

GETTING TECHNOLOGY TO SMALLHOLDER FARMERS

Panel Moderator: Steven Leath

October 19, 2017 - 2:00 p.m.

Introduction

Ambassador Kenneth M. Quinn

President - World Food Prize Foundation

Well, lunch was terrific, wasn't it? Rajiv Shaw, wow! What a day this has been. What day this has been, and the afternoon is only going to get better. So I want to invite our first panel to come up onto the stage, please. And a member of our Council of Advisors, Dr. Steven Leath, the President of Auburn University... Everybody now say, "War Eagle! War Eagle!" If you're from Auburn, that's what you say, greeting. And Robb Fraley. And Dr. Leath is going to be the moderate for this panel. He'll introduce everyone, and then later this afternoon before we go to the capitol, I have to run upstairs and change; and he's going to step back in as the master of ceremonies. So, Dr. Leath, over to you.

Panel Members

Dr. Steven Leath President, Auburn University

Robert T. Fraley 2013 World Food Prize Laureate

Enock Chikava Deputy Director of Agricultural Development, Global Growth and Opportunity at The Bill & Melinda Gates Foundation

Howard-Yana Shapiro Chief Agricultural Officer, Mars

Dr. Steven Leath

Panel Moderator

Good afternoon, folks. We've got an important set of topics to discuss today. We've seen many changes in technologies over the last 20, 30 years with the Golden Age of Biotechnology, and there's many other technologies that are affecting agriculture, but we've probably been slower to getting that technology to smallholder farmers than we would like or that we can. And so that's what we're going to talk about today, and I've got three panelists with me today. You've got their long bios in front of you, but briefly I will introduce my panel members.

First, Enock Chikava, Deputy Director of Agricultural Development at the Gates Foundation. He has had a long career in Africa, Europe, the United States; and now he's responsible for developing poverty reducing systems, services and partnerships primarily in Sub-Saharan Africa and also in Asia. So we're thrilled to have you with us today.

Sitting to his left is Dr. Robb Fraley. Many of you have seen him before. Robb is a 2013 World Food Prize Laureate. We're always glad to have one of our laureates on stage. Some of them call him the father of agricultural biotechnology, much deserved. Over a hundred publications and patents in his field and truly a thought leader in not only agriculture but agricultural biotechnology.

And then to Robb's left is Dr. Howard-Yana Shapiro, who is the Chief Agricultural Officer at Mars. Mars as many of you know is a global company with a broad product line in foods, confectionaries, pet foods and other things. And he's got a broad portfolio there where he's responsible for plant genetics, integrated pest management, bio-control, water conservation, and many sustainability issues. Interesting, before that he served as Vice President of Agriculture and Vice President of Research for Seeds for Change, and that's an organization that he founded with his wife.

And we're glad to have these panelists with us today.

In the interest of time, I'd like to dive right in. And, Robb, if you're willing to kick it off for us, what I'd like maybe to start on is – We've had all these technologies for years and we keep getting more, and we've been slow to getting them to smallholder farmers. So what's different about today? What makes you optimistic that we can deliver these technologies?

Robb Great. Well, I think I'd just frame it into a couple things. So there's never been a more important time as we think about food security and agricultural innovation, and we look at the challenges of both feeding a growing population but also farming better and smarter and more sustainably. But I think what makes this time so special and so unique is just the absolute explosion of new technology coming into ag and the very few barriers, particularly financial and cost, that allow us to exploit it.

You know, on the biology side, just a couple of ways to think about it. You know, when they first sequenced the human genome, it was a million dollars, nearly a billion dollars if you really added it up. Today in our labs we can sequence for \$10 enough of a corn genome to map and breed from. And so the cost curves have changed dramatically, and that allows the applicability, I think, to literally all the world's crops. And you throw on top of that some of the use of artificial intelligence to come up with better, faster breeding regimes. I think it can be pretty remarkable. And then you look at the great, I think, democratization the tools like gene editing are going to have. I think it really causes us to rethink how we use advance biology and breeding techniques for all crops, for smallholder crops around the world.

