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Postharvest in Horticulture: Reducing losses and improving quality to capture high-value crops¹

Overview

The Feed the Future Innovation Lab for Collaborative Research on Horticulture (Horticulture Innovation Lab) held a forum “Postharvest in Horticulture: Reducing losses and improving quality to capture high-value crops” at the University of California, Washington Center in Washington, D.C. on July 24, 2014 to provide stakeholders with an introduction to Horticulture Innovation Lab’s projects related to postharvest technology and gather input on knowledge gaps in the field on which new research is still needed.

Since its inception in 2009, the Horticulture Innovation Lab has funded 38 collaborative research projects in 30 countries, 14 of which are current Feed the Future countries. This is an exciting time for horticultural crops, because they are high value and nutritious; however too few people eat the daily recommended amount, often due to lack of access. The Horticulture Innovation Lab does research that takes into account the entire value chain and social aspects including gender issues. It is committed to promoting a diet rich in vegetables, gender equality, and a better life for those most in need, while at the same time building capacity in students and institutions. Through collaborative research with 15 U.S. and nearly 100 host country partners, it is addressing its research goals by improving the production of fruits and vegetables and increasing availability of horticultural crops. The Horticulture Innovation Lab has emphasized improving postharvest handling through specific projects on this topic as well as incorporating strong consideration of postharvest challenges in its value chain projects. Projects have also focused on food safety and improving market linkages.

Notable projects focusing on postharvest in the Horticulture Innovation Lab portfolio include:

- [Opening a regional postharvest training center](#): Benin, Gabon, Ghana, Kenya, Rwanda, Tanzania Diane Barrett of UC Davis leads "Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center"
- [Improving postharvest practices with local market support](#): Zambia Jim Simon of Rutgers, The State University of New Jersey, leads "Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry"
- [Developing a participatory extension model to enhance smallholder production and marketing](#): Democratic Republic of Congo, Uganda Kate Scow of UC Davis leads

¹ This summary was prepared by Cultural Practice, LLC (CP) in collaboration with Feed the Future Innovation Lab for Collaborative Research on Horticulture.

"Increasing the Capacity of Smallholder Farmers to Produce and Market Vegetable Crops"

- [Developing energy solutions for horticulture production](#): Honduras, Kenya, Thailand Kurt Kornbluth, James Thompson, and Michael Reid leads "Innovative Energy Solutions in Horticulture"
- [Demonstrating low-cost cooling technology](#): Honduras, India, Uganda Michael Reid of UC Davis led "Coolrooms and Cool Transport for Small-Scale Farmers"
- [Improving tomato production through local GAPs](#): Nigeria Sally Miller of The Ohio State University led "Enhancing Trade in Horticultural Crops through Food Safety and Phytosanitary Measures"
- [Implementing drying beads for seeds](#): Nepal, Bangladesh, Kenya, Tanzania, Uganda, Rwanda Kent Bradford of University of California, Davis, leads "Seed Systems – Improving Seed Quality for Smallholders"

A full list of postharvest projects is available here:

<http://horticulture.ucdavis.edu/main/projects.htm#postharvest>

A full list of food safety projects is available here:

http://horticulture.ucdavis.edu/main/projects.htm#food_safety

The Horticulture Innovation Lab has established three regional centers in Honduras, Thailand, and Kenya, which conduct trainings, disseminate information, and test and adapt horticultural technologies including postharvest technologies like the [CoolBot](#). The regional centers are one part of the Horticulture Innovation Lab's capacity building efforts to train trainers, conduct farmer trainings, and engage graduate students in horticultural research. Additionally, the Innovation Lab's [Trellis Fund](#), now in its third funding cycle, has been a unique opportunity for U.S. graduate students to provide their expertise to address important issues related to horticultural production and marketing in developing countries. One of those students, Elana Peach-Fine, who worked with the Horticulture Innovation Lab Trellis Fund, [won the 2013 BIFAD Award](#) for Scientific Excellence in a Feed the Future Innovation Lab for Collaborative Research.

