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A Guide for the

Postharvest Handling of Fresh Flowers

to Extend Their Useful Life

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PART I

The postharvest handling of cut flowers will be discussed in detail in this and the following two issues of the "Illinois State Florists' Association Bulletin." These presentations will differ from those in many other published reports and books on the subject in that specific recommendations are made. We are aware that there is no general concensus on proper flower handling, yet feel that postharvest losses can be significantly reduced if certain procedures are followed.

This series will consist of three parts: PART I—Introduction to Postharvest Handling, Temperature, and Relative Humidity; PART II—Proper Storage Procedures, Sanitation, Preservatives, and Water Quality; and PART III—Ethylene, How to Evaluate a New Product, the Systems Approach to Solving Postharvest Losses, and Specific Recommendations for Various Cut Flowers.

Before you begin reading the discussions that follow, one important point should be made: *Education of your employees is essential.* Everyone in your establishment must understand the importance of proper postharvest care, but even more importantly, how to accomplish it. This won't happen overnight, but only through a commitment to do a better job. Formal discussions with your employees about postharvest care, coupled with actual involvement in the various procedures, will help reduce your floral losses.

Introduction to Postharvest Concerns

'Vaselife' is a vague term with different connotations from one person to the next. But to the ultimate consumer, the most important member of the floral marketing channel, vaselife is the length of time that elapses from when he or she buys a floral product to when it is discarded. If some of the roses purchased didn't open, if the gerberas start drooping a few hours after the arrangement is received, or if the snapdragons keep dropping florets, the consumer is going to decide that these flowers had little or no vaselife. However, this person will often voice no complaint to you. Instead, the purchaser may buy a different kind of gift next time, or find something less fragile and transitory to decorate the dining table. This is lost future business because consumers are intelligent enough to recognize a poor return on investment when they experience one.

As florists, we are professionals and the quality of flowers that we send out from our shops should be as good as the artistic designs in which we use them. In this series, handling procedures are presented that will help reduce consumer dissatisfaction and increase repeat sales.

Unfortunately, members of the florist industry spend a great deal of time placing the responsibility for quality on everybody else in the handling chain but themselves. If we consider all of the handling steps for

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POSTHARVEST HANDLING OF FRESH FLOWERS

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cut flowers, it is obvious why no one should accept full responsibility. Growers harvest, grade, box, precool, and store flowers for short periods, then deliver them to a shipper. The shipper may temporarily store flowers before loading them for transport. The flowers are then received by the wholesaler, stored, placed into orders, and finally loaded onto trucks for delivery to retailers. Retailers recut the stems, place the flowers into solutions and put them into storage, then work them into arrangements and deliver to customers. As you can readily see, at least fifteen or twenty handling procedures are involved.

Because flowers go through so many handling phases before the retailer receives them, much can go wrong that will reduce quality. Because the public deals only with the retail florist, however, a customer who is dissatisfied with a flower purchase will likely blame only the retailer for the lack of good quality. Therefore, the retailer must take as much control as possible over the proper care and handling of fresh flowers and foliages.

What Determines Postharvest Life?

The postharvest life of flowers (and foliages) begins when they are cut from the stock plants by the grower. Postharvest life includes the storage life of the flowers (the time period from cutting until they are sold to the ultimate consumer) *plus* the vaselife (the time elapsing from sale of the flowers until the consumer throws them away). Two major components determine postharvest life or quality: *genetic makeup*, and *environment*. The genetic factor should be understood, but generally this component can't be altered. On the other hand, the environment can be controlled and manipulated to help maintain cut flower quality.

Genetic considerations. The genes or genetic background of a particular variety determines the inherent postharvest life of its flowers—or their potential to last. Some kinds of flowers tend to stay in good condition longer than others, even if handled exactly the same. The genes of a particular species determine its internal biological processes that relate to postharvest life; e.g., chrysanthemums usually have a longer useful life than roses or carnations. But even within a given species, postharvest life can vary greatly. As an example, the 'Forever Yours' rose, once popular with florists, has a rather poor postharvest life. Not only was its vaselife short, but many times the blooms didn't even make it through the storage phase. Compare 'Forever Yours,' however, with the variety 'Samantha' which is now gaining in popularity. Not only does 'Samantha' store and ship well, but also performs excellently for the customer, opening fully and maintaining a true red color.