And then you shift over and you look at the digital and the data science tools. I mean, literally, every farmer's field in the world now has been mapped, and we're starting to understand the soil and all the different components. Everyone's well aware that the cell phone explosion has touched the smallest farmers in the world, and they now have the ability to get agronomic information, pricing information,

weather information that's never been possible. I just think what's going on is amazing.

You know, just the last little piece I tie in to this that you may not be aware of, but in the last three years there has been over \$10 billion of private and venture capital investment in new startup ag and food technology companies. There's literally a thousand new companies on the face of the earth now that are studying microbes, they're doing gene editing; they're building sensors or satellites. And all of these are available, I think, at a cost position that can impact farmers right here in Iowa but farmers across the globe in India and Africa. This is the time to take advantage of just unparalleled technology advancement in agriculture.

Steven Enock/Howard, you share that optimism?

Howard Well, I'm an optimist largely because I'm a plant breeder. Every plant breeder has to be an optimist. If you go back to the early days of plant breeding when you would walk the field with 10,000 plants, grading them; and you would remember doing that—some of us still do—that was how we made our first decisions. And the first sequencers were the size of a school bus. And now you could backpack a small sequencer into a field and get information. So everything has moved very quickly.

What hasn't kept up is a body of people to use the information, to use the tools, to be able to extrapolate and create new varieties. And this leads to the whole question of caloric density in plant breeding or nutritional density in plant breeding. And I think one of the things we have to really recognize is you can eat calories and you can be malnourished. But what we need to do as a collective group is work on the nutrition side. I mean, we have brilliant yield potential in Africa, in India and all over Asia, based on work that companies like Robb represents and others, Syngenta, what-have-you.

But the reality is, we haven't worked on nutrition. So with all these tools, now is the moment to work on nutrition. We need zinc to stop cretinism. We need Vitamin A to stop night blindness. We need iron for hemoglobin development. We need folates for neural tube development. So we have this situation right now, with all the tools in the world, if we don't take advantage of them, increase the nutritional value... And it's not just maize and soybeans and the big five, it's all the food which is the backbone of the system. And we were talking before we came out here about systems. The food system in Africa in particular is based on hundreds of varieties of foods that are eaten every day. So there needs to be an impact in that area as well.

Steven Talking about systems, I know you folks at Gates, Enock, have worried about systems and do we have the systems in place to really integrate these technologies in Africa. Talk a little bit about that.

Enock Yes. So I'm equally fired up, because I think it's the right time. So again like in Africa there's a story. If you see an African in the [inaudible], particularly in Des Moines, and just spend five minutes with them, there's a long story. And I think the overarching theme here is there is that pathway out of poverty. And you find that you have isolated cases.

I have my own story. Growing up on a farm, 4 hectares, 11 children, getting all the income out of farming. We had to be smarter at that level. And when we started, 200 kg yield. Now I'm proud that my dad is now getting 8 tons per hectare. So it not different from an Iowa farmer. There's been a lot of changes along the way.

But the problem is... I have one story out of a village of 50 people. You go to another village, you pick up one story, one story, so you got isolated stories. So that's why we need to come up with the highway. We need a bigger story. How can we take people out of poverty at scale? And you can't do that if people are still operating in isolated boxes, especially when you get into public breeding. I'm sure there is a private sector and public sector in breeding. And both systems are developing newer products, very rich pipeline, which is going to change the lives of the people at the farm level. And private sector, I am sure they will reach about 20, 30% of most of the smallholder farmers. The bulk is still maybe going to be driven by the public sector.

And we need the public breeding system. We need to create a system with several players from the time you do the breeding and you do the delivery and then the promotion of adoption. And I think the donor community has also been a comfort in the past, that we created competition between the CG system and then AGRA is doing something else; ATF is doing something; ITA is doing several things. But now we are beginning to think this in terms of a system, that we all want to do the same thing. But maybe we need to divide each other's responsibilities and begin to have a very clear handoff – you know, who does what in that system. And I'm sure this came up earlier on in terms of alignment among the key goals, and then partnering for the common success. And so we have begun to see one common theme, that this is the time to do so. So, see, that's one thing.