Horticulture Innovation Lab's most successful projects and initiatives focusing on postharvest were featured during the forum. The session was opened by Dr. Elizabeth Mitcham, Director of the Horticulture Innovation Lab who provided an overview of the Lab and the importance of addressing postharvest handling in development projects. The next presentation focused on postharvest technologies for the developing world, and was presented by Dr. Michael Reid, Horticulture Innovation Lab leader for innovative technologies. Dr. Jeff LeJeune from The Ohio State University presented his work on food safety and awareness of microbial and chemical food safety risks in Central America. Dr. Jim Simon of Rutgers University discussed the value of improving postharvest practices. David Miller, University of California, Davis, highlighted how "shared-interest" savings groups can facilitate technology adoption. Britta Hansen with the Horticulture Innovation Lab presented the model of the three Regional Centers and how they promote adoption of postharvest technologies. To conclude the session, John Bowman, Sr.

Agricultural Advisor in USAID's Bureau for Food Security provided an overview of USAID's postharvest portfolio.

A summary of the highlights of each session are presented below. The presentations themselves are available at the workshop website:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/

Useful resources on postharvest from the Horticulture Innovation Lab and UC Davis:

- Horticulture Innovation Lab Website: <http://horticulture.ucdavis.edu/>
- Horticulture Knowledge Bank: <http://hortkb.weebly.com/>
- The Horticulture Innovation Lab invites practitioners to add project information to the [Horticulture map](#) to assist practitioners in finding projects to collaborate with on horticulture.
- Collaborate with the Horticulture Innovation Lab: <http://horticulture.ucdavis.edu/main/funding.htm>
- Postharvest Technology Center (information on postharvest handling of horticultural crops, some materials in Spanish, French, Arabic): <http://postharvest.ucdavis.edu/>.
- Manual on small-scale postharvest practices on horticultural crops in various languages: <http://postharvest.ucdavis.edu/libraries/Small-Scale Postharvest Practices A Manual for Horticultural Crops/>
- Facebook: <https://www.facebook.com/HortCRSP/>
- Twitter: <https://twitter.com/HortCRSP>

The Horticulture Innovation Lab and Its Focus on Improving Postharvest Practices

Presenter: Dr. Beth Mitcham, Horticulture Innovation Lab Director

Production and consumption of horticulture crops can bring nutritional benefits through diet diversification and has the potential to benefit women who are typically heavily engaged in horticulture crop production and marketing. However, consumption of fruits and vegetables remains very low in much of the developing world often due to poor access or lack of sufficient income to purchase them. The Horticulture Innovation Lab takes technical knowledge and applies it to increase smallholders' participation in markets, builds local scientific and technical capacity and facilitates the development of policies and that improve local horticultural trade. Addressing postharvest losses through applied research is one of the ways the Horticulture Innovation Lab is working to address these challenges and improve smallholder farmers' income and livelihoods.

In developing countries, an estimated 32 percent of produce is lost. Yet, only five percent of research funding has been allocated to activities on postharvest. An increased investment in postharvest research is critical to reduce losses and improving food security. Postharvest loss can be caused by improper ripeness, poor initial quality, mechanical damage, inadequate sanitation, inadequate drying, decay, improper product temperature, excessive water loss, and delays between harvest and marketing. Some key interventions to reduce losses include selecting varieties with good shelf life potential, harvesting at proper maturity, avoiding sun exposure to reduce water loss and temperature gain after harvest, cooling (or drying) quickly to the lowest

safe temperature, protect from physical damage, maintain the cold chain (or dry chain), and expedite marketing whenever possible. For example, using storage containers like reusable plastic containers and plastic bags can improve the quality of produce over time by protecting it from damage and also by serving as a moisture barrier to reduce water loss.

The Horticulture Innovation Lab has been looking at how different technologies can help to reduce postharvest loss including cold storage solutions. Sufficient cold storage is lacking in developing countries and it is often viewed as difficult or impossible to introduce. The Horticulture Innovation Lab is working on making cold storage feasible for farmers who do not have access to proper temperature control.

Capacity building in postharvest is also a key focus of the Horticulture Innovation Lab. Principal Investigator, Diane Barrett, UC Davis, for the “Extension of Appropriate Postharvest Technology in Sub-Saharan Africa: A Postharvest Training and Services Center” project worked with the World Vegetable Center (AVRDC) to train master trainers on postharvest practices in Sub-Saharan Africa through a new Postharvest Training and Services Center, which includes cold storage, storage shed, solar driers, and a shade structure for local farmers. In 2012, this program trained 40 master trainers through a one year online course and an on-hands training at the [Postharvest Service Center](#).

