refer to Uganda, from area to area we would be looking at standardizing the ratio of extension workers to farmer groups and to farmers so that when we're doing the research it's a comparable ratio. And in that case what we're looking at is ensuring that the extension worker is not so stretched that he or she may not be able to get to the farmers' groups on a regular basis. But probably the less satisfying answer to that is that it does vary from country to country.

Laura Ostenso: Great –

Dr. Howarth Bouis: And I'll just add that it varies a lot from the root crops to the grains that can be multiplied quickly. Sweet potato vines, once they're cut, they have to be replanted within two or three or four days or they go bad. Cassava stocks don't multiple quickly. You cut them and I think they have to be planted within 10 to 14 days. So the private sector is not interested in developing – working in private seed markets, so in those kinds of instances you work with the NGOs, you work with their farmer networks, and you make the vines, you make the stocks available. It's a relatively expensive approach as compared with say the hybrid maizes that are now being marketed by the seed companies in Zambia.

But in the end what you want is for the farmers who adopt that your each directly with the extension system is for them, if they like the crop and they like the technology, well, then they give vines to their neighbors. They give vines to their relatives. And it starts diffusing through farmer to farmer dissemination if it's something that's popular. And then once you reach sort of a critical mass it

starts to sell itself. So that's what – you have to start somewhere, and when you first start it's kind of expensive to get it out to the first farmers, but if it's something that's really a good deal for the farmer, something that the farmers like, it starts expanding. And then once you hit 25 percent of the market people are saying, "Oh, what are you growing? What's that?" And it just passes by word of mouth, and so then it becomes very efficient. It sort of disseminates on itself. That's the beauty of seeds; they multiple themselves.

Laura Ostenso: I like that. I think we can quote that really nicely in terms of seed systems. And there was actually a question earlier from one of the participants in terms of seed systems. How have these been – how as kind of the framework or national piece of seed systems been either a barrier or a non-barrier?

Dr. Howarth Bouis: Well, I – yeah, it's been – I'd say it varies by crop. It's been a barrier, as I've said, for the vines: for the sweet potato, for the cassava. We've figured out ways of improving the multiplication rates, for example, of the cassava so that we've lowered the cost. At the other end of the spectrum are the hybrid maize varieties, the hybrid pearl millet varieties that are just – it's really in the hands of the seed companies now in terms of marketing their seed to their regular customers and reaching that critical mass that I talked about previously.

But one of my favorite examples on that is an innovation in the orange sweet potato. So normally the farmers pass the vines on from neighbor to neighbor. The markets for vines are not well-developed. But HarvestPlus has figured out a way through tissue culture to produce vines that are virus-free, and we find that when those vines are planted we can as much as double yields. So these vines – it's almost like a hybrid seed. These vines are much more valuable than the normal vines because they're virus-free and they increase production. So the way the plants get the viruses is through the white fly that flies from plant to plant, so screen houses – a system of screen houses has been developed where the vines are initially virus-free, they're transferred to other areas that have the nets and the flies are kept off, to finally where you have a big enough supply where farmers can come and buy the vines. But they have to pay more for the vines because they're more valuable. So we've created a seed system – a private sector seed system for the vines. Farmers have to pay a little bit more for the vines, but then they realize when they double yields, hey, it's worth it, and so there's a huge demand for these virus-free vines. So we're actually starting to create a private market for the vines where no private market has existed before.

Laura Ostenso: Wow. And someone asks do these improved varieties either in seeds or, for example, you're speaking about the vine, do they require an annual purchase or can they save them for the next season?

Dr. Howarth Bouis: If the – I gave the example of the hybrid varieties, the maize and the pearl millet. Hybrid varieties need to be purchased each year. The seeds are more expensive, but again the yields are higher and more than pay for the expense of the seeds.

This is why maybe I think 80 percent of maize product in Zambia is now hybrids. A similar percentage of pearl millets in India are hybrid seeds.

The beans, no – you replant the beans from your production, but the quality of the seed goes down year after year. And it is worthwhile to replace your seed after a couple of years 'cause your yields go back up.

Again the vines, the sweet potato vines, once they get infected with a virus, you can replant them but your yields keep declining, so it really pays to go get the virus-free vines so that you can maintain your production at higher levels.

Dr. Anne-Marie Ball: So let me just also add that when Howdy talks about virus in sweet potato, it's not just the orange sweet potato. It's all sweet potato. It's all beans. It's all maize. It's – that's a common issue, so it's not specific to the biofortified crops.