The second thing is about also the governments are getting ready more and more. I think for many years we have been talking about only food security, but we are not talking about a [inaudible] inclusive agricultural transformation. And transformation takes long, very long time. So we are beginning to see some of the governments who are thinking of agriculture as an investment area, not a drain to the fiscals. And what they're investing in agriculture for the long haul, ten to fifteen years, they need to put their resources there. They need to build their requisite capacity so that when technologies can now flow seamlessly within the system. It was often the government could be that elephant in the room, through wrong policies, regulations, but I'm glad that this is the moment, because the language is more unified around – we have a problem, and you all have your role to play. But systems will then help us to know who does what in that system.

Steven While we're on that topic, you touched about different roles of folks in the system, public and private. I'm guessing our other guests have some feel for public/private partnerships and moving this technology forward. Any comments in that area?

Howard This is a slide that's up now of the African Orphan Crops Consortium. It's an uncommon collaboration. You look at the names of the people who are collaborating. These are all being done specifically to improve 101 food crops simultaneously in Africa. This is the backbone of the food system, chosen by African scientists, anthropologists, food scientists, sociologists and farmers' groups. So this is represents what I consider to be the future – pretty odd bedfellows, if you will.

I want to call out AGRA in particular, which has started over a hundred seed companies in Africa, so that the work that this group does includes an African plant breeding academy where we bring some of the best and brightest women and men – the current class has 18 women and 17 men in it – to our plant breeding academy held at ICRAF in Nairobi, one of the CG centers. And three times a year for two weeks they're trained and led by the distinguished plant breeder, Rita Mumm, formerly of the University of Illinois. They go back, and they have all the tools. We've sequenced these crops, 101 crops. We've finished 47 sequences now. We have breeding programs on 56 crops, basically driving nutrition first, understanding the yield is critical. We can't forget yield.

And this funny word that people talk about called "resilience," "water-use efficiency" and "nutrient-use efficiency" and then "pest and disease resistance." These group of a hundred who have already graduated from the academy have already built the African Plant Breeding Association network, so they are talking to each other. So for them, the first time in their lives, they know who is working in Africa on these sorts of problems. What are they working on? Bambara – critical protein source all over Africa. Spider plant – and referring back to Akin Adesina's comment about agroecosystems going across Africa as opposed to borders, these are the foods that go across those agroecosystems. Baobab – many of you have never probably eaten baobab, but the leaves are really delicious in the time of an extreme drought when nothing else will grow. Cocoa yams. So the foods of Africa are being improved nutritionally first. But this is the methodology.

These are the kinds of organizations being put together. Everyone has the same vote. There is no directorate. There is no leader. We meet twice a year as a board for consensus voting to do the work. The reference genomes are done by BGI, one of the powerhouses on earth. All the resequencing, 10,000 re-sequences, are done in Nairobi by African scientists and African technicians doing the work, all available free, all available in the public domain so everyone has access to improve those crops. This for me is the future.

Steven Robb, what's your take on public/private partnerships in a role like this to help solve these issues?

Robb Well, I think it's absolutely essential. Nobody has all of the capability, all the resources, all the ability to position within a given country. So it takes everybody working together. My experience has largely been based on the ten-year collaboration that we've had with USAID and the Gates Foundation and AGRA and CIMMYT to build the water-efficient maize breeding program for Africa. And ten years later this has become the largest independent breeding program in Africa for corn. It's really seen hundreds of new high-yielding hybrids, and it's all built on using a lot of these modern, advance breeding tools. And I think in many ways it's a template for what we can now do for the next crops.