Breeders are not entirely at fault for these problems of lasting quality. Among the priorities set for flower breeding programs have been improved production, disease resistance, better flower and stem characteristics, and improved flower color. Postharvest quality may be considered, but seems to have a rather low priority. Then also ask yourself this question: Would a grower want to grow a variety that produced only half as many blooms per square foot as another, just because its blooms lasted 3 days longer?

Characteristics of individual varieties such as vaselife, opening qualities, and color durability can be measured and observed. These differences between varieties, however, are not well enough known because wholesalers and retailers often don't know the actual names of the flower varieties they are buying or selling. This is not to say that growers are keeping the flower names a secret, but they sometimes fail to label what they sell. Also, when wholesalers and retailers order flowers, they may order by color, size, or stem length—with too little regard for how well the red rose, the white carnation, or the yellow tulip will last after it is cut. The fruit and vegetable industries are far ahead of the floral industry when it comes to knowing the differences between cultivars (varieties). Even most consumers are well aware of the differences between a 'Red Delicious' and a 'Jonathan' apple.

The solution to this dilemma involves four steps. First, retailers must learn the differences between flower varieties available to them. Read professional journals, magazines, and catalogs to gain information on new varieties. Second, use posters, pictures, and labels around the shop to drive home the point about knowing different varieties. Third, monitor and record information on specific varieties, and don't depend on others to tell you. In other words, make your own observations, tests, and records. Finally, demand correctly labeled flowers from the grower and/or wholesaler. If enough pressure is applied, they'll be forced to do it.

Environmental factors. Even if a flower has been bred for extended postharvest life, flower quality will be reduced if its surrounding environment is below the optimum. Although a great deal of research has been devoted to standardizing storage and handling practices from the grower to the retailer, our industry hasn't always responded quickly to these research findings. Considering the great distances flowers often travel, and the diverse group of growers and shippers involved, standardization is a good idea—but difficult to implement.

There are two important points that need to be made regarding the environment in which flowers are placed. First, as the environment changes, biological reactions within the flower also change. For example, as the temperature rises, reactions increase that reduce postharvest life. Second, we have to accept the fact that ideal environmental control is difficult to achieve because of the number of handlers involved

and the equipment required, and because of our lack of detailed and up-to-date information on the proper handling of specific varieties.

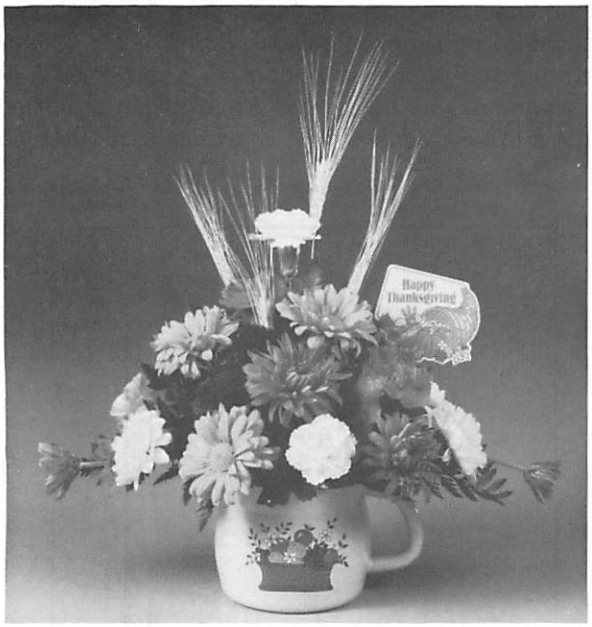
How can the retailer know if handlers ahead of him in the marketing channel have done their job? First, start by reading this series of articles in which specific points related to proper handling will be presented. Furthermore, these points can be discussed with the people who handle your product. If they don't want to discuss these subjects or if they cannot give you straight answers, look for suppliers who are truly serious about their handling practices. Remember that suppliers who are really concerned about their own handling procedures are probably buying crops from other suppliers who are also concerned.

Following are two (of many) pertinent topics you might want to discuss with your supplier:

1. *Are the flowers precooled before shipment?* Precooling is simply the rapid removal of heat from a crop before it is stored or transported. If the flowers are greenhouse grown, then the greenhouse heat must be removed prior to storage. This problem is complicated when boxes are packed and then stacked improperly, making it difficult to rapidly remove heat from the boxes. Boxes used for precooling can easily be identified by the holes or flaps at each end. If the seals on the flaps are not broken, then the flowers probably were not precooled. There's little question about it—precooled flowers will last longer, and growers who do precool are concerned about quality. They often "sell" this point by so labeling their shipping boxes.

