OVERVIEW PAPER

Innovative Small-scale Postharvest Technologies for reducing losses in Horticultural Crops

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ABSTRACT

A comprehensive research project reassessed 12 past international horticultural projects, characterized current causes of postharvest losses of 18 horticultural crops in four countries, then field tested a variety of low cost postharvest technology innovations that could potentially reduce these postharvest losses, improve market value and improve incomes for small farmers. This presentation briefly outlines the postharvest technologies found to be most successful, the technologies were not adopted or not maintained after the end of past projects, the most common knowledge gaps found for 30 commodity systems. The results of a series of field trials and cost/benefit analyses of potential postharvest technology innovations led to identification of many small-scale innovations that can reduce postharvest losses, add value and improve returns by at least 30%. The concluding consensus recommendation is to avoid building expensive, complex postharvest infrastructure that is difficult for smallholders to utilize and manage, and instead to promote integrated postharvest management systems focusing on incremental adoption of small scale postharvest innovations.

Keywords: Postharvest technologies, small scale, cost/benefit, horticulture

INTRODUCTION

Since the 1980s I have been involved in the field of international horticultural development, specializing in small scale postharvest technologies. Associated with a variety of projects in more than 25 countries I have worked as a private consultant on loss assessments, program development, postharvest training and project management. During the past few years I've had the privilege of leading a comprehensive research project aimed at reassessing the results of some of those projects. The research project attempted to assess the current causes and sources of postharvest losses of horticultural crops followed by field testing of a variety of low cost

postharvest innovative technologies that could address the existing problems. Working with colleagues from the World Food Logistics Organization (WFLO), the University of California at Davis (UCD), the International Institute of Tropical Agriculture (IITA) and Amity University (India), with the financial support of the Bill & Melinda Gates Foundation (BMGF), a wide range of small scale, cost effective postharvest innovations were identified, tested and found to be effective in reducing postharvest losses and improving incomes at the level of small scale farmers and produce marketers.

MATERIALS AND METHODS

More than 300 participants in 12 horticultural development projects conducted in Egypt, Indonesia, Kenya, Ghana and India were interviewed by the assessment team in 2009. What had worked, what had not worked, what kinds of technologies were still in use after the completion of the projects and other related questions were used as assessment parameters. These were followed by a series of 30 Commodity Systems Assessments (CSA) conducted during which the assessment teams interviewed hundreds of people in Ghana, Benin, Rwanda and India who were involved in the production, postharvest handling and marketing of 18 different fruits and vegetable crops. The Commodity Systems Assessment considered 25 steps or components related to the handling and marketing of horticultural crops (LaGra, 1990; Kitinoja and Kasmire, 2002). In addition, a series of twenty one field trials were conducted on a wide variety of appropriate postharvest technology (APT) options during 2009-10 and a total of 21 cost/benefit analyses we performed during the field trials. Finally all the results of the assessment were analyzed using accepted standard procedures.

RESULTS AND DISCUSSION

Impact on the farmers

It was found that each of the 12 projects managed to achieve positive short term results across a wide range of indicators of success. Many of the projects assisted farmers to become active marketers, rather than being passive price takers. In some cases, farmers were successfully encouraged to take on more responsibility for their crops and become direct marketers, after learning how to grade, pack, handle and sell their produce directly to the retailer or consumer.

Successful postharvest technologies

- Upon analyzing the adoption rates of the postharvest technologies considered, it was found that the simpler the postharvest technology, the better its chance of adoption, sustainability and its being still in use over the long term as indicated below. Small scale postharvest practices such as the use of maturity indices to identify proper harvest timing, improved containers to protect crops from damage during handling and transport, the use of shade, sorting/grading to enhance market value, and use of on-farm storage practices have been found to be simple, easy to try and successful.
- Improved practices were adopted if they fit well into an existing value chain and marketing system (representing small steps of incremental improvement rather than requiring big changes in practices).

- Encouraging farmers to learn more about marketing and taking more responsibility for their crops after harvest led to reduced losses.
- Sustainability of the adoption of technological innovations depended mostly upon their profitability in the local setting.
- Developing new or improved market links was found to help sustain the use of technical improvements.
- Development of upgraded or alternative value chains (through cooling, temporary storage or processing) were found to be appealing.

Empowering local institutions through capacity building (i.e.: training extension workers) seemed to have helped generate continuous local action after the completion of the project and resulted in improved chances of sustainability.

Unsuccessful postharvest technologies

The results of the assessment showed that large scale efforts to provide packinghouses or complex postharvest infrastructure such as cold storage facilities were generally less successful, due to the following three reasons most commonly reported:

- Problems with selection of sites (poor location for growers making access difficult)
- High costs of energy for operation (electricity, fossil fuels)
- Lack of trained local personnel needed for successful management.

