HORTICULTURAL EXTENSION MANUAL

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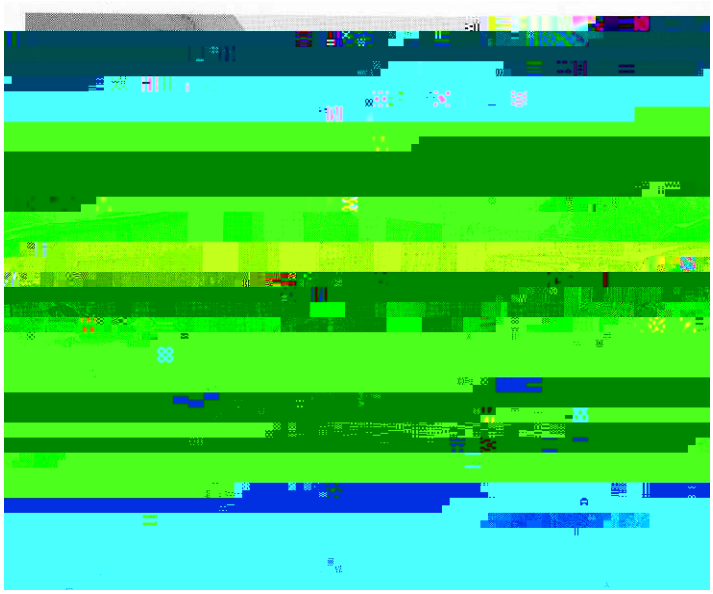
Part I. Identifying Scale-Appropriate Horticultural Technology

An enormous amount of technically useful horticultural technology is described in textbooks and manuals, and new or improved technologies for handling and marketing horticultural crops are regularly reported on in technical and trade journals. Throughout the United States and abroad, extension specialists at universities and experiment stations recommend potentially useful production and postharvest handling practices in newsletters, extension publications, videos, and via the Internet. Extension agents, farm advisors, postharvest consultants, and development personnel must be able to identify technologies that are cost-effective, feasible, and appropriate for their clients, as well as acceptable to consumers. With all the technologies from which to choose, how can extension professionals help their clientele determine whether any given horticultural technology will solve the problem at hand?

It is all too common to hear of technical fixes that caused more problems than they solved. Expensive imported tractors can be seen sitting rusting in fields in many parts of the world due to a lack of fuel and spare parts. During the 1970s and 80s, postharvest losses were often attributed to a lack of storage facilities on-farm and in wholesale markets. Yet when large-scale commercial storage and marketing facilities were constructed they sat unused in many parts of the world. An example from Senegal shows an enormous new concrete marketplace sitting empty while vendors continue to use their overcrowded marketplace of thatched wooden booths (figure 1). Various studies have determined the lack of use of new postharvest structures in Africa, India, and Latin America to be due to high fees, inconvenient locations, management problems, or perceived security issues. In the United States and in European countries, consumers are often willing to pay more for produce that has been produced and handled in what is considered a safe manner, perhaps by avoiding the use of pesticides or by participating in a food safety program at the farm and packinghouse level. By becoming aware of a host

of possible factors that can affect whether a horticultural technology is cost-effective, feasible, and/or appropriate for the client, as well as culturally acceptable to consumers, extension professionals can assist in the transfer of information that is truly useful to their clientele.



Factors Affecting the Adoption of Improved Horticultural Technology

Casual observation or conversation with producers, postharvest handlers and marketers of horticultural crops provides a large number of examples of typical practices and

use a practice known to protect produce because of its cost or because consumers perceive the practice as undesirable. On occasion, a lack of reliable supplies, market information, or other infrastructural problems may make changes in handling impractical.

A variety of methods of postharvest loss assessment can be used to pinpoint the

Most involve direct observation of handling practices and the interviewing of key individuals regarding their standard postharvest practices. The United Nations Food and Agriculture Organization (UN FAO) has published loss assessment manuals for various commodities that focus on measuring physical losses (changes in weight or quantity of produce) and losses in value (quality changes or decrease in market price per unit). Any method used for loss assessment must attempt to understand postharvest losses within the context of the whole system of production, handling, and marketing of the commodity in

	Institutional linkages (i.e., communication between research and extension).
	Government investment priorities in facilitating services.
	Budget for maintenance of existing infrastructure.
	Availability of staff with management skills for running facilities.
	Condition of communications systems (telephone, mail, FAX, e-mail services).
Marketing system	Availability of marketing options and alternative outlets.
	Direct sales vs. consignment (Who is responsible for losses? Who suffers financially?).
	Degree of cooperation and coordination among buyers and/or sellers.
	Establishment and viability of marketing cooperatives.
	Reliability of recordkeeping to help trace problems back to sources.
Market information	Availability of resources for collecting and analyzing data.
	Reliability of information.
	Timeliness of information.