2. *Do you handle your flowers dry or wet?* Research has shown that many flower crops have a better postharvest life if they are handled dry (i.e., never placed in water until received by the retailer), rather than wet (moved in and out of water and/or preservative as they move along the marketing channel). Roses and carnations are two such crops. Unfortunately, no very definite statements can be made at this time specifying which crops should be handled dry or wet. However, your suppliers should know about, and have experience with, these practices and also should be investigating this factor for you. Flowers handled dry should be so labeled. In some cases, especially around holiday time, larger quantities of flowers are received, so dry handling can give you more cooler room and, at the same time, help improve cut flower keeping quality for the consumer.

Once you know about the flowers you are buying and how your suppliers are handling them, it is up to you, the retailer, to take control of their postharvest life. As you read through these discussions, mark sections that should be points of discussion with both your suppliers and your employees.



A bountiful harvest of colorful fall flowers displayed in the Autumn Harvest Bouquet is FTD's nationally advertised product for Thanksgiving. Designed as a centerpiece, the Autumn Harvest Bouquet features red mini carnations, yellow cushion pompons, light bronzy daisy pompons, bronze cushion pompons & buds, yellow mini carnations & leatherleaf, accented with oak leaves & stalks of natural wheat. The flowers are arranged in an FTD exclusive enamel-coated pitcher, decorated with a colorful autumn fruit basket design. It can be used to serve hot or cold syrup, sauces or gravy once the flowers have been removed.

Managing Temperature and Relative Humidity in the Cooler

Some points you should understand include:

1. How temperature and relative humidity affect flower quality.
2. How to effectively cool the refrigerator.
3. How to maintain adequate humidity in the refrigerator.
4. How to properly monitor cooling temperatures and relative humidity.

Flowers and foliages spend most of their postharvest lives in the retail shop refrigerator. After investing in a refrigeration unit and in hundreds of dollars worth of fresh flowers and foliage material, it only makes good sense to understand how to use refrigeration to the best advantage. Proper temperature control is important, but humidity control is equally so. Both can be adjusted to maximize the vase life of florist products. The purpose of cooling is to slow down the flowers' metabolic processes, particularly *respiration* (use of carbohydrates) and their *transpiration* (loss of water through pores, known as stomates, in the leaves and flowers). In addition, flowers produce ethylene, the "old-age hormone," at reduced rates when stored at low temperatures. Flowers are also less sensitive to ethylene when temperatures are kept low.

Limiting respiration. Respiration is the process that uses sugars within the plant to create energy for flower maintenance. Refrigeration slows down respiration, thus reducing the use of sugars. At warmer

temperatures, respiration will proceed at a faster rate and sugar may need to be added (it is the basic ingredient in so-called floral preservatives). Generally speaking, the faster respiration takes place, the more quickly flowers will deteriorate.

Each time the storage temperature increases by 18°F, the metabolic processes approximately double in rate. Thus, flowers stored at 50°F will use up their internal carbohydrate and water supplies twice as fast as flowers stored at 32°F. The faster these supplies are depleted, the shorter the vaselife will be. It is commonly misunderstood that flowers will freeze at temperatures at or near 32°F. However, the water held inside flowers and leaves is not pure water. The various components dissolved in the water lower its freezing point, so storing many flowers at temperatures close to 32°C will not damage them.

It is true that some crops will suffer chilling damage at temperatures below 45°F. However, the majority of common flower crops will store quite well at temperatures as close to 32° as possible. Your supplier, as well as readily available educational materials, should help you identify proper storage temperatures for various crops. It is true, however, that all too little specific information is available on specific varieties within a species.

Two additional advantages of maintaining lower temperatures are limiting the growth of microorganisms, to be discussed in a later section, and reducing ethylene production. At low temperatures, microorganisms are much less active than at higher temperature levels. This means that the damage fungi and bacteria can cause is effectively reduced. Microorganisms can make your products unusable by making them unsightly or by causing them to age quickly. Did you know that some organisms that are present on cooler walls or on decaying plant materials can produce ethylene? And ethylene production, like microorganism growth, is temperature dependent. The more efficient your cooler is, and the closer you keep it set to the proper product temperature, the less ethylene will be produced. In addition, reducing the cooler temperature will also slow ethylene's action, if this gas is present.