This is just one example of the ways the Horticulture Innovation Lab uses partnerships to improve postharvest practices. Building on this theme of collaboration during the discussion the Horticulture Innovation Lab Director Beth Mitcham highlighted how potential collaborators can use the [Horticulture Innovation Lab's map of projects](#) to find common areas of interest for future collaboration. The Innovation Lab has also developed a [map of horticulture project worldwide](#) where implementers can share information about their ongoing projects to facilitate increased collaboration and knowledge of ongoing work on horticulture.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/mitcham_postharvest_horticulture_innovation_lab.pdf

Postharvest Technologies for the Developing World

Presenter: Dr. Michael Reid, Horticulture Innovation Lab, University of California, Davis

The Horticulture Innovation Lab is committed to developing and finding innovative ways to use existing technologies in developing countries to improve postharvest loss, while anticipating future technologies that might be used as technologies become more affordable and accessible. Michael Reid, Leader of Implementation of Innovative Technology and Special Projects at the Horticulture Innovation Lab discussed the importance of using a variety of technologies to reduce postharvest loss including germplasm manipulation and storage technologies.

Germplasm manipulation of horticultural crops can be addressed through molecular tools, but most manipulation is applied to major crops instead of horticultural crops. Genetic manipulation can change the postharvest characteristics. Many postharvest fruits and flowers are regulated by

ethylene, a major cause of postharvest loss and modulation by ethylene synthesis can improve the life of horticultural crops. For example, research has shown that the shelf life of Charentais melons is greatly improved through biotechnology.

Some innovative cooling and shading methods can also improve the quality of produce. Some produce must be cooled by water and ice, some by air, and water. In Bangladesh the Horticulture Innovation Lab and the International Potato Center have constructed small-scale cool storage facilities for potatoes and vegetables that use a regular (and relatively inexpensive) air conditioner controlled by a small electronic controller called a [CoolBot](#). A major issue has been connecting the rooms to the grid, but the investigators are also demonstrating the use of solar energy as an alternative energy source. The room itself is built with structural insulated panels. They are also exploring alternatives, including spray foam and agricultural residues in hollow walls. The CoolBot is then used to regulate the air temperature to preserve the produce. Adequate access to shade is also necessary to improve the quality of produce, because daily temperature and humidity variation can affect horticultural crop storage. Harvesting at the coolest part of the day is a key, and may involve cooling at night and maintaining lower temperatures by shading after harvest.

Other technologies like a chimney dryers, root cellars and earthbags could also be used for storing and preserving food. One attendee recommended that the Innovation Lab consider the work that the Defense Advanced Research Projects Agency (DARPA) has done in Iraq to preserve food and keep people cool. Technologies that will become more readily available as they become more affordable include Aerogel, a low density silica gel that can be used for insulation of storage facilities and lithium batteries used to store energy for cooling systems.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/reid_postharvest_technologies_developing_world.pdf

Produce Food Safety: Challenges in Implementing Improved Practices

Presenter: Dr. Jeff LeJeune, The Ohio State University

The Horticulture Innovation Lab project, “Delivering Vegetable Safety Education through Established Social Networks in Latin America” (2011-2014) in Guatemala, Honduras, and Nicaragua aims to build social networks to disseminate information about vegetable microbial contamination and promote management changes to improve food safety and quality. The project, led by Ohio State University, with collaborators at the Universidad de San Carlos (Guatemala), Zamorano University (Honduras), and PROMIPAC (Nicaragua). A similar project on Food Safety in Nigeria “Enhancing Trade in Horticultural Crops through Food Safety and Phytosanitary Measures” was enhancing regional and international trade in Nigerian tomatoes by developing a science-based Good Agricultural Practices (GAPs) curriculum and training program to improve production, food safety and phytosanitary compliance. These two projects have spun off and developed other projects through Africa Rising- TZ, FDA-Guatemala, Global Food Safety Partnerships, and low-mechanization Amish farmer studies in the U.S.

By delivering information to men and women farmers through social networks like greenhouse associations, organic production associations, health clinics, schools and extension services the project working in Central America aimed to increase awareness about the food safety issues that can have negative effects on farmers' health and income. Through participatory research and outreach activities this project's goals included: 1) decreased food contamination; 2) improved health of farmers and improved produce quality; 3) increased market opportunities to improve farmers' economic viability; and 4) validation of a model system for effective delivery of agricultural assistance in Central American countries.