Socioeconomic factors

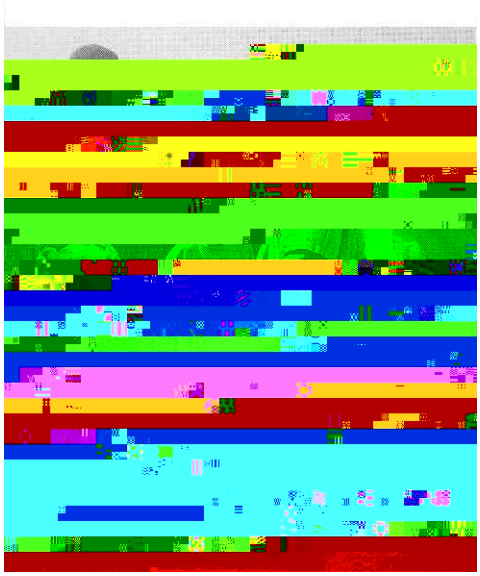
The potential for changing most improper horticultural practices will be affected by a wide range of socioeconomic factors. In general, socioeconomic factors have to do with costs and benefits (actual, perceived, short-term, and long-term). Some of the many examples found in the literature are listed in the first column of table 3.

Table 3. Factors affecting implementation of improved postharvest handling and food processing practices, leading to increased losses and quality deterioration.

Socioeconomic factors	Cultural factors	Institutional factors
High cost of plastic sheeting forces handlers to sun-dry their vegetables directly on the soil (dust, insects, molds). (Morocco; Kitinoja 1996)	Onions are harvested very early, leading to high losses but responding to consumer demand for the flavor of early onions. (Chad; Kitinoja 1992)	Government established fees set for potato storage facilities was so low that storages sat empty (operators would have lost money by running the facility). (UP, India; Kitinoja 1995a)
Very early harvest (before maturity) to take advantage of higher market prices at beginning of season. (India; Reid et al. 1997) (Morocco; Kitinoja 1996)	Health and environmental concerns (irradiation, waxes, pesticides, non-recyclable packaging materials). (USA; Krimsky and Plough 1988)	Women cannot own property and therefore often have no collateral to offer in return for loans. (Africa; Madeley 1987)
Inter-island freight rates charged by unit rather than by weight or volume of produce. (Caribbean; Schurr 1988)	Washing produce is associated with the use of toxic chemicals, specifically pesticides (lowers perceived value).(Morocco; Kitinoja 1995b)	Poor roads, lack of loading docks, cooling and storage facilities, telephone services, inadequate power supply. (Costa Rica; Breslin 1996)

Socioeconomic factors Cultural factors

provides an incentive for handlers to use the largest possible container in order to reduce their shipping costs, regardless of the lack of protection offered by such packages to the produce within. A recent example comes from Tanzania, where cabbages are loaded into jute sacks that have been expanded beyond their intended size so traders can avoid paying for freight on additional packages (figure 2).



Even when the overloading of containers and transport vehicles is a well-known cause of losses due to compression damage and reduced ventilation, overloading is common in an effort to reduce immediate handling and transportation costs. While handlers may explain that they use these practices because the number of vehicles is limited or because the handling of a few very large packages is quicker than hand-stacking many small packages, these practices always compromise quality later on down the postharvest chain.

Large-scale growers or shippers may be using a particular practice because it is cost-effective, and losses of a certain magnitude may be deemed acceptable. Redesigning and producing a new package for specialty fruits, for example, might cost more than the new package saves in reduced losses. Studies have shown that profit-motivated decisions, such as choosing to use less packaging materials in order to maximize individual return

on investment, can increase postharvest losses later in the commodity system. Yet any serious opposition, since the added cost may be viewed as excessive, especially if the produce is sold to an intermediary who then benefits from the investment.