Monitoring temperature. With your present refrigerator, or after purchasing a new one, it is important to monitor the temperatures within the unit. This requires a reliable thermometer, correctly placed in the cooler. Do not rely solely on the thermostat setting!

Use an alcohol thermometer, rather than the mercury type. It is too easy for a mercury thermometer to be broken, which can cause toxicity problems for both flowers and employees. If alcohol thermometers are broken, the alcohol will not be toxic. And as an added benefit, the alcohol is usually colored red or blue, making it much easier to read than the silver-colored mercury. In some cases, mercury thermometers must be used, but if so, be sure that they are securely mounted and shielded.

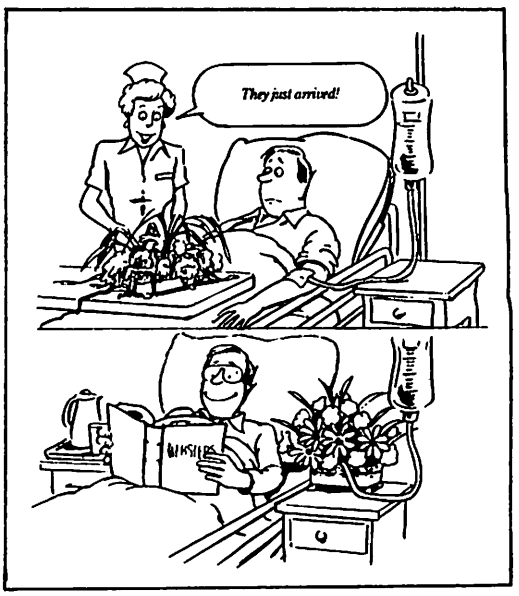
Do not use a thermometer of the type where the glass tube is mounted on a plate of some kind. If the temperature scale is printed on the plate and the tube slips out of place in the mounting, the temperature reading will be inaccurate. Ideally, the temperature scale should be embossed on the glass thermometer tube itself.

Be certain your thermometer is properly calibrated. Its accuracy should be determined regularly by placing the bulb end into a container of ice and water. After several minutes, the thermometer should read exactly 32°F. If it doesn't, make note of the deviation; or better still, buy a new one that is accurate.

The so-called maximum/minimum thermometers are also useful. These thermometers will tell you the highest and lowest temperatures that occurred in the refrigerator since the last time you checked. It is an investment that will give you information about temperature variations in your cooler, and may provide some clues as to why certain problems occurred.

Proper placement of the thermometer in the refrigerator really means mounting it at the height where flowers are stored. It does no good to read the temperature on the wall, or up on a shelf where no flowers are stored. Equally bad would be to mount the thermometer next to the cooling coils. Temperatures can deviate greatly throughout the cooler, so it is worthwhile to use several thermometers at the various heights that flowers are stored.

It is a good idea to place the thermometers in jars or flasks of water. Keeping them in water helps to buffer against small deviations in temperature that may occur when you open the door while taking a temperature reading. And if there are temperature variations in different parts of your cooler, this situation can sometimes be used to your advantage. For example, foliages and



AFMC RESEARCH FINDING NO. 6: Consumers feel their floral purchases aren't always as fresh as they should be.

tropical flowers can be placed in the warmer spots, while other flowers could be kept in the colder areas. Many coolers also have "cold pockets," and these are good places for flowers handled dry or boxed.

After purchasing reliable thermometers and staging them in the approximate areas where flowers are stored in the refrigerator, temperatures should be monitored and recorded at least daily. A situation all too often encountered, however, is that they are seldom looked at again until the unit breaks down. Select one key employee to check the thermometers on a regular basis and keep a record of these readings. Problems will be detected when they first occur and you will have written documentation of the temperature variations in case you need to have repairs made. This recording of temperatures also makes it clear to employees that proper temperature maintenance is important and that you are willing to designate an employee to be your "postharvest specialist."