Lead PI Jeff LeJeune and his team used a participatory approach with researchers, farmers, and extensionists to develop innovative ways to address food safety that is communicated effectively by considering relevance, whether it is understandable, trusted and through a preferred medium to bring about behavior change through knowledge transfer pathways. Researchers interviewed 40 small-stakeholder farmers in Latin America about chemical residues and microbial threats. Researchers found that most farmer information on these topics came from friends and family, and representatives from agro chemical companies. There was a general concern about the availability of information provided to farmers. Through the Horticulture Innovation Lab's Regional Center for in Honduras, the project worked with Zamorano University to harness their networks and provide training to NGOs and academics who would then go to their partners and integrate food safety information into other topic areas.

The discussion following the presentation focused on how the susceptibility to certain illnesses is linked to foodborne illness in developing countries. Attendees noted that in developing countries tolerance for foodborne illness may be higher than in developed countries since it is more common. Discussants noted, however, that there has not enough research on the relationship between illness and food safety.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/lejeune_food_safety_challenges.pdf

Demonstrated Value of Improving Postharvest Practices

Presenter: Dr. Jim Simon, Rutgers University

The project "Sustainable Development of Horticultural Crops in Zambia by Introducing Postharvest Technologies and Practices for Food Security, Income Generation and in Support of the Tourism Industry" (2010-2011) led by Rutgers University aimed to strengthen the value chain for fresh market vegetables with a focus on postharvest handling through locally produced commercial vegetables into southern Zambia's Livingstone region markets for the tourism and supermarket industries. Rutgers University collaborated with Purdue University, Global Cold Chain Alliance, World Food Logistics Organization (US); Stellenbosch University (South Africa), and Agribusiness in Sustainable Natural African Plant Products (ASNAPP) (Zambia). It also collaborated with local private sector partners including Sun International Hotels, David Livingstone Hotel, Freshmark/Shoprite and SPAR supermarkets.

This project focused on strengthening the value chain to scale up production of horticultural crops, including chilies, using public-private partnerships for economic development and introducing new postharvest technologies to improve the quality of produce. It used a market-first approach to bring postharvest practices and encourage entrepreneurship. In southern Zambia the project worked with ASNAPP and Sun International hotel to develop quality produce for sale to local supermarkets. When the project started there were no postharvest technologies in use by these groups, farmers would harvest full ripe and immediately deliver the produce to the hotels and supermarkets. With the added technologies and improved practices this project has generated about \$600,000 in additional income each year.

Some of the challenges researchers faced implementing this project came to light during the discussion session. Jim Simon noted that one of the most difficult issues is working within the cultural context to achieve results. Additionally, engaging with local universities can be challenging, but the Horticulture Innovation Lab has found creative ways to bring researchers from host country universities into projects that do not require contracting directly through the university itself.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/simon_value_improving_postharvest_practices.pdf

Regional Centers: Encouraging Adoption and Scaling of Technologies

Presenter: Britta Hansen, Horticulture Innovation Lab, Program Officer-Regional Centers

The Horticulture Innovation has three Regional Centers: in Honduras, Thailand and Kenya. The regional centers aim to improve income for smallholder farmers in the region, increase smallholders' access to nutritious fruits and vegetables, improve gender equality in the horticultural sector, and increase the capacity of host institutions. The centers provide a space for demonstrating technologies, a way to develop new partnerships in the horticulture sector, create training and technology plans, provide smallholders with networking opportunities, and provide trainings.

The three centers to date have accomplished the following activities related to postharvest technologies:

- South East Asia- Kasetsart University
 - Curriculum development on Postharvest training, access to postharvest technologies including drying beads, solar drying and Zero-energy cooling technologies, and development of a [D-Lab](#)
- East Africa-Kenya Agriculture Research Institute
 - Solar drying of mango and postharvest handling
- Central America- EAP Zamorano University
 - Curriculum development on Postharvest training, access to postharvest technologies including drying beads, solar drying and Zero-energy cooling technologies, and development of a [D-Lab](#)

The Regional Center in Honduras has been providing short courses on postharvest modeled on the renowned UC Davis postharvest short course. In one week the center trained 40 participants including many medium sized growers sponsored by small businesses and large supermarkets. The center also traveled to Guatemala to 200 Guatemalan extension workers in postharvest technologies. The Regional Center in Thailand has been training farmers on basic postharvest practices in Cambodia and Thailand. Extension workers from Nepal, Bangladesh and Cambodia traveled to the center in Thailand to get trained in postharvest physiology and new technologies.