Sometimes the reasons for the choice of a given horticultural practice are complex. While field-packing is known to reduce losses by decreasing the number of times produce is handled, choosing to field-pack vegetables or to use a packinghouse will depend on many factors. The practical decision may be based on factors such as the amount of new investment required, what equipment and facilities are already owned or available, and the expertise of managers and packers. In the United States, another typical dilemma occurs when a choice must be made between performing a handling practice such as harvesting or grading by using manual labor or with machinery designed to enhance efficiency. Which is a better choice for a given operation and its community depends on the philosophy of the owners, the cost of equipment, the expected returns, the availability of trained labor, and the level of local unemployment.

Extension educators must always consider many socioeconomic factors whenever assessing horticultural technology for its suitability for their clientele. Small-scale handlers may not be able to afford to implement well-known technical practices such as sorting, cooling, or improved packaging on their own without reducing profits. If the technology requires the use of credit, prevailing interest rates or access to collateral can affect the decision of whether or not to make a change in handling practices. The cost-effectiveness of postharvest technology will always be a primary factor in whether it will be considered appropriate.

Other cultural factors that can affect whether handlers will adopt changes in horticultural technology include religious traditions, gender barriers, the local definition of losses, and traditional secondary uses for low-quality produce (e.g., animal feed, food banks). If agro-processing is to play a role in reducing food losses, recommended technologies must result in high-quality, healthful foods that consumers find to be good-tasting and easy to prepare. Extension professionals must be aware of these many cultural factors in order to best identify scale-appropriate technology and before attempting to develop educational programs targeting specific clientele.

Institutional factors

The adoption of horticultural technology can be affected by existing laws or regulations providing incentives or disincentives, as well as by facilitating services provided (or not provided) by governments, universities, and the private sector. The third column of table 3 provides some examples of various institutional factors that may affect whether people make changes in technology.

Institutional factors include public sector policies such as commodity price supports or controls, land tenure and property rights, regulations regarding the use of pesticides and acceptable levels of residues, and types or sizes of packages. Secondary institutions can become involved when, for example, fees are charged as part of mandatory marketing orders. The status of these policies and regulations within a state or country may affect whether someone is willing or able to make individual changes in their postharvest practices. For example, the decision to provide price supports may increase production, which may lead to the requirement for more supplies for postharvest treatments, packaging, and storage facilities. If any of these are inadequate or lacking, postharvest losses may increase.

Also of concern are the availability and condition of facilitating services such as the physical infrastructure (e.g., roads, storage facilities), power supply, quality control and inspection services, availability of credit or loans, extension systems, and communications and market information systems. When services related to horticultural

production or postharvest technology are nonexistent, skewed to serve certain groups over others, or poorly managed, adoption of technology can be negatively affected. For example, in many countries, market information is collected but not analyzed and hence goes unused. The FAO suggests limiting the scope of a market information system to a few commodities in major markets, then aiming to collect, analyze, and disseminate information (on prices, supply, and movements of produce) to users immediately (on the same day or at latest the next day). And while many of the people involved in horticultural production, handling, and marketing are women, most extension agents are men. A 1995
scientists were women, extension services and agricultural technologies could be made more appropriate to female farmers. The representation of women in these fields is

agents (also known as family resource or home advisors) may be better suited to working directly with women than are most agricultural agents, since their contacts with rural women have already been established.

Extension of Horticultural Information

Whenever extension efforts are undertaken in horticultural technology, it is important that the appropriate audience be targeted. For example, growers need to learn about fertilization rates, harvesters need to learn about maturity indices, while transport operators need information on temperature management during loading and shipping. In many regions of the world, poorly developed infrastructure hinders the movement of produce and market information. The lack of linkages between agencies or a lack of resources for extension work and agricultural education leaves handlers without basic knowledge regarding causes of losses and with a shortage of skills related to improved postharvest handling practices. Postharvest educational needs assessments undertaken in many countries point to a wide range of training requirements before local handlers are ready to make improvements in postharvest technology within their operations.