Keep the cool air in. Once your refrigerator is at the proper temperature level(s), it is important to retain the cool air within the cooler. This is best accomplished by organizing activities and also by using barriers that reduce the loss of cooled air. The easiest means of maintaining proper-level temperatures is to analyze how you do things. How many times an hour does someone walk in and out of the refrigerator? Is one person responsible for stocking all of your designers with flowers and greens? These are just two questions that should be examined. Having a single person responsible for delivering stock to all your designers is especially important if you have an undersized cooling system. Such a cooler cannot cool a product rapidly once it is warmed up. And if you have two coolers, take advantage of this situation by using one for products that are used routinely, while the other is used for products stored for longer periods.

Understandably, most florist coolers must be entered on a regular basis. Using plastic barriers over the doors may help keep cool air in, but this barrier must not interfere with flower handling. For example, delicate arrangements might be damaged by being brushed against the plastic sheet unless proper precautions are taken.

The bottom line is that for most flower crops, temperatures between 32° and 35°F are ideal for maintaining optimum vaselife because their development and senescence are greatly slowed down while under refrigeration. Optimum temperatures for most foliages are between 40° and 45°F, while tropical flowers should be maintained between 45° and 50°F. Specific crop recommendations will be presented later in this series.

Selecting a refrigerator. It is not our intent to recommend types or brands of refrigerators, but rather to identify questions that should concern you. Temperature obviously can and must be adequately controlled. First, a good reliable refrigeration unit should be selected. Because the vaselife quality of your flowers depends upon how well they are stored, it certainly doesn't pay to skimp on a refrigerator. More money will be lost because of breakdowns or improper temperature maintenance than will be saved by purchasing a cheap unit. Several reliable companies manufacture coolers especially designed for florists, including many good display units.

First of all, a floral refrigeration unit should be designed specifically for the storage of floral products. Such units are widely available with reliable temperature and relative humidity controls. Second, the cooler should be very well insulated, both for efficient operation and for uniform temperatures. A third point is that the cooler should possess enough cooling capacity to handle maximum heat loads (e.g., at Mother's Day). Many companies submit bids based only on heat units produced by stored flowers and foliage that need to be removed from the cooler. This is a mistake to avoid. The company must depend on you to provide all information that should be plugged into a formula for determining cooling compressor size. Your new refrigerator should be designed to accommodate periods of maximum use, and take into account how often the doors are opened, the number of internal lights that are usually turned on, and other factors. Adding more cooling power will increase the cost, but based on a percentage of the total purchase, won't be unduly great. Remember that there is no "universal" cooler that answers everyone's needs; each operation is different.

A fourth point to consider is that the refrigerator should control temperature without much fluctuation (i.e., no more than 1 degree above or below the thermostat setting). Some older coolers don't have controls that are this exact; in fact, many have variations of as much as 5°F. If this is the case, then you must run your refrigerator warmer—let's say at 38°F—so that temperatures never go below 33°. This means, of course, that the temperature will go to 43° (5 degrees higher than 38°) before the cooler turns on again.

Fifth, be sure to include a self-closing door to eliminate the loss of cold air when the door is accidentally left ajar. A sixth consideration: Include an electric defrost cycle so that ice doesn't build up on the coils. Iced-up coils reduce the efficiency of the refrigerator drastically. A final point to keep in mind is the temperature differential between the cooling coils and that of the cooler interior. This differential should be 5 degrees or less, ensuring that the normal operation of your cooler won't remove large amounts of water vapor from the air inside.

High relative humidity also crucial. Thus far we have centered our discussion on management of temperature in the cooler—and this is *the* factor upon which most people focus their concerns. However, it is essential to remember that maintaining high relative humidity is just as important if you want your flowers to have the longest possible vaselife.

Relative humidity is defined as the amount of water vapor in the air, compared to the total amount of water vapor the air can hold at that *same temperature*. This means that as the temperature changes, so does the relative humidity. Several postharvest manuals go into great detail explaining how these factors interact, but let it suffice to say here that for most crops we want to have a relative humidity of 85% to 90% or greater in the cooler.

Concern over relative humidity involves several points. First, water within the flower and its foliage is essential to maintain turgidity and to promote chemical reactions that prolong flower life. In some instances, dehydrated flowers can be revived by placing them into the proper solution (to be discussed later), but chances are that the vaselife will be reduced. Remember, too, that dry flower handling requires a high relative humidity in storage if vaselife is not to be reduced.