To date there have been some challenges integrating the regional centers with existing projects, working across countries, sourcing materials and imports, moving products around the world, connecting to the private sector and marketing new technologies. The Horticulture Innovation Lab is committed to making the Regional Centers of Innovation sustainable,

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/hansen_centers_scaling_technologies_adoption.pdf

“Shared Interest” Savings Groups Facilitate Technology Adoption

Presenter: Dr. David Miller, University of California, Davis, Project Administrator

The Practicing Agricultural Community Entrepreneurship (PACE) project in Cambodia led by two UC Davis alumni that examined how savings groups can be used to facilitate technology adoption. These savings groups are not made up of just farmers; they include input providers, farmer families, processors, transporters, collectors, wholesalers and marketers. This project to work with savings groups was led by the University of California, Davis in collaboration with the Royal University of Agriculture (Cambodia) and Oxfam International.

The goals of the PACE initiative at the University of California, Davis are to 1) Design & implement projects within local and regional agricultural communities in developing countries, particularly Feed the Future countries; 2) Enhance the graduate interns' competency-based skills, with a particular focus on designing and implementing agricultural or environmentally focused projects; 3) Enhance partnerships between agriculture research institutions & NGOs operating in agricultural communities, 4) Build student to student collaborations between US agriculture universities and counterparts abroad, and 5) Further the development goals of countries in target regions. This particular activity has worked with savings groups investing in technologies like net houses for their crops. Demonstration sites were also used to provide smallholders with access to postharvest technologies.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/miller.pdf

Overview of USAID's Postharvest Portfolio under Bureau for Food Security

Presenter: Dr. John Bowman, USAID, Bureau for Food Security

In the past few years USAID has increased their investment in postharvest activities. Through Feed the Future, The USAID, Bureau for Food Security, Agriculture Research and Policy (ARP) is supporting many programs working on postharvest loss including:

ARP Office (Washington, DC)

- Feed the Future Innovation Labs (Horticulture, Integrated Pest Management, RPHL, Food Processing, and formerly Bean/Cowpea, INTSORMIL)
- AVRDC (Core + PH)
- CGIARs (IRRI, CIMMYT, CIP, CSISA)
- Biotechnology (ABSP2 – LBR potato/AATF – insect resistant cowpea)

Markets, public/private partnerships (MPI) (Washington, DC)

- AflaSTOP

Run by Missions

- Rwanda – PHH + storage
- EAR – Compete/MLI
- Tanzania – TAPP, Tuboroshe
- Kenya – KHCP/KAVES
- Ghana – ADVANCE
- Uganda – WFP-P4P, UCE, DANIDA/ABI-Trust

The new [Feed the Future Food Security Innovation Center](#), leading USAID's Feed the Future research strategy, includes seven programmatic focus areas including Research on Nutritious and Safe Foods, through which postharvest issues are addressed. This programmatic area includes diverse projects working on nutrition and food safety. There are three new investments on postharvest including an investment in the World Vegetable Center (AVRDC), the Post Harvest Loss Reduction Innovation Lab led by Kansas State University, and the Food Processing Innovation Lab led by Purdue University.

USAID's investment in AVRDC is focusing on postharvest management. AVRDC has examined tomato-disease resistance and better marketability of these tomatoes. Through this activity AVRDC has increased production of disease-resistant tomato varieties by 40% in Tanzania. The new program run out of Arusha is working in Tanzania, Kenya, Mali, Ghana, Ethiopia, Bangladesh, and Cambodia to reduce postharvest loss of high volume and high value vegetable commodities. AVRDC has been working with the Horticulture Innovation Lab on food processing in Tanzania with a women's group called Wodsta on a pickled mango project.

The new [Feed the Future Post Harvest Loss Reduction Innovation Lab](#) led by Kansas State University, working in close collaboration with University of Illinois, will operate in four countries including Bangladesh, Ethiopia, Ghana, and Guatemala. The Innovation Lab focuses on enhancing capacity to improve postharvest practices, expanding access to Post-Harvest Service Centers, and testing best practices and technologies. They are working on improving

postharvest technologies and practices including on-farm drying, use of solar driven fans, hermetic storage, GrainPro Designed Cocoons, and Silos. They are collaborating with seven U.S. institutions, eight international universities in Bangladesh, Ethiopia, Germany, Ghana, Guatemala, Switzerland, and Uganda, four international agencies including the CGIAR centers and the UN Food and Agriculture Organization, and at least eight private industry partners.