Equity and gender issues were not given any strong focus in most of the projects assessed (women's access to education and resources, and access of the poorest of the poor to information, credit and markets is still limited). There were unintended impacts of large-scale infrastructural development projects, including "the rich get richer" scenario, where people with access to assistance leaped ahead of those without access. Governments often did not provide adequate support (i.e.: providing the right kinds of incentives, improved access to credit, timely provision of required licenses or permits) in promoting long-term success. The modern postharvest facilities adopted were sometimes abandoned upon the cessation of project funding.

Results of Commodity Systems Assessments

During the assessments the team found problems and issues at every step, each of which need to be addressed in order to improve efficiencies in the value chains. The constraints were similar for all the four countries and were found as part of the existing value chains for many of the crops. The key constraints identified included:

- Lack of availability of basic postharvest equipment, tools and supplies in rural areas (shade, packinghouses, transport vehicles, cooling equipment, packages, storage structures, processing equipment, etc.)
- Lack of local knowledge and technical capacity (few local postharvest trainers exist)
- Lack of farmer access to any existing postharvest information, supplies, market information and credit
- Lack of trustworthiness of the existing postharvest information (misuse is common when recommendations intended for one crop are applied to a different kind of crop).

- Lack of financial incentives for farmers to use improved handling practices (often due to the role of intermediaries)
- Limited market access for smallholders (who often lack information on market prices, or any means of transport).

In general, people in SSA and South Asia were found to be clamoring for information on improved small scale postharvest practices and simple tools that could be used on farm and at the village level to reduce losses and improve incomes.

Results of Field Trials and Cost/Benefit Analyses

The results of the field trials and cost/benefit analyses showed that all 21 were found to be profitable for small farmers, of which 81% (17 technology /crop combinations) were found to increase returns by 30% or more (Kitinoja *et al.*, 2012). The costs incurred included the capital expenditures (equipment, tools) as well as recurring costs (for expendable supplies). The benefits included increased volume of produce for sale, improved quality reflected in increased market value, and/or improved shelf life, allowing later sales and higher market prices. Full details can be found on pages 216-268 in the final project report (Kitinoja, 2010): http://ucce.ucdavis.edu/files/datastore/234-1847.pdf .

Table 1 provides a summary of six examples of the types of problems that were identified during the field trials, the potential solutions that were tested for each case, and examples of the measured effects on loss reduction or postharvest quality (and related market value) as well as calculations of any potential improvements in profits due to the improved practice or technology.

CONCLUSIONS AND RECOMMENDATIONS

The use of simple technologies either alone or in combination helped both women and men farmers to reduce postharvest losses of the horticultural crops studied in Sub-Saharan Africa and South Asia. The general principles that are being achieved by their use (lower temperature, more protection from sun and mechanical damage, and quicker handling) are expected to work well for all horticultural crops. It is recommended that the basic training materials developed for the promotion of the studied technologies be modified as needed to fit the local conditions and updated to reflect local costs and benefits.

The following five major categories of postharvest technology were identified and found to meet the evaluation criteria of reducing losses, are of appropriate scale, cost effective, easy to use on a trial basis and capable of generating increased incomes from horticultural crops by at least 30% at household level. .

- Improved containers
- Use of shade
- Field packing systems
- Low energy cool storage: zero energy cool chambers
- CoolBot™ equipped small cold rooms.

Moreover, three additional categories of technologies were recommended to have demonstrated success across many countries and crops over many years. Curing is found to be especially important if fresh roots and tuber crops are to be stored for any length of time. Curing allows any wounds from harvesting to heal before becoming entry points for decay organisms and lead to increased rates of water loss.

Despite the fact that they are less profitable due to high costs incurred, simple food processing methods such as drying, canning sauces or jams are found to be helpful in improving food availability for rural families by transforming highly perishable produce into more stable food products.

Our general recommendation is to avoid building expensive and complex postharvest infrastructure that is difficult for smallholders to utilize and manage, and instead to **promote the development of an integrated postharvest management system** (Kitinoja *et al*., 2011). As part of this integrated postharvest development system, smallholder farmers can be trained by locally based postharvest specialists.

Many of the postharvest innovations identified could be scaled up simply by increasing the number of units (shade covers, plastic crates, field packing stations, cool chambers, etc.) in use. Taking these postharvest technologies into the public realm on a large scale seems to require active extension efforts that target smallholder farmer and women's groups. Extension and outreach innovations should include providing postharvest education in local marketplaces where people work and shop, thereby improving their access to information, forming new women's marketing groups and using posters with colorful illustrations rather than written materials to impart key postharvest information to illiterate target audiences (Kitinoja *et al*., 2011).