Extension workers worldwide have an opportunity to extend appropriate technology to a variety of clientele who can then use recommended practices to increase marketable

yields, reduce losses, maintain produce quality, and increase profits. The final decision of

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Part II. Extension Methods for Transferring Horticultural Technology

There is a great need for effective extension programming in horticultural technology to information useful to fresh-market horticultural crops growers and those involved in

Table 4. Examples of extension program objectives, extension messages and related research topics for extension programs

Postharvest activity	**Extension objective**	**Extension message**	**Related applied research topics**
Crop selection	Ensure that farmers grow crops appropriate to market conditions and demand.	with market potential.	Prices, quality, yields, returns, and marketing strategies.
Harvesting	Ensure that produce is harvested at the time or quality required by the market.	Correct time and quality level to harvest crops for marketing.	Adaptation of technology to meet time or market requirements.
Preparation for market	Maximize value to growers.	On-farm cleaning, trimming, and selection of produce for market.	Adaptation of technology to meet time or market requirements.
Grading	Allow pooling of output and collective marketing. Improve output quality.	Grading methods for horticultural products, advantages of selling graded produce.	Formulate and monitor standards for marketable produce.
Packaging	Maximize returns to producers and handlers by minimizing damage.	Demonstrate packaging products for transport, storage, and sales.	Adapt traditional packaging materials to crop and market requirements.
Transport	Ensure that produce reaches buyers without delay or loss.	Encourage improved handling and packaging	

primarily of horticultural growers, handlers and marketers within a specific county or region.

To plan any extension program, one must first identify a specific problem and then identify and understand the needs of the clientele being addressed. Sometimes the

produce shipping, marketing, and distribution industry is very heterogeneous and widespread, often including handlers at distant points in the same country or in more than one country. Farm workers or market intermediaries may be less well educated than average, or extension programs might target clientele who speak a language different

role and objectives and may be suspicious of any attempts to change their production or handling practices, techniques, or facilities. The reputation of extension work has been tarnished by poorly designed extension services that failed to serve their clientele. Indeed,

clientele, a program must first demonstrate that it can benefit them, most often economically.

Six steps to developing high-quality extension programs
After identifying and learning about the intended audience for the extension program, the following steps can be helpful.

Step 1. Identify the horticultural problems to be targeted and work with stakeholders (planners, funding agencies, cooperators, clientele) to determine their priorities. A traditional educational needs assessment or commodity systems assessment, undertaken with the participation of representatives of the intended audience, can help identify key production, postharvest and marketing problems. It is not possible to develop extension educational programs on all problems at one time. Determine which are the most important for a given audience and which can be realistically resolved by providing educational information on production or postharvest principles and/or practices.

Step 2. Develop the long- and short-range (1-year) objectives of the extension

described by a model developed by Bennett (1979): INPUTS and resources must be utilized to get the program started; ACTIVITIES are then implemented to INVOLVE people in programs; participants REACT to what they experience; which leads to CHANGES in KNOWLEDGE, SKILLS, ATTITUDES, or ASPIRATIONS; PRACTICE

Applied research studies in production practices often aim at improving market yield while maintaining profitability. Applied research studies in postharvest technology seek to identify the causes or magnitude of deterioration or losses and to develop and evaluate possible corrective measures. Adaptive research attempts to modify an existing technology to better fit the exact conditions in which it will be used in practice. While some research must be conducted in laboratories, and other research can be conducted in industry facilities, all research must use scientifically sound methods and procedures.

APPLIED POSTHARVEST RESEARCH

Answering the following questions can guide researchers as they plan and design postharvest studies. Researchers must describe the exact conditions of their original studies so that others can replicate the research.

Research Hypothesis

- Is the hypothesis conceptually clear, specific, and subject to empirical testing?
- Is the hypothesis related to a body of theory and a specific postharvest problem?

Objectives

- Are the research objectives clear, specific, and measurable?
- Does the problem statement encompass and agree with all the relevant facts, explanatory concepts, and relationships among the variables under study?
- How will learning the answers help to solve a postharvest problem?

Research Design

- How will you set up the study to observe the hypothesized relationship between variables?
- Have you accounted for intervening variables that might also affect the dependent variable?
- How will you measure or control threats to the internal validity and external validity of the study?
- What experimental controls will you use?

Subject Selection

- How will you select your produce samples for experimental studies? (Describe sample size, characteristics, sampling site, sampling method).
- Are the samples are an adequate representation of the whole population?

they can also be handled by telephone, through the mail, or even by FAX or e-mail and can involve individuals, companies, or other groups such as grower cooperatives.

As with most extension methods, the language and socioeconomic status of the extension

Temperature

Objectives: to demonstrate how temperature affects the rate of ripening, senescence and visual quality (decay, color changes) in fresh produce.