A second concern about relative humidity arises from the mechanics of refrigeration. Refrigerators cool air by condensing water from the air onto supercooled coils. The water the coils take out of the air within your cooler is, in actuality, the moisture necessary to maintain a high relative humidity condition. This process cannot be stopped, but it can be minimized. New floral coolers have been designed with coolant systems that don't remove as much water vapor. This is another reason why a refrigerator purchase shouldn't necessarily be made with the lowest bidder—but with the lowest bidder who is familiar with floral coolers and offers models that meet your cooler requirements.

It is important to remember that plants, as well as refrigerators, are dynamic, changing systems. Refrigerators, as discussed above, remove water vapor from the air in normal operation. Floral products also inherently use water to help transport nutrients and to cool the product. Gases, including water vapor, move from a region of higher concentration to one of lower concentration. The internal environment of a flower possesses a relative humidity close to 100%. However, the relative humidity around the flower in a cooler is generally well below this level. Consequently, water moves out of the flower, trying to reach a balance with the outside air. If the relative humidity in the cooler is very low, water loss can be so severe that the flower will wilt and not recover.

Therefore, temperatures in the cooler should be kept low and the relative humidity of the air high in order to prevent the water from moving out of the flower and leaves. Excess water loss may not only cause wilting, but also discoloration, failure of the flower to open, and an acceleration of senescence. If flowers are stored dry (i.e., out of water), it is essential that the relative humidity be kept high, for once those flowers lose water, they have no means of replenishing the supply.

Raising and monitoring relative humidity. The point has already been made that flowers need to be maintained at a high relative humidity, but that normal cooler operation tends to reduce the relative humidity.

Refrigerators should be kept at relative humidities of 85% or higher. Cooler humidity is determined by the difference in temperature of the cooling coils and the temperature of the air inside the cooler. This is called the "temperature differential" (TD). The smaller the TD, the less the reduction in relative humidity. Ideally, the coil temperature should be no more than 3 degrees less than the desired cooler temperature. This type of unit is available from companies specializing in floral cooler design and production.

If your existing cooler cannot maintain an adequate relative humidity level, then water vapor must be added. There is only one acceptable method for accomplishing this: a commercial humidifier. These are simple to install and prices start as low as $250. These units should include a humidistat for humidity control. Wetting floors and periodically using a mist bottle do not make good sense when we consider that coolers remove water vapor on a constant basis, while these methods supply only periodic or sporadic additions of moisture. The key factor is to provide a *constant* supply of water vapor.

Once the cooler is properly adjusted, relative humidity should be monitored and recorded as often as the temperature levels. The instrument usually used to measure relative humidity is called a "sling psychrometer." It consists of a "wet bulb" and a "dry bulb" thermometer which are mounted close together. The psychrometer is swung rapidly in the air inside the cooler for several minutes. The differences in temperature between the two thermometers is then used to determine relative humidity on a phychrometric scale provided with the instrument. The reading is easy to take and interpret. Note that psychrometers come in both manual and electronic models. They should be as common as thermometers in every floral establishment. Just as temperature is monitored daily, so should relative humidity be checked daily. Again, appoint an employee to make and record the relative humidity in your cooler(s) each day, and it should be his duty also to notify the manager of any serious deviations.

There is a simple quick-test for checking on relative humidity—but, it should *not* replace the purchase of a reliable psychrometer. Simply wet a paper towel and suspend it on a wire in your cooler. If the towel dries out rather rapidly, then you have a tell-tale clue that the relative humidity is quite low. If the towel, however, is still moist after it has been left in the cooler overnight, you have an indication that the relative humidity in the cooler is not excessively low.

It's Up to You!

Flowers and foliages are complex plant systems and their reactions are controlled by their genetic makeup and by the environment into which they are placed. The surrounding environment is comprised of many factors, of which temperature and relative humidity are of prime interest. Having the right equipment and using it properly are required if a postharvest program is to be successful. Having one person responsible for

postharvest monitoring is essential. Be sure to give this person ample time to accomplish the necessary checking.

It is the dream of every researcher, florist, and salesperson to come up with "the" magic chemical to maintain flowers in usable condition for a period of time never before possible. Someday this may happen, but until that time, environmental regulation is the key to maintaining flower quality. Only with a dedicated commitment to education about, and implementation of, proper environmental control methods for cut flowers and foliages will quality be maintained along the whole production/marketing chain.

In our next article, a checklist will be presented to help you evaluate whether or not you now have an adequate postharvest program—or whether you just enjoy reading about the subject, but don't get around to doing anything about it in your own operation.