And I think one of the things that we can now do with the cost curves of these technologies coming down so dramatically give the opportunity to systematically step back and plan and build the capability for really doing this across the broad scope of African crops is now possible – it's feasible to do. And that for me, that's really exciting. And there is so much that can be done and so much that needs to be

done. I know some of the sidebars at this meeting have been to address some of the unique challenges that we're facing with Armyworm in Africa. And again that's another, I think, really incredible opportunity for collaborations that bring the best of what we can do with breeding, with biotech, with chemistry, with biologicals, with IPM, to address a really important challenge. But I think there is both. The fact that the technology is now ready and real and affordable, in many ways the barriers become, as Dr. Shapiro said, making sure, as always, the capacity building, I would say that certainly in the case of the biotech and the gene editing tools, the regulatory environment.

One of the areas that we have seen, and I know going back to discussions decades ago with Norm Borlaug when he and the team were trying to introduce the quality protein maize into Africa, being able now to marry what I think could become very, very sophisticated, effective breeding programs, we now need to address seed production in a pan-African way. And I know Enock's an expert on this is, so I'll let him build on that.

Steven Why don't we talk about seed production a little bit, and we can go back and talk about some of the barriers later, but let's talk about that, Enock.

Enock So we spend maybe the past two years just analyzing the seed system, again to understand what are the root causes of failure and look at the 11 countries that did that together with the USAID. And we realize that there are three main barriers to the seed system.

Firstly, there's lack of coordination between the various players, so those who do breeding, and then they need to pass it on to the next level. So that is one bucket, the second bucket which is very consistent for all staples and even some of the vegetable varieties, was around the early generation set. And maybe I will explain a little bit here, that all the work of breeding, which can take seven... now shorter [inaudible] but then we produce 5 kg of breeder seed. Now, how do you take that 5 kg and maintain those qualities? And multiple to thousands of tons, which can be used over the life of that variety which can be 15 to 20 years. So maintaining that quality and ensure that many of the seed companies can benefit from it has been a major bottleneck especially for most of the public breeding systems.

So when you [inaudible] the pipeline coming from [inaudible] and various other products. But also in the delivery site, in the last mile, we had AGRA working with 114 smaller seed companies. Very very useful, and I give you a quick example here. In Malawi in 2004 when I was responsible for some business there, the adoption rate of hybrids was 8%, but we only had three regional big companies. And the company I worked for had 75% of 8%, so which again didn't make sense. So, but the coming in of AGRA in 2006 created seven new smaller seed companies. And when I left the country in 2008 after five years, the adoption rate was 45%. So there was not a market for everybody, you know.

But the bottleneck on the early generation seed, when you have hundreds of seed companies, each one without any capacity to be handling it from breeder seed to commercial seed, we then had to think very creatively. So we came up with this innovative way of solving a common problem to all these seed companies, so we

created this specialized foundation seed company, which is called QualiBasic Seeds, which is based in Nairobi, by taking care of all the seed company seed in east and southern Africa. Because they all have one common problem – and again this is where we had philanthropy coming in to identify what is really failing in the system, who can use the philanthropic funding to remove those bottlenecks. But also ensure that it is sustainable, you know, it is going to be continual even after the funding. So that is going to be five years, and then it is going to be spun off, and we're hoping that all these seed companies will be benefiting when it is through a grant who will then buy a stake within the company, and then they can run. We looked at other models, like the Illinois Foundation seed here in India was similar.

But in Africa this is the first of its kind, which is going to be solving a common problem in a very sustainable way. So talking about partnerships, and now we talk about PPP, which is a private/ public partnership. I need another P. We need philanthropy in there. And philanthropy does not give money – it invests in return for a model which is sustainable. So more and more we are looking at those innovative ways of removing what is failing in the system. So, see that's one good example. I will give you two more, and then maybe that's it.

