PROCEEDINGS OF
NATIONAL FLORICULTURAL CONFERENCE
on COMMODITY HANDLING

68620

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</tbody>
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Preface

This publication contains cultural and economic information on the post-harvest handling of floral crops including fresh (cut) flowers, foliage plants, and flowering plants. It was prepared for the 1976 "National Floricultural Conference on Commodity Handling" sponsored by The Ohio State University. Both this publication and the conference were direct results of information obtained by the floriculture faculty in the Department of Horticulture at The Ohio State University. The purpose was to inform producers, wholesalers, and retailers of floral crops, on proper post-harvest handling techniques as well as the economic impacts of adopting such techniques. The information contained is neither inclusive nor technical in nature, but contains useful messages believed to be essential for improving product quality, profits and consumer satisfaction. References for any of the information presented can be obtained from the senior author.
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PRODUCT LOSS

Introduction

Extreme perishability of floral crops has resulted in a history of substantial losses from unsalable and reduced value commodity during the harvest and post-harvest activities. These market losses have perpetuated despite efforts to improve the speed and sophistication of the transportation system utilized by the industry. Many technological improvements that have the potential of reducing loss and maintaining quality during production, harvest, handling, storage, wholesaling, retailing, and utilization have been avoided by the industry. These pre-harvest, harvest, and post-parvest technologies will be explored in subsequent sections. The purpose here is to explore the industry and consumer costs of the market losses in floriculture as well as the consequences of our industry's failure to reduce these losses and improve its productive capacity.

APPROXIMATELY 20 PERCENT OF ALL FLORAL CROPS ARE UNSALABLE DUE TO IMPROPER HANDLING.

Shrinkage

The floricultural industry has had a record of substantial losses from unsalable product due to damage during harvest, handling, transportation, and storage. Quantification of the exact magnitude of these losses has been hidden in poor records as well as a complex marketing system with diversity of firms and products. Some firms have assumed these losses to be nonexistent while others have assumed them to be very high resulting in corresponding price adjustments.

Shrinkage reduces the productive capacity of the floral industry. The term yield is an approximation of this productive capacity. The term by itself is much too vague to be meaningful because it does not reflect at what point in the marketing system that it is measured. The term becomes more meaningful when subdivided into (1) potential yield, (2) marketable yield, and (3) consumer yield.

The potential yield is the total amount of floral crops being produced where the marketable yield reflects the adjustment for product that was never harvested or removed from the production area. Marketable yield is a good measure of the productive capacity of the industry because it represents that part of the crop available to be marketed. Consumer yield is that which is available to the consumer for utilization for a reasonable period of time. The difference between the consumer yield and marketable yield is referred to as waste or shrinkage and is the subject upon which this report is focused.

Through informal and formal surveys, it is estimated that the shrinkage factor for the floral industry approximates 20%. This does not include the 5% (or even 10% for some crops and producers) difference between the potential yield and marketable yield. The 20% post-harvest
shrinkage includes the unsalable product and the reduced value product as well as the product that is damaged during marketing resulting in less effective or shorter consumer utilization. In many cases the consumer does not perceive that the product was damaged but visualizes the product to be old or just not long-lasting.

IMPROPER PRODUCT HANDLING BY THE ENTIRE INDUSTRY IS TO BLAME FOR SUBSTANTIAL POST-HARVEST SHRINKAGE.

Sources

The post-harvest handling encompasses all procedures and environments involving the harvesting and handling of floral crops from producer to and including the consumer. Consequently, the entire industry is to blame for the improper handling of floral crops, the primary causal factor in creating a 20% shrinkage. While this level of shrinkage does not approach the over 40% post-harvest losses of many other horticultural commodities such as strawberries and potatoes, it has a more significant impact on the industry because of the lack of alternative market outlets for the reduced value or damaged product. For example, fresh market apples is a primary market and cider apples is an alternative or secondary market. The floral industry must absorb the shrinkage and pass the entire loss on to the ultimate consumer.