The concept of a Postharvest Training and Services Center (PTSC) pulls together all these findings and provides a comprehensive package of training, demonstrations, goods, services and advice targeting the bottlenecks and missing components of the value chain. Currently I am involved in piloting the general concept under the USAID HORT CRSP program in East Africa, working with UC Davis, WFLO, UGA and AVRDC in Arusha, Tanzania. I believe that each village and community on this planet needs a PTSC, whether it is called a postharvest shop, a postharvest technology store, a postharvest education center, a marketing association or by any other name. The low cost innovative postharvest technologies, postharvest goods and services provided to smallholder farmers and marketers will allow them to join in modern value chains, improve their potential to reach new markets and customers, and help to reduce food losses while increasing incomes.

REFERENCES

Kitinoja, L., AlHassan, HA., Saran, S. and Roy SK. 2012. Identification of Appropriate Postharvest Technologies for Improving Market Access and Incomes for Small Horticultural Farmers in Sub- Saharan Africa and South Asia. Invited paper for the IHC Postharvest Symposium, Lisbon, August 23, 2010. *ActaHort (IHC 2010) 934: 31-53*.

Kitinoja, L., Saran, S., Roy, SK. and Kader, AA. 2011. Postharvest Technology for Developing Countries: Challenges and Opportunities in Research, Outreach and Advocacy. *J of the Science of Food and Agriculture*, 91: 597–603.

Kitinoja, L. 2010. Identification of Appropriate Postharvest Technologies for Improving Market Access and Incomes for Small Horticultural Farmers in Sub-Saharan Africa and South Asia. WFLO Grant Final Report to the Bill & Melinda Gates Foundation, March 2010. 318 pp.

Kitinoja, L. and Kasmire, RF. 2002. Making the Link: Extension of Postharvest Technology, Chapter 38 in Kader, A.A. (ed), *Postharvest Technology for Horticultural Crops* (3rd Edition), UC DANR Publication 3311. pp. 481-509.

LaGra, J.1990. *A Commodity System Assessment Methodology for Problem and Project Identification.* Moscow, Idaho: Postharvest Institute for Perishables.

Table 1. Summary of postharvest innovation options, strategies and results

Problem Identified	**Potential Solutions**	**Examples of APT field trials**	**Examples of effects on loss reduction or postharvest quality**	**Profit potential (additional profit compared to current practice)**
Produce loses value due to weight loss or wilting	Protect produce from the sun, keep it cooler during handling and preparation for marketing	Provide shade at farm	Cooler temperature by 6 to 10°C Reduced losses from 30% to 15% Improved market value/kg by 50%	Cloth shade structure for tomatoes in Cape Verde: $30 / 200 kg
Produce loses value due to mechanical damage during the marketing period	Protect produce from damage by using better quality packages and containers	Plastic crates Liners for existing containers Smaller containers	Reduced damage by 30 to 60% Improved market value/kg by 40 - 140%	Plastic crates for tomatoes in cape Verde: $40 / 200 kg Crate liners for guava in India: $52.60 /1000 kg Smaller sacks (1/2 size) for cabbages in Ghana: $83 /1000 kg
Produce has low market value due to poor appearance, decay or damage during handling	Add value by using proper harvesting, sorting, grading and packing practices	Field packing of tomatoes Cling film for cauliflower	Reduce losses from 30% to 10% Improve market value/kg by 50 - 100%	Tomatoes in Rwanda: $198 / 1000 kg Wrapping cauliflower in peri-urban India: $119 / 1000 kg
Produce loses value due to exposure to high temperature if it cannot be sold right away	Short term storage in cool chambers	Low cost "Zero energy cool chamber" for vegetables	Reduce temperature by 5 to 10°C Increase shelf life by days or weeks (depending upon crop) Reduce weight loss in radishes from 13% to 7%; in tomatoes from 8% to 3%. Reduce losses from 30 - 60% to 10 - 36%	Vegetables in India:$140 - $390 / 1000 kg Cabbages in northern Ghana: $58 / 200 kg load

Problem Identified	**Potential Solutions**	**Examples of APT field trials**	**Examples of effects on loss reduction or postharvest quality**	**Profit potential (additional profit compared to current practice)**
Market value vary widely between the time of harvest and the time of local shortage	Store produce for a month to several months in low cost cold room	CoolBot™ equipped cold room on farm for potatoes in India or onions in Ghana	Reduce temperature to 2°C Increase shelf life to 4 to 8 months Reduce losses to less than 5%	Potatoes in India: $1296 / 6MT (low value crop) Onions in northern Ghana: $8790 / 6MT (high value crop)
Market value plunges during peak harvest period	Transform produce to a more stable product that can be stored for months, then consumed or sold when market prices recover	Solar drying of vegetables and fruits Canning and bottling of processed tomato products	Reduce losses to less than 2% Longer shelf life (up to one year) Improved market value/kg (% increase depends upon crop)	Solar drying of chili peppers in Benin: $15.05 / 15 kg Whole tomato concentrate in India: $3 /100 kg