In cassava, you can clean up all these viruses, and we have done great work, and we now have a lot of cassava varieties. But then if you clean the material, and then as it is distributed, it is mixed with unclean, you know, the clean and unclean mixed. Everything we cleaned over in the past five years is then re-infested. So the first step is to make sure that we create new standards in some of this informal seeds. Like cassava, I mean, you don't know it's a non-formal system. So we call it formalizing the informal seed system. So we are now creating new standards, new grades in cassava, in yam, and we have some very excellent, innovative models in Tanzania, in Uganda, as well as in Nigeria and Ghana for the yam. And we think more and more that is what philanthropy should do – find out what can we all work together with the government and many other partners and to remove those bottlenecks. If we do a good job, it should sustain itself and crowd in private sector and then becomes a self-sustaining mechanism.

Steven So we think of all these crops that need breeding assistance, and we've got to prioritize them and fund them. And, Robb, you've probably encountered a regulatory barrier or two in your career. So realistically, if we sit in the audience and think, is it realistic to deliver these technologies across numerous countries in short order? What do you see as the barriers, or can we really get this done?

Robb Well, again kind of going back to the model that we worked on with the WEMA project. So as I said, WEMA is this large collaboration to develop drought tolerance, maize for Africa. It includes both breeding advances, as includes biotech as well, so biotech drought genes. And then when we talk about the system challenges, as [inaudible] was saying earlier, if you have this great field of green, drought-resistance corn, it's going to be the first thing that the insects will go after. So you have to build in insect control traits, and those technologies have been donated as well to the WEMA project with the hopes that with the collective effort we can start to look at pan-African approvals so that not every individual country needs to develop that capability but that there could be enough cross-representation that you could do some of these things at a multi-country level.

Steven [inaudible] is that happening?

Robb It's starting to happen, and we're in the various final phases of various sign-offs and final approvals, but that's certainly one of the ways of reducing costs and also expanding and amplifying the benefits of the technology. And we've been able to see that happen. It's not uncommon for that approach to work with the pharmaceutical industry as well for pan-African approval. So that's one thing to think about.

And then I think the other important thing is, you know, that's the focus based on a biotech or a GMO approach. I'm sure there's been lots of discussions at the meeting – with the rapid advances that are being made in gene editing, those need to also be built into this system. Already in the U.S. the USDA has approved I think 11 different gene edited food products. Many companies are involved in that, but gene editing, as you all know, it's a tool that's being used broadly by virtually every scientist who studies biology in the world. So I think it has the unique opportunity to democratize access to technology in much the same way we're seeing with the digital tools. So I hope that the combination of 20+ years of experience with biotech crops around the world without any single food or feed safety issue, with the ability to do pan-African approvals to help reduce the cost and accelerate the distribution. And then really thinking in the future that these new advanced next-generation biotech tools neither warrant or deserve the cost and the scrutiny that have been forced on the first generation.

Steven Howard, what about you, especially with all these crops we have to look at?

Howard I love gene editing. I'm glad I lived long enough to have it come into my world. When you think about what it can do. And yesterday the gentleman from the Broad talked about it. I'm part of the West Coast gene editing group with Jennifer Doudna, and we have projects. Because much of the work we're talking about can be lost to aflatoxins, fumonisins and ochratoxin 1A. When you think about that, all the work that we're really talking about, if it doesn't have aflatoxin resistance, it's lost, whether it's in storage or in the field coming out. And the jury is still out on the total efficacy of biocontrol in the soil. Gene editing allows this to happen. You can actually go in and gene edit out with the target RNAi the receptor genes for aflatoxin. So when aflatoxin knocks on the door of the plant, it says you can't come in, there's no place for it to go. Aflatoxin in the United States in a good year – and a bad year for me is a billion and six dollars in losses – a billion and six. So in Africa they say 450 million a year, but that's underreported because there's no rural sector.

Aflatoxin causes liver cancer, the biggest cause of liver cancer in Nigeria, impacts immunosuppression of a healthy body, likely is related to stunting. Stunting is all part of this when we start to think about being able to deliver nutritious food, high-yielding, resilient to climate change, to a community, whether it's India. And it turns out 37% of the rural sector children are stunted – 37%. It's unconscionable. They won't be Norman Borlaug, they won't be Barbara McClintock. Their neural tubes don't develop. They won't have the intellectual, the physical or the economic power to move forward. India is 48% of the rural sector, 48%; 80% anemia is generally across the whole population of India. When you think that what gene editing might do to solve these problems, it's almost a hallelujah moment, really, to be honest.

