SESSION I: INTERNATIONAL PERSPECTIVES
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International Experts - Hunger and Nutrition

DR. HOWARTH BOUIS
Director
Harvest Plus
CGIAR Biofortification Challenge Program

I'm going to provide some background that I think is useful, because some of you may not know much about biofortification. What this slide shows – that dash line across the middle indicates a 100 hundred percent increase between 1965 and the year 2000. That blue bar at the far right is population in developing countries. Population has doubled during that same period. And those brown bars show how cereal production has increased over the same period. This is the great success of the Green Revolution. Cereal production in South Asia and in developing countries in general has more than doubled.

Now what I want to point out, though, is those green bars. That's pulse production, but it's representative of production of all nonstaple foods in South Asia. You'll see the production increase by about 25%, somewhere around there, but not nearly as fast as population. I think this is the basic underlying cause, one of the causes of why food quality, why dietary quality is so poor in developing countries.

These data are taken from Bangladesh, and it divides the diet into the staple foods, which in Bangladesh is rice, then the green portion of the nonstaple plant foods, which have more vitamins and minerals in them than do the staples. The red slice of the pie is the animal and fish products which provide only 3% of the energy in rural Bangladesh. This staple-based food basket is primarily caused by poverty. Consumers want to eat more meat and fish, but they simply can't afford it.

The price of rice in Bangladesh today is 40% lower than it was 30 years ago, 40 years ago. The price of fish during that same period has doubled. I've studied food prices in Bangladesh, and I can't find a single nonstaple food whose price hasn't increased during that period. This is the underlying cause for a lot of the micronutrient malnutrition that we see. It's not the fault of the Green Revolution. The problem is that we haven't been able to achieve the same kinds of productivity increases in the nonstaple foods as we have for the cereals.

So by way of background then, what does the biofortification strategy want to do? It wants to take the foods that are already eaten in large quantities, those cereals, and put more vitamins and minerals in them as a way of improving the vitamin and mineral intake and reducing micronutrient malnutrition.

The overall strategy of the program that I direct, which we call HarvestPlus, is to develop micronutrient-dense staple food crops, using the best conventional breeding techniques and

modern biotechnology, adding pro-vitamin A, iron and zinc in concentrations that have measurable effects on nutritional status.

So what are some of the key features of biofortification? I'm only going to mention three things. First, is that obviously it's one of the first attempts to use agriculture as a public health intervention.

The second feature is that you can take bio-fortified seeds that you developed at a central location and you can spread those seeds out all across the world to various countries for adaptation. Basically, you can leverage that research at a central location, bring the seeds all over the world, and bring the benefits all over the world. And once those crops are established in the food systems, then they're available across time as well. So this is what makes the biofortification strategy highly cost-effective and why we feel that it's a very sustainable strategy.

The third feature is that it complements existing strategies. Biofortification is not a silver bullet. It will not replace existing strategies. Biofortification starts in the rural areas with the farmers who produce the biofortified crops. They eat the biofortified crops, their families eat the biofortified crops. They also sell part of the marketed surplus; they make their way into the food systems, and then those foods reach the urban areas. It is a rural to urban nutrition intervention. Existing strategies tend to start in the urban areas and reach out to the rural areas. So we feel it's highly complementary to existing strategies.

That's a very brief overview of what biofortification is all about. So let me talk about some of the recent developments, that have come out in the year since I came here last year.

First, Harvest Plus isn't the only biofortification program in town anymore. There are lots of other activities that are going on around the world now. If you add up the figures on this slide, it's estimated that about a hundred million dollars will be spent on the biofortification strategy over the next five or six years. That's something on the order of 15, 17, 18 million dollars a year. But I don't want you to think that that's a large number. For example, 500 million vitamin A supplements are given out *each year*. Estimates of the cost per capsule are anywhere between 50¢ and a dollar, so that's a minimum of $250 million that's being spent each year on vitamin A supplements – tremendous investment; that should be expanded. But that's the level at which funds are being spent on supplements, and so the investments in biofortification at this point are much lower, although much higher now in the next five or six years than over the past ten years. So we're growing.

About two thirds of that funding is coming from the Gates Foundation, from public health donors; also part of the funds are coming from the Global Health Bureau of USAID. Only one third of the funding is coming from agricultural donors. Health is a new source of funding for the agricultural community. Agricultural solutions to public health problems have taken hold.

Also notice that all combined, about half of the funding is going toward conventional breeding techniques, and about half of the funding is going toward transgenic techniques.

Last year, Ingo Potrykus, the father of Golden Rice, was here. He showed us some of the golden rice that was grown and harvested in Louisiana last year. Golden Rice is a transgenic. That's the

rice in the center picture. It has about 8 micrograms per gram of beta-carotene. The original variety of golden rice was around 1.5 micrograms per gram. Progress is being made. In fact,, a new variety, a new strain, has been developed, which we call Syngenta Golden Rice II. An article was published in *Nature Biotechnology* in April, and you can see that on the far right-hand picture, which is now deep orange. And the beta-carotene in that is up to 36 micrograms per gram. So we've really made a quantum leap in the nutrient density, the beta-carotene density in the golden rice.