Laura Ostenso: Great. We have a couple questions here in terms of climate smart crops and hoping just to get more information and insight in terms of how climate smart crops are bred with biofortified crops.

Dr. Howarth Bouis: Okay, I'll give the example again of beans that – where the basic development of the varieties, the biofortified varieties has been done at CIAT, our center in Columbia. Steve Beebe has been the head of the bean breeding program at least since 1994. He came to our first conference in 1994 and has been breeding high iron beans. And there was – I bring his name up because about – I think it was three months ago there was some articles on the internet about the heat-beater beans that Steve Beebe has developed at CIAT. So beans in general are not very tolerant to high temperatures, so beans tend to be grown at higher elevations, so the country of Rwanda is a high elevation country where the temperatures don't get that high. But CIAT has been working all along on developing heat-tolerant varieties. We all know that with climate change the temperature is rising, so the area in which beans can grow is shrinking. But because the heat tolerance – they've developed heat-tolerant beans, the actual area can now expand because of this breeding. So at the same time that Steve's breeding program for heat-tolerant beans – he's doing that at the same time – he's combining that with high iron so that we have heat-tolerant, high iron beans. And that's exactly what we're trying to do, is piggyback on what all the agricultural research institutes are doing to develop varieties that are drought tolerant, that are heat tolerant, that are climate smart. At the same time you can combine high minerals and vitamins in those same varieties. So it becomes mainstream – breeding for minerals and vitamins is a mainstream trait within the agricultural research institutes.

Laura Ostenso: And what are some insights regarding how we can sustain breeding-based biofortification in the soil if the soil is not fertile for the micronutrients in question?

Dr. Howarth Bouis: Yeah. So this – the question often comes up, aren't we depleting the soils of zinc and iron over time? We're loading more into the seed, so eventually – and we all know about zinc deficient soils and iron deficient soils. So this is a basic lesson that I learned from Ross Welch who was a USDA scientist who I met back in 1993 who convinced me that this was a workable solution. He said that these are trace minerals. There are enough trace – there's enough zinc, there's enough iron in all soils to support this strategy. It's actually a very low percentage of – the amount of zinc and iron that's transferred to the seeds is a very, very low percentage of what's actually in the soil. So you're not – it isn't like nitrogen and phosphorous where you can deplete the soils with just a few crops and you have to add it back through fertilizers.

There are soils that are called zinc deficient, iron deficient, but it's not because there isn't physically a lot of iron and zinc in the soils. It's because the pH in the soils, the chemical properties of the soils are such that the iron and zinc is bound in the soils and not available to some genotypes of the same crop. But some genotypes can exude substances from the roots, change the chemistry of the soil around the roots, and make the zinc and the iron available to the plant, and then that can be trans-located into the seed if you have the right genes in the crop that you've put in through the breeding process. So all soils have enough iron and zinc to support the strategy.

Laura Ostenso: So veering again to adoption, we have a question about how do you know the varieties are reaching those who are nutrient deprived, especially with hybrid seeds which tend to be purchased by "better off" farmers? So how do we know we're really reaching the most rural communities?

Dr. Howarth Bouis: Well, initially, yeah, we face a dilemma as we initially roll out the crops. I showed this slide where we had the maize on the supermarket shelves in the Pick n Pay in Zambia and I said that wasn't our target audience. We have to – our vision is that eventually most of the maize in Zambia will be orange maize, but we have to create the demand. We have to make sure that the biofortified crops are marketed. We could pursue a strategy where we just target the poorest, most vitamin A deficient farmers in Zambia, and just focus on those and forget about the marketing system, but that would be a very slow way for us to achieve our vision that all maize in Zambia will be orange maize. So we don't ignore – there are a lot of small holder farmers that buy hybrid maize. We are developing open pollinated varieties that will be made available to the poorer farmers. It's just that the breeding process has gone faster with the hybrid maize. It's out now. We're using that to help develop the marketing system. But eventually there will be open pollinated varieties. We'll have to work with the NGOs, with their farmer networks. It will be more expensive. It won't be through the private sector. But we'll reach them and eventually everybody will have access to the orange maize. So that's one example.

Laura Ostenso: Great. And you just mentioned, as you did earlier, the role of the private sector. We have a question specifically about input suppliers and what role you see for them in delivering extension.