And then in storage we have to figure out storage. So on Monday we launched a project on Foldit, which is a website for protein folding. I encourage you all to go to the Foldit. It's a gamer's site; 460 people play these games. They have made phenomenal discoveries that no computer can match and no academic institution has ever matched on creating unique enzymes and proteins. So we're trying to develop new enzymes, new folded proteins that will actually detect aflatoxin and degrade it. It's a game. You should go on this site and see what's going on. It's the most advanced game I've ever seen in my life. And these people who are not biochemists have no idea that they can't do it. It's an advantage.

So when I start to think about things like this that are going on, and then on the other extreme the Great Green Wall, which is a program in Africa that you may or may not be aware of. The Great Green Wall is agroecosystems where people are actually planting nitrogen-fixing trees. And in Malawi, as a good example, they've increased the yields three to eight times with essentially no fertilizer, just using these nitrogen-fixing trees, after three years. They lose their leaves in the summer when they would compete with the maize, and they put them on in the winter. This was driven by Dennis Garrity, the former DG at ICRAF as well.

So there is very complicated things that we are talking about, which are democratized, which is agreement word that Robb used. Every biology department, including high school in the United States is looking at gene editing. And then you have the Great Green Wall, which will deliver fertilizer without having a truck come down a highway which isn't passable.

So it's this mixture, and its systematics go back to Enock's point. If we don't take a systematic approach to this, if we don't understand why governments get in the way, if we don't understand why there is not translation to scale, if we don't understand why there's not adoption, if we don't figure these small pieces out together, then I think we really will not see the benefit that everyone in this room and everyone on this stage believe is possible. And that's the reason for optimism, because the tools are available, the will is available. Now it's the translation to scale that's available. And the big donors in this room, like USAID, they're important players – the Gates Foundation, private industries like ourselves and Monsanto. None of this is possible without this, what I call uncommon collaborations.

Steven Do you gentleman think the smallholders are ready for this? Do they know this technology is even available to them or possible for them at their level? Or is that an educational effort that needs to go out from all of us?

Enock So I mean, smallholder farmers are rational business people, and I can talk about my own experience here, that to raise the maize yield on a smallholder farm from 200 kg to currently 8 tons per hectare, it has been a lot of planning. And I get and I am privileged that I studied agriculture, worked for farmers' union, understood what was failing in the system, and of course spend a lot of time educating my own parents. You know, each time I'll buy a bag of seed. Now they know that for them to keep up with the climate change, they need to plant newer varieties. I mean, we call it varietal turnover. But it is – how do we package that information and then deliver it to people with very little education, people who are dispersed geologically, people isolated from markets and so on. And I think that's where we have the huge promise

of digital technology. And right now at the Gates Foundation we are working on a portfolio which is called Digital Farmer Services. Again taking advantage of the proliferation of new tools and technologies, we can reach farmers at scale. We need to develop bigger platforms, because we find that every service provider is developing an application, a seed company, just to sell their own seed, fertilizer company, to sell their own.

So if each one is just developing these small applications, it's going to be costly. But how about creating a highway where all these small applications can be loaded onto, and then everyone benefits from that big platform, and then we share the cost, and then we are reaching smallholder with the specific messages which are timely. For example, rather than explaining the science behind changing varieties, if we just have one line that says – As you walk into your distribution point, or if you go into an agro dealer, ask when that variety was released. Anything which is older than ten years means you're planting a variety which was bred under completely different conditions than this season. So we can use all that and then agree to package that into messages which can be delivered by SMS, as we got a lot of examples in Kenya, in Ethiopia, Digital Green in India. They're already taking these messages and packaging them. So that's one big thing.