It will become evident if it already hasn't that growers, shippers, wholesalers, and retailers of all types are the cause of product shrinkage and play important roles in reducing it. Retailers must not only assure the consumer of a quality product that lasts a reasonable period of time but must also educate and inform them on in-home usage. Too often retailers are incapable of performing these functions.

RETAILERS SHOULD HAVE CONTROL OVER PRODUCT HANDLING PRIOR TO RECEIPT.

While retailers carry much of the blame, they have little control over the type or kind of product they receive or how it was handled during harvesting, shipping, and wholesaling. Again, too often growers, shippers, and wholesalers fail to concern themselves with the proper pre-harvest, harvest, and post-harvest procedures that will insure minimum shrinkage and maximize consumer satisfaction.

The floral industry's lack of concern for shrinkage is manifested in its inability to effectively define and utilize grades and standards. Without adequate product quality description, it remains difficult to quantify post-harvest deterioration such as is done for fresh fruits and vegetables. Consequently, buyers receive a product varying substantially in quality yet have no standard other than a vague and subjective description to report the absence of quality to the seller.
THE ECONOMIC LOSS OF POST-HARVEST SHRINKAGE COSTS THE CONSUMER 90 CENTS FOR EVERY FRESH FLOWER ARRANGEMENT AND 60 CENTS FOR EVERY FLOWERING PLANT.

Economic Importance

The economic importance of a 20% post-harvest shrinkage is important. If we assume industry growth rates witnessed during the late 1960's, the economic value of shrinkage in 1975 was $134 million. This is certainly conceivable since there was little post-harvest technology change during this period that would reduce shrinkage. This converts to an economic loss of approximately 90 cents for every fresh flower arrangement and 60 cents for every flowering plant.

<table>
<thead>
<tr>
<th>Year</th>
<th>Farm Value ($ million)</th>
<th>Shrinkage ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>1971</td>
<td>530</td>
<td>106</td>
</tr>
<tr>
<td>1972</td>
<td>562</td>
<td>112</td>
</tr>
<tr>
<td>1973</td>
<td>596</td>
<td>119</td>
</tr>
<tr>
<td>1974</td>
<td>631</td>
<td>126</td>
</tr>
<tr>
<td>1975</td>
<td>669</td>
<td>134</td>
</tr>
</tbody>
</table>

If we consider that product shrinkage occurs all along the marketing channel after the value of wholesaling and retailing have been added, the potential economic loss swells to well over $300 million. This leads to the question regarding whether our industry can afford losses of this magnitude when technologies are available that would aid in reducing the level of shrinkage (i.e., bud-harvesting, preservatives, precooling, etc.).

WILL THE FLORAL INDUSTRY MAKE ADJUSTMENTS TO REDUCE SHRINKAGE BEFORE IT IS FORCED TO BY GOVERNMENT, BIG BUSINESS, CONSUMER GROUPS, OR LOSS OF CONSUMER PURCHASING?

Consequences

To disregard the economic value of this shrinkage would place a liability on the industry affecting its growth and expansion in the future. It would most probably have a detrimental impact on consumer purchasing. It may invite government or consumer group investigation. It may invite big business into an industry composed of small businesses that could not efficiently market its product at a reasonable profit. It would most certainly continue to have a detrimental impact on the economic viability of many firms engaged in producing, wholesaling, and retailing floral crops.
Probably the most significant impact of post-harvest shrinkage involves the reduction of the productive capacity of the industry affecting consumer purchasing. With the substantial labor and capital requirements for floriculture production, increasing fuel, labor, and other cost components strongly affected by inflation will dictate higher consumer costs. As aggregate demand shifts from traditional sales (i.e., funeral, wedding, illness usage) having a relatively inelastic demand base and little price sensitivity to non-traditional sales (i.e., mass, impulse, non-event oriented sales) having a somewhat more elastic demand base and greater price sensitivity, demand expansion will depend on floriculture's ability to compete with non-floricultural products for the consumer's dollar.