[Feed the Future Innovation Lab for Food Processing and Post-harvest Handling at Purdue University](#) focuses on developing sustainable, market-driven value chains that reduce food losses, improve food and nutrition security, and contribute to economic growth for farmers in Kenya and Senegal. The Innovation Lab is working on product development of pre-gelatinized instant porridges and couscous and improving processing operations. They are partnering with the North Carolina A&T University, University of Pretoria, South Africa, Institut de Technologie Alimentaire (Sengal); Jomo Kenyatta Univ. of Agric. & Technology, University of Eldoret, CIMMYT (Kenya), International Institute of Tropical Agriculture (Nigeria), and A to Z Textiles (Tanzania).

Two other ongoing USAID-funded projects continue to address postharvest issues. The USAID funded Fintrac-led [Kenya Horticulture Competitiveness Project](#) (KHCP) works with small farmers to improve field production of high value horticulture crops for export markets primarily to Europe. The project has linked the chilli processing and indigenous amaranth dehydration for export. The Horticulture Innovation Lab project “Sustainable African Indigenous Vegetable Production and Market-chain Development for Improved Health and Nutrition and Income Generation by Smallholders” (2011- 2014) focuses on strengthening the African indigenous vegetable (AIV) industry also collaborated with KHCP. The [Tanzania Agriculture Production Program \(TAPP\)](#) has focused its efforts on field production and postharvest activities. The project has introduced charcoal coolers and worked with farmers to cure onions and vanilla to increase their postharvest life, thus providing access to higher priced markets. The program has also used solar drying to support women’s groups producing pineapple, mango, and other horticultural crops.

USAID-funded project face many challenges in addressing postharvest loss. Value chain projects may claim to be working on postharvest, but tend to focus their work on production issues which are often more compelling than reducing loss. Increased public-private sector research is needed to promote the economic advantages of addressing postharvest management. Future postharvest needs include more user-friendly postharvest knowledge platforms, long-term investment in human, institutional, and social capital, more risk-based assessment, decision support tools for value chain actors, and more adaptive research on predicting results of biotic stress.

The full presentation is available here:

http://horticulture.ucdavis.edu/main/events/dc_postharvest/bowman_usaid_post-harvest_strategy.pdf

Discussion

- 1. What postharvest challenges do you see in your work and projects?**
 - 2. How have you solved them? Have you?**
 - 3. Do you have good examples of success?**
 - 4. What challenges remain?**
 - 5. Why do you think we've made so little progress in reducing postharvest losses?**
- Cost of the technologies to the farmer are high. Greater adoption is possible with lower costs.
 - Lack of infrastructure is a challenge including road systems. Access to clean water is key in ensuring food safety.
 - Increased advocacy around about the threats of mycotoxins. Aflatoxin, once a hidden issue, has become more of interested because of death.
 - Postharvest is one special area in the value chain and, at the end of the sequesnce, often does not gain needed attention or investment.
 - Solutions not introduced through a market system. It is unsustainable. Use value chain for the solution
 - Emphasis has been on production and high yielding varieties, rather than reducing postharvest losses, even though greater protection of products after harvest could compensate for a lower level of productivity.
 - Looking for silver bullet solution. For each product there's a different solution. E.g., Cambodia issues of having excessive cucumbers. Solutions are manifold.
 - Two key challenges: introducing postharvest solutions that are hyper local, but if not part of a larger market system how helpful
 - Sometime researchers or practitioners say sometimes that cold storage isn't possible rather than aiming high to introduce better technologies that are also more expensive but will perform well. Where private sector has made those investments, it has been oriented towards exporting high value goods, owned and operated only by large exporters.
 - Donors haven't worked on policy that affects food safety infrastructure, because you have to convince the host country government to invest in infrastructure.
 - Research investment on postharvest has been small at USAID . Still huge postharvest losses in the U.S. The donor perspective is that private sector needs to step up.
 - Need innovative research to make postharvest practices feasible in developing countries.
 - There is a bottle neck in knowledge transfer. We need leap frog technologies and convince smallholders to adopt the practices.
 - Increase consumers were awareness of emerging technologies.

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