The second big thing is again I mean we have learned this again in development that government is very, very important, because we cannot be more interested in reducing poverty than the governments themselves. If that is the case, we want to be successful, and so we try to do this a lot. So this [inaudible] means we are actually helping the government to become successful. And I realize that even within the regulatory environment, the ability to package that information and communicate it to the politicians in a way that they can own the message and use it for their own benefit and say – you know what? I am bringing this new technology because I want you to become successful. It's different from maybe another company saying, I'm doing it because they think there's always a profit motive which is not bad. Or if it is a donor organization, say, oh, you are now having the vision over the country. So we need to be smarter at how do we package the evidence, how do we package debtors, how do we package all these things and let the government own it. In any case, the government is spending more money than the donors do. If their money is in the right places, you will see kind of starting to take off. And that's one kind of organization that we at AGRA and I'm sure others have mentioned that in terms of the role is going to be around getting government but also packaging it in such a way that they own it, they seem to be driving the ag transformation process. You realize that they will do many other things in support of the technology.

The third thing is about what you call it – “gene editing,” I learned, you know, a ton this week. Maybe just by calling it “gene editing,” you're already starting from a wrong perspective. People say genes – you're editing them? You're deleting certain things and editing others? We need to be smarter at what we call it. When we deliberate, let's call it something which is easier to understand, and they can own the message and run with it.

Steven Well, you make a point. I think we did start some of those on a bad premise. When we talk about “gene editing,” “gene silencing,” some of the public will ask the question, “Is that a GMO? What does it mean?” And I think there are issues of

communication. Is that a barrier to making some of these technologies acceptable in some countries, just a lack of understanding or a fear of them?

Robb You know, I think it can be. On the other hand, I think where farmers have experienced the tools, we have seen a big difference. You know, I grew up on a small farm in Illinois. I've been in agriculture and farming all my life. I mean, I don't think I've ever met a farmer yet who didn't want to grow more, who wanted to leave that land to their kids or continually innovating and do more.

I think the challenge is removing a lot of the barriers. In India today we've operated a, electronic communication to farmers. We reach four million smallholder farmers literally every day with the text message. They're ready to use the technology. They want to know better agronomy. They want to know market prices. In the case of the project I mentioned with WEMA, I mean hundreds of thousands of farmers have now planted the seeds, because they're better.

The beauty, I think, of the advances in biology and the advances in data science and basically how they're converging together, is there's never been technology that has truly such a low barrier to adoption, if you think about it. I always use the description, you know – you can breed those 40,000 genes in the seed; you can put in a half a dozen or a dozen biotech traits. We'll be putting in probably 15 or 20 gene-edited traits in that seed. But in the end you end up with a better seed, and ever farmer in the world knows what to do with a seed. So the barriers to adoption are pretty low.

And now you look at what's happening on the digital side. I mean, it's phenomenal. I mean, 70% of the smallholders in Africa have a cell phone. They've overcome language barriers, education barriers, communication barriers. We've got a new application that's pretty cool. A farmer can now take a picture of a leaf. That picture goes up to the Cloud, gets compared to about 20 million photographs and will identify that disease within a few seconds at a 95% accuracy. Just think of what that means in terms of getting the right information, the right advice, how that can prevent food waste, how it can increase yields. I mean, these digital tools are going to be so intuitive, that, hell, we'll be using them to design inhibitors for aflatoxins and things like that. Yeah. What do you think?

Howard I think there's... I want to go back to one thing first that Enock said. It's called engaging governments. That's a theory of change. I would rather make it a change of theory and induce the governments. I'm much more interested in inducing them to understand what is necessary to have a healthy rural society, have a healthy rural population. Engaging sometimes is not..., doesn't really quite get it was much as we would like to have it happen. In the area of technology, thank goodness the cell phone came along and no one decided to cut down whatever trees are left in Africa to build telephone poles to string the lines to have wire phones.