This is a revision of a diagram that I showed last year, and it shows that if women in rural Bangladesh were to completely switch over from eating the varieties of rice which they eat now, to eating golden rice day in and day out, using conservative assumptions about the bioavailability, about losses in the processing and cooking, that they would be consuming 200% of their recommended daily allowance, up from just 50% right now. And the preschool children, the 3 to 5-year-olds who actually eat substantial amounts of rice, they too would consuming a hundred percent of the recommended daily allowance.

I want to point out that two human nutritional efficacy trials will be published this year. This is a sweet potato efficacy trial that was already published in the *American Journal of Clinical Nutrition*. The densities in sweet potato were so high that, after 12 weeks of just giving one snack a day, they were able to detect an improvement in vitamin A status. So for sweet potato, we feel that we already have varieties that are productive, just as productive as the white varieties. And we've already been able to establish the nutritional efficacy. The other study was on the high-iron rice, which improved iron stores, and that article will be published in the *Journal of Nutrition*, in December of this year.

In the time remaining, I would like to talk a little bit about selected challenges. I would like to talk a little bit about how we're getting into what we call "reaching end users." We've done a lot of upstream breeding, we've done some of the nutritional efficacy trials, we've done the retention studies, and now we're starting to move into activities that are related to dissemination of the biofortification crops. First about wheat. This is the area in Pakistan where most of the wheat is grown, the Pakistan Punjab. Where single varieties dominate production. The variety on the left, it's called Inkilab 91, it provides more than 50% of the total wheat area in Pakistan. You can see the next variety is only 5% of the area – it's called Pakistan 81. Had you gone to the Pakistan Punjab ten years earlier, it would have been Pakistan 81 that was occupying 50% of the area. What happened was that a virus (rust) came to the area, and Pakistan 81 was susceptible to the rust, and it had to be replaced by rust-resistant Inkilab 91. Sooner or later, a new rust is going to arrive to which Inkilab 91 will be susceptible, and it will have to be replaced by varieties that are resistant. In fact, that new rust is already starting to occur. This is a picture that was taken five months ago, and you can see the Inkilab 91 at the left. It's being affected by a new strain of rust, and the variety at the right is an advanced, biofortified line. In Mexico it was higher yielding than Inkilab 91. We put in the genes to give it resistance to this new rust, and it was also high in zinc.

So you can see in the case of wheat zinc density will piggyback on an agronomic advantage. When this new rust becomes a serious problem in Pakistan, a lot of that Inkilab is going to have to be replaced, and it is hoped that some of the candidate varieties will be bio-fortified.

HarvestPlus recognizes that farmers won't adopt bio-fortified crops because they're high in zinc; they'll adopt them because they're rust resistant, because they're more profitable. The zinc will get into the food system much like we put fluoride in the water system. It will be invisible, but it will be there to increase zinc intakes.

For now these varieties are high in zinc in Mexico, but preliminary data now indicates that it isn't as high in zinc as we had hoped when it was planted in Pakistan. We have more work to do.

We have our interdisciplinary wheat crop team meeting in Beijing this week to discuss why the zinc levels were not as high in Pakistan as in Mexico and what the genotype environment effects are. The team will decided where we will have to make adjustments.

High beta-carotene orange flesh sweet potato is a different case where we're introducing a variety that has a characteristic that is very visible. White varieties are commonly eaten. We want to get families to switch to consuming this orange flesh variety. This will require a huge behavior change and communication effort.

So when you have a situation like this where the orange flesh varieties are just as productive but not more productive, adoption has to be driven by a nutrition message. You have to do three things simultaneously. You have to create demand for this new product. Once you've created the demand, you have to make sure the supply is there, and then you have to make sure the markets are up and running.

There are various ways of creating demand. This particular picture is a community theater that's being conducted in some villages in Mozambique as a way of getting across the message of why vitamin A is important for your health. There are so many different marketing and communication strategies that can be tried. Some of them will be successful but not cost effective. We have to find those techniques that are the most cost effective and accomplish the goal that we set for ourselves

We've undertaken some pilot activities in Mozambique and also in Uganda. This shows vine marketing. Sweet potatoes are propagated through vine production, so it's like developing the seed system for cereals. You have to develop a supply system for vine availability, vine supply.

At the same time you have to do market development. This slide shows a market stand that's been set up in an area in rural Mozambique where farmers and consumers know this orange flesh sweet potato stand and will buy any supply that's brought there At this point in the Mozambique pilot project, the problem is supply, not demand. They sell out every day, and if they could get more supply in, they would make a bigger profit at this particular stand.

The message that's painted on the side of the stand is partly market development technique and partly demand creation. The message, in Portuguese, is calling the orange flesh sweet potato "the sweet that gives health."