Dr. Howarth Bouis: Well, I guess the main input is the seed, is the seed. I've talked a lot about the seed system. I suppose the other main suppliers would be the fertilizer dealers. The basic tenet of the strategy is that we're trying to be the least invasive as possible. We're not seeking a major change in behavior. If a famer is growing a non-biofortified variety and they're using fertilizer and they're using irrigation or they're organic or they're not organic or they're not using fertilizer and not irrigation – whatever their current practice is, we just want them to substitute one for one the biofortified variety for the non-biofortified variety. It will be – our promise is that it will be just as high yielding, and in the best of circumstances it will be even higher yielding given the same inputs that they're currently using. We're not asking farmers to change their practices in terms of their input use. No, just keep the same practices that you have. If there is an opportunity to do some extension, if there is some best practices in terms of agronomics and we can work those inexpensively into the extension program, we'll teach them the better practice along with introducing the biofortified variety. But it's not a necessary element to our strategy.

Laura Ostenso: Right, and it sounds like really meeting – meeting farmers and input suppliers and each actor where they are versus kind of pushing them into a specific space.

Dr. Howarth Bouis: It was interesting. I was invited by the ethics department at Purdue University to give a presentation on the strategy, and I was really surprised that an ethics department would invite me to give a strategy. So I asked them, "What attracted you about this strategy?" He said, "Because you're so non-invasive. It's a very simple thing to switch in a biofortified variety for a non. You're not asking them to change their life, their behavior, et cetera. It's just a simple, cost-effective technology and we thought that was very ethical." So it turned out he had no idea that the basic science for the orange maize was also done at Purdue University, so we got the – so I introduced the ethics department to the people in the agriculture department and we had a nice seminar between agriculture and ethics at Purdue.

Laura Ostenso: That's awesome. So you've talked a lot about different people you've been speaking with and different partnerships, and all the way from nitty-gritty science to directly on the field with farmers to extension agencies and national research institutes. How have you looked at your work in terms of these different partnerships? It's a huge topic within – especially within international development. So how have you been looking at those partnerships and engaging all of these different actors towards this strategy?

Dr. Howarth Bouis: Well, it's – you know, from the beginning it's been – you know, we've been trying to bring together the agriculture and the nutrition communities. When we

first tried to get the biofortification strategy funded the agricultural donors said, "Well, the nutrition is for the nutritionists to solve; it's not for us to solve. We're about high yields. We're about reducing poverty." And when we went to the nutrition donors they said, "We don't give money to agricultural research institutes. That's not what we do. We fund supplementation, we fund fortification, et cetera." So trying to – in the initial years it was very difficult to get those two communities to engage with one another, talk with one another. We had a conference that was actually sponsored by USAID at the International Rice Research Institute in 1999, and we had 100 people and half of them were nutritionists and half of them were plant scientists. And almost all the nutritionists said, "This is the first time we've ever visited an agricultural research institute," and they were kind of fascinated to see all the experiments in the field and everything.

So of course it's more complicated than that. It's getting all the stakeholders, the national government policymakers involved. At our conference in Kigali a year ago we had the minister of agriculture and the minister of health from Rwanda, the minister of agriculture and the minister of health from Nigeria, the minister of agriculture, the minister of health, and the minister of education from Uganda. They were all there and they were all advocating for biofortification, so it has really been nice to bring those communities together. Of course that's happening globally now. People recognize that agriculture and nutrition are vitally linked and agriculture is part of the solution.

Laura Ostenso: Definitely really important and definitely a great note to kind of start winding down from our incredible presentation with our awesome guests from HarvestPlus. I'm going to ask one more question that came from a variety of folks, which is where do we get more information about this? Where do we go to learn more about biofortification efforts and this strategy that you've been talking about today through HarvestPlus?

Dr. Howarth Bouis: Well, I guess you go – the main place to start would be our website, HarvestPlus.org, and our contact information is there and then we'll answer your e-mails and get you in touch with all the right people.

Laura Ostenso: Great. Thank you so much, and thank you to all of our participants for joining this webinar today. We look forward to continuing the discussion, and please visit HarvestPlus.org – did I get that right?

Dr. Howarth Bouis: Yeah.

Laura Ostenso: And also please feel free to check out Agrilinks.org. In about two weeks we'll definitely have all of these resources posted, including the webinar itself so you can share and get this information out to our huge, wonderful international development community. Thanks so much.

Dr. Howarth Bouis: Yeah, thank you, everybody.

Dr. Anne-Marie Ball: Thank you very much.