Materials: Select 8 kgs each of 6 or 7 different fruits and vegetables (papaya, avocado, tomatoes, green onions, spinach, chili peppers, eggplant, okra, green beans) of uniform maturity and quality. Randomly divide each product into four groups of 2 kg each and place each commodity into an open tray or basket. Weigh each sample and mark the initial weight on a label placed into the tray.

Set-up: 7 days prior to demonstration of the results, place selected products under controlled temperatures (0 C, 10 C and 20 C) and at ambient temperature (27 to 32C). Mark each label with the temperature at which that sample will be held. For tropical products such as papaya, eggplant, tomatoes or chili peppers, on the 5^{th} day, remove produce from 0 and 10C and leave them out at ambient conditions for the last 2 days. This will allow any chilling injury symptoms to develop in time for your demonstration.

3. Cost of labor	$_____	$_____
4. Cost of power	$_____	$_____
5. Other	$_____	$_____
Total direct costs	$_____	$_____

Benefits

Base these figures on expected yield, quality, amount of produce at various grades, and predicted market prices. Use either wholesale or retail prices or a combination if you will sell both ways.

	Current practice	**New practice**
1. Expected sales (wholesale)		
Highest grade	$_____	$_____
Second grade	$_____	$_____
Lowest grade	$_____	$_____
Subtotal: Sales (wholesale)	$_____	$_____
2. Expected sales (retail)		
Highest grade	$_____	$_____
Second grade	$_____	$_____
Lowest grade	$_____	$_____
Subtotal: Sales (retail)	$_____	$_____
3. Total Expected Sales	$_____	$_____

4. Comparative Advantage		
(Total Sales - Total direct Costs)	**Current practice**	**New practice**
Which practice is most profitable?	$_____	$_____

Part 4: Recovery of Invested Capital (ROIC)

How long will it take to pay for your investment in the new practice or technology?

1. Actual capital outlay for new practice = $_____

Figure 3b. Cost/Benefit Worksheet

Assume that you harvest 1000 kg of the commodity.

Research has shown that there is a strong correlation between the characteristics of an innovation and its rate of adoption (Rogers 1995). Table 5 lists the characteristics that are known to be important. Horticultural technologies that have these characteristics can be demonstrated successfully in extension programs.

Table 5. Characteristics of an innovation that enhance adoption

Characteristic	Comments
Relative advantage	Does the innovation enable the client to achieve his goals better or at lower cost than he could previously? Horticultural technology that is clearly cost-effective will be of most interest to potential users.
Compatibility	Is the innovation compatible with socio-cultural values and beliefs, with technology must not cause more problems than it solves.
Complexity	Can the innovation be adopted without complex knowledge or skills? If the technology is difficult to understand or use, clients will be less likely to want to try it for themselves.
Trialability	Can the client try the innovation on a small scale on his own before making the decision on whether to make large-scale changes in practices? If a large investment is required before the user can see any results, the new technology will remain a training exercise.
Observability	Can the client see the effects of changes made by others when they adopted the innovation?

Source: Rogers 1995; Van den Ban and Hawkins 1996.

Short courses

Tour in the early spring, during which participants visit harvest, packing, shipping, and warehousing operations throughout south and central Florida.

A tour can be an effective way to introduce a new subject to an audience. Providing a brief outline of what participants might expect to see can help them to focus their observations. Figure 4 is an observation schedule used by short course participants to organize their notes on observations and interview results. This example was used during tours of organic produce growers, shippers, and marketers in northern California. Industry cooperation is essential for a successful tour, since participants will have many questions and will appreciate the opportunity for direct interaction with the owners or managers of the site.

Figure 4. Interview and observation schedule for postharvest tours

SMALL SCALE POSTHARVEST HANDLING OF ORGANIC HORTICULTURAL CROPS
INTERVIEWS AND OBSERVATIONS

Site_____
Date_____
Commodity_____

Use the following outline to take notes as you ask questions about the commodity system during field visits and market tours.