DEMAND THEORY DICTATES A STRONG LINK BETWEEN CONSUMER UTILITY AND PRICE RELATIONSHIP FOR FLORAL CROPS AND THAT FOR OTHER PRODUCTS AND SERVICES.

Consequently, passing on substantial economic losses to consumers or not providing the consumer with the high quality, long-lasting product will damage this utility creation process resulting in less consumer purchasing for floral products and services. While there are many influencing variables, it is hypothesized that recent conditions in fresh flower marketing are in part due to decline in the competitive position of fresh flowers relative to other floral and non-floral commodities.

The subsequent sections of this report will focus on avoiding such consequences through information, stimulation, motivation, and reaction by the industry.

YOU CAN DECIDE IF ANYONE CARES ENOUGH TO TAKE ACTION.
QUALITY

Introduction

BEFORE THE FLORAL INDUSTRY CAN EFFECTIVELY ALTER PRODUCT QUALITY TO HELP MAXIMIZE CONSUMER SATISFACTION AND PROFIT, THE MEANING, COMPONENTS, AND MEASUREMENT OF QUALITY AS WELL AS FACTORS THAT AFFECT AND/OR HELP MAINTAIN QUALITY HAVE TO BE KNOWN.

Definition of Quality

QUALITY IS DEFINED AS THE ATTRIBUTES OF FLORAL COMMODITIES THAT RELATE TO THEIR BEAUTY AND/OR USEFULNESS.

Growers produce, wholesalers and shippers handle, retailers sell, and consumers purchase "quality" floral crops. Since all people in the floral marketing channel use the term quality, it is important that everyone has a basic concept of its meaning.

Components of Quality

THE QUALITY OF FLORAL COMMODITIES AT THE TIME OF PURCHASE IS ASSESSED FROM THE RELATIVE VALUES OF SEVERAL CHARACTERISTICS WHICH TOGETHER WILL DETERMINE THE ACCEPTABILITY OF THE PRODUCT TO BUYERS AND ULTIMATELY TO CONSUMERS. HOWEVER, ONCE PURCHASED, QUALITY CHARACTERISTICS CHANGE WITH POST-HARVEST LASTING QUALITY BECOMING A MAJOR CHARACTERISTIC.

There are three main components of quality at the time of purchase: 1) appearance, 2) chemical, and 3) anatomical.

Commodity size, form (shape), surface and cleanliness, color, and condition are all appearance factors. While often psychological, these appearance factors represent the single most important quality component of floral crops and, thus, are important factors in determining consumer purchasing.

Generally, the larger the size of the floral commodity, the higher the quality it is said to possess. However, this is not always the case. The optimum size of a commodity can be related to consumer purchasing power (i.e., lower income purchasers may only have the capability to purchase smaller-sized commodities) or ultimate use by consumers (i.e., long-stemmed or large flowers or foliage plants may not be suitable for many uses and vice-versa).

The form (shape) refers to the external appearance or outlines of floral crops that have to conform with consumers' preconceived notions of what they should look like. For example, roses have been completely accepted by consumers in the U.S. as bud-harvested flowers (i.e., petals not expanded or reflexed), while carnations and chrysanthemums are generally preconceived by these same consumers as being fully opened and not as bud-flowers. In Europe, however, more consumers view high quality flowers as always being bud-harvested.
The surface of a commodity should be free of blemishes due to physical, entomological, pathological, and/or physiological disorders. Quality products should be clean, free of residues from pesticides and other pre- or post-harvest chemicals as well as free from pathogens and insects themselves. Floral crops grown out-of-doors normally present greater problems in this regard compared to greenhouse-grown crops. The cleanliness factor has become increasingly important since the publication of "Silent Spring" by Rachel Carson. She emphasized that some areas of agriculture indiscriminately used pesticides resulting in unnecessary residues.