You're actually correct. The cell phone is a radical change. It's so amazing. They know what their prices are in commodities I'm interested in, like cacao. On the London strike, they know exactly what that price is. So when a historic [inaudible] comes by, one of the intermediate traders and says, "I'll give you X," he goes, "No,

I'll wait." Because he knows the price is 3X. So there's an ability to really move this forward at a really rapid rate.

What Robb talked about, identifying with 95% accuracy a disease, is astonishing. They have soil testing kits developed by the Booker Instrument Company in Germany for the CG, ICRAF, particularly, that can do a soil analysis of the first 50 elements of the periodic table in less than a minute. It used to take weeks to get a soil sample. It's also backpackable. Satellites traveling over Africa, Asia, United States at 25,000 miles an hour can tell you almost anything you want to know about a plant. And if you can write the algorithm to differentiate a pod from a leaf from a tree trunk, then you'll be able to count pods of cacao on a tree going 25,000 miles an hour. It's incomprehensible. The question is – how democratized? How ubiquitous will this information become? How advanced will it be? And how would it be adopted by everyone? Everyone should have the same game play. It's unfair to think we're going to have it because we live here and they're going to have it and they don't have it.

The last point I'd make on this – We need to be careful not to romanticize the smallholder. This is a really tough situation, to be a smallholder. If you're on degraded land and you're a smallholder, it is really very difficult. Are we going to have fewer smallholders in the future? I think that's probably true. I think we'll move from one to two, three hectares, to five to ten hectares. I think there will be a movement in many crops in that way, not everywhere but some places.

So it's very important to understand that, if you make less than a dollar a day, it's hard to make a good decision. If you get to three or four or five dollars a day, your decision-making tree really changes. And what we're talking about here is getting to that five to ten dollars a day for an individual farmer for his family. And that's really the real revolution, is making that huge shift.

Steven We have just a couple minutes left. Any parting comments from the panelists?

Enock For me the system's thinking is very important. We need to amplify all these good stories. Today in Africa you hear Ethiopia there, Rwanda there, two countries out of 55. We need to find something common so that we can see maybe 30 countries in the next ten years. What do we need to do that? And I think we are beginning to understand, you know, what is that recipe, you know, needed. What are the minimum building blocks of a transforming economy? And we believe that the government is a key player. We need to partner, and I think we are beginning to talk about the right things, and I'm sure... I mean, this is maybe the first time we are beginning to see even TAAT to being launched and several other organizations working together.

Robb Yeah, I couldn't agree more. I mean, the idea for getting the panel together was to really share just the unbelievable transformative tools that are coming into the agricultural space and how they're game changing in all aspects. I think now really the opportunity is how do we take this to the next level from the oversight, from the organization. And what I sense just in talking to folks is there's just a huge amount of alignment, agreement and interest in stepping this up and bringing together the capabilities across the public, the private sectors to do this. It can be done.

Steven Howard.

Howard I would say for my closing comment – the word is “nutrition.” It’s nutrition security, not food security. And it’s a human right to have nutrition security. We can’t have populations that are stunted. I mean, we can’t go to sleep at night thinking that we aren’t trying to solve some of these problems. It’s incomprehensible that a society would allow stunted people because of interventions we know we can make that aren’t being allowed to be made at the pace that we really should. So for me that’s a major piece.

The other part is that the people that are going to hit hardest in many of the cases of climate change are the poorest small farmers. And somehow, notwithstanding governments here or governments there that don't believe in that, we have to also take these sorts of considerations to play in our social interactions every day. But I am still very optimistic, and it’s what a plant breeder is. It’s a walking optimism.

And I'm looking right here at Gurdev Khush, and when I realize... And on my wall in my office at UC Davis. So I have the diagram of what it took him to get down to his release, which is the most used rice in the world. And it was months and years and years and years of crossing. We now have the ability to shrink that down to a much faster perspective. And with all of our technologies, if we don't take advantage and induce these changes, we have lost an opportunity for more than a generation.

Steven Folks, I'd appreciate it if you'd thank our panelists.