Production Management
- Choice of cultivars
- Cultural practices
- Field sanitation

Harvest Practices
- Maturity indices
- Containers/tools
- Handling methods

Preparation for Marketing
- Sorting/grading
- Sanitation
- Quality control practices
- Pest management

Packaging/Shipping Containers
- Packing methods
- Packaging materials

Cooling/ Temperature Management
- Cooling methods
- Temperature/RH control

Brief, single-subject guides. This type of publication addresses a single specific subject or development in a direct, simple style. The UC Postharvest Technology Research and Information Center *Produce Fact Sheets* are examples, where information is provided regarding recommendations for maintaining postharvest quality of an individual commodity (fig. 5).

Progress reports. These publications extend current information on ongoing projects to cooperators, research sponsors, industry personnel, and others. An example might be results of a just-completed preliminary study on the effects of a questionable, presently used industry practice. They are usually brief reports, no more than a few pages long. Their main advantages are timeliness, brevity, and directness, and they keep interested persons informed about ongoing results.

Newsletters and quarterlies. These periodical publications extend information to broad audiences on a regular basis, typically four to six times a year. A good newsletter is an effective route for extension of brief, pertinent reports and articles to the postharvest industry and to fellow extension and research workers. The University of Florida postharvest newsletters for industry, *Packinghouse Newsletter* and *Handling Florida Vegetables*, is another effective newsletter. The horticultural industry also has its own newsletters, mostly intended for internal communication.

Trade publications. Articles in trade magazines and newspapers are most effective for extending information to industry handlers, who read them regularly. Magazines and bulletins produced by grower-shipper associations include *The Western Grower and Shipper*, published by the Western Growers Association; the monthly *PMA Bulletin*, published by the Produce Marketing Association; and *Fresh Outlook*, published quarterly by the United Fresh Fruit and Vegetable Association. The weekly newspapers of the fresh produce industry, *The Packer* and *Produce News*, are also included in this group. Articles by extension workers in trade publications extend information to a broad audience that may otherwise be hard to reach. These trade associations and their publications can be

very effective media for extending postharvest information. Several postharvest extension specialists have regularly published columns in these types of publications.

Visual media. Videotapes and CD-ROM programs are becoming increasingly popular methods of extension as costs of production decline and computer technology makes production and editing feasible on a small scale. The United Nations Food and Agriculture Organization (UN FAO) has a website (http://www.fao.org/inpho) which offers access to a library of horticultural documents in several languages. The University of California markets a wide selection of slide sets and videos related to recommended production and postharvest handling practices. Examples include the slide set

agent. CSAM can help build links between agencies and individuals, close information gaps, and help people solve problems while focusing on usable postharvest technology.

Sample CSAM Questions. Table 6 is a list of system components and sample questions for investigating the commodity system. The team begins by considering these questions in relation to any commodity of interest, and then adds any other information that is

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Extension program development

Horticultural extension work requires knowledge and skill in planning, implementing, and evaluating educational programs. Extension workers need to use creativity and initiative in program approaches, teaching techniques, and extension methods. They also must be highly self-motivated and must seek to involve clientele throughout. Using informal and formal needs assessments, extension workers must seek out production and postharvest handling problems and the groups that face them. Including clientele in this first stage of program planning is essential, since farmers and industry handlers generally will not reveal their problems until extension agents gain their confidence. Encouraging active participation during programs helps people gain maximum value from educational opportunities and increases the likelihood that clientele will provide constructive feedback. For readers interested in more information on this topic, a variety of references related to extension program development are listed at the end of this manual.

Staying current. Extension workers should continue to take courses and short courses in horticultural technology when possible and use sabbatical leaves to advance their capabilities. They must be familiar with modern research techniques, production practices, postharvest equipment, and instrumentation. New postharvest technologies such as smart films and ethylene-absorbing films for packaging are on the horizon, and it

- **Summary of the proposal:** Who are you, whom do you represent, what is your

  you want to offer, how much money are you requesting, and what will the major

Extension workers who are interested in developing new informal teaching skills or in reading about the successful methods of others can find information in the *Journal of Extension*
HortTechnology. Recent articles have dealt with the topics of on-farm demonstration, small-group learning activities, task analysis, and using computers in extension programs. An enormous amount of published and unpublished information on informal teaching methods is available in most educational libraries in the form of microfiche (ERIC documents).

An entire field is dedicated to agricultural communication, including non-technical writing for newsletters, extension manuals, fact sheets, and multimedia. Some of the most recent literature on agricultural communication is available via the University of Illinois at Champaign-Urbana and the Illinois Cooperative Extension Service. Back issues of this publication and a bibliography of literature on extension methods can be accessed free of charge via the Internet (http://www.ag.uiuc.edu). The Department of Agricultural Education at the Ohio State University publishes the quarterly newsletter *Agricultural Communication* that offers updates on extension methods, writing techniques, and multimedia productions. The editors also review books and short courses dealing with professional skill development.

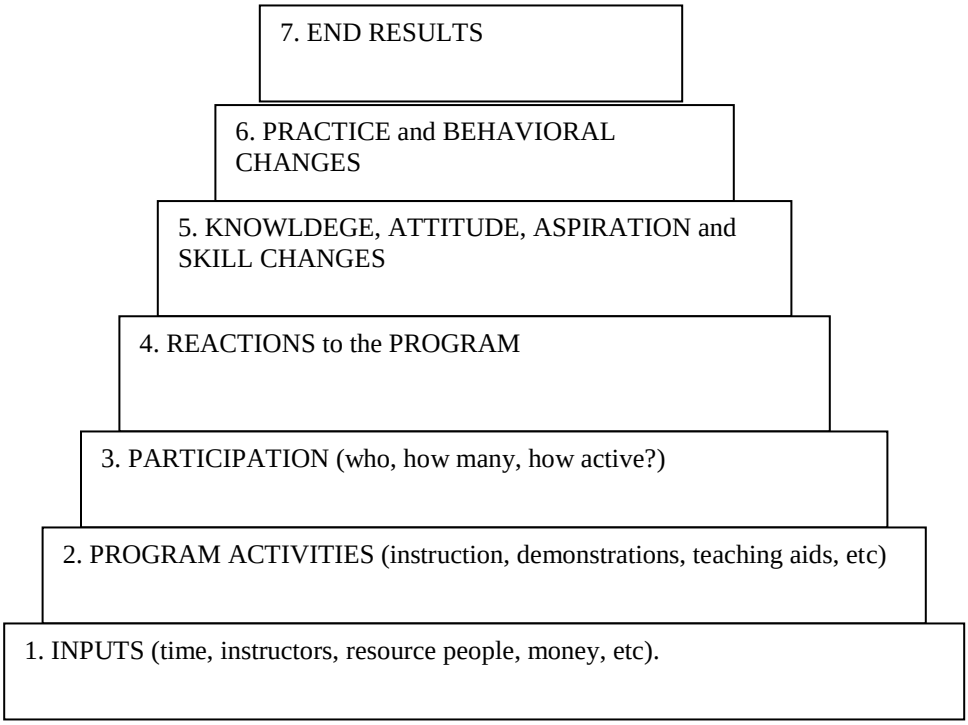
Marketing extension programs. Even the best horticultural extension programs will be

programs requires planning ahead, developing high-quality promotional materials, and getting the word out via direct mail, posters or brochures, word-of-mouth, or the Internet.

for postharvest extension programs in table 7. Similar to quality program planning, where the needs of the clientele determine the objectives of the extension effort, the more an

	information is being offered to clientele?
Place	How and where will the program be delivered to growers, shippers and/or marketers?
Promotion	How will the planned target audience be informed about the program

Figure 6. Program theory of action/evaluation hierarchy.
(Adapted from Bennett 1979; Patton 1986)



Many resources are available to those interested in learning how to perform well-designed program evaluations. Several useful references are the books by Patton (1982; 1986) and Rossi and Freeman (1985) on program evaluation practices, and the journal *Evaluation and Program Planning*.

Planning an extension program evaluation

An evaluation of the results of the horticultural extension program can help generate ideas for improving the program. When planning an evaluation, consider the following steps (see Kitinoja 1992).

Step 1. Identify and describe the extension program.

- What are the objectives of the program?
- Where and when will it be held, and who will be involved?

Step 2. Purpose of the evaluation.

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- Develop a timeline and estimate the time needed for each phase of the evaluation (planning, stakeholder input, design and testing of data collection instruments, data collection, data analyses, stakeholder feedback, reporting).

Step 8. Gather evidence (collect data).

- Who will collect data, and when will collection begin and conclude?

Step 9. Analyze, summarize, interpret, and draw implications.

- What analysis methods will you use?
- How will you seek assistance in determining what the results mean or their implications for the program?

Step 10. Report results.

- Describe the outcomes of steps 1 through 9.
- Who will receive the report(s)?
- When will the report be completed?

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