Color appeals to consumers as much as or more than flavor does in edible horticultural commodities. In fact, it has been stated that the control of color during the processing of fruits and vegetables is without doubt the most important single quality factor affecting grower-processor relationships and consumer acceptance of products. This is also important for floral crops. Large amounts of sprays and tints are used in the industry to fulfill specific consumer needs. Holidays are very often color specific: greens, whites, and reds for Christmas; yellows and violets for Easter; etc.

The term condition, while used frequently when referring to floral crops, has a somewhat nebulous meaning. One concept of condition relates to those characteristics of quality which have intangible factors about them and include such things as freshness and absence of damage. The condition of floral commodities is defined here as those factors affecting quality not inclusively covered under the headings of size, form, surface and cleanliness, and color.

Chemical factors influencing quality have become less important. With floral crops, we are generally only concerned with the odor (fragrance) factor. There are fewer floral crops being grown because of their fragrance. In fact, many breeding programs result with products in which the fragrance factors may have been eliminated in lieu of more desirable traits.

Anatomical factors as components of quality include those physical characteristics not visible on the surface of the product (i.e., crispness, toughness, etc.) often called substance or texture. While more directly related to edible crops, floral crops should normally be turgid and not flaccid. However, there may be times when allowing plants to wilt actually improves their post-harvest quality. For example, experience has shown that allowing standard chrysanthemums to wilt slightly during their last 2 to 3 weeks prior to harvest can increase their post-harvest keeping quality. Foliage and flowering plants should not be allowed to wilt, especially at the consumer level, as soluble salts damage may result. On the other hand, over-watering problems are thought by many researchers to be a serious problem of containerized plants in the home.
Table 1 lists the approximate importance of the heretofore described components of quality as related to some floral crops. These figures approximate consumer appeal for products at the time of purchase.

### TABLE 1. Percent distribution of quality components of floral crops

<table>
<thead>
<tr>
<th>Quality Characteristics</th>
<th>Fresh Flowers</th>
<th>Flowering Plants</th>
<th>Foliage Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Surface &amp; Cleanliness</td>
<td>20</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Condition</td>
<td>25</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Size</td>
<td>15</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Form</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

If the floral industry is to expect repeat purchases, it is important to know how these consumers view quality floral commodities once they have been purchased. When consumers were asked their preference between roses, carnations, and chrysanthemums at the time of purchase and after they had their preferred flower in their homes for 5 days, roses followed by carnations rated substantially higher when purchased compared to chrysanthemums (Table 2). However, after 5 days their preferences changed in favor of chrysanthemums. The reasons for this change in quality preference is presented in Table 3. After 5 days, flowers (e.g., chrysanthemums) that had a better post-harvest lasting quality rated higher.

### TABLE 2. Consumer preference of 3 fresh flower species upon receipt and after 5 days

<table>
<thead>
<tr>
<th>Flower</th>
<th>When Received (%)</th>
<th>After 5 Days (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roses</td>
<td>51</td>
<td>20</td>
</tr>
<tr>
<td>Carnations</td>
<td>41</td>
<td>34</td>
</tr>
<tr>
<td>Chrysanthemums</td>
<td>4.5</td>
<td>36</td>
</tr>
<tr>
<td>No preference</td>
<td>3.5</td>
<td>10</td>
</tr>
</tbody>
</table>
TABLE 3. Consumer reasons given for responses presented in Table 2

<table>
<thead>
<tr>
<th>Reason</th>
<th>When Received (%)</th>
<th>After 5 Days (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always liked best</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Actual appearance</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Past experience</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Last longer&lt;sup&gt;z&lt;/sup&gt;</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>More attractive&lt;sup&gt;z&lt;/sup&gt;</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Other reasons</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>No reasons given</td>
<td>21</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>z</sup>Both related to post-harvest lasting qualities.

In conclusion, as consumers become more knowledgeable of floral commodities, they will rate potential lasting quality very high at the time of purchase. Thus, more floral crops including containerized plants need to be produced that have good post-harvest characteristics. Could this be the major problem that people in the marketing channel of fresh flowers face today?

Measurement of Quality

FAILURE OF THE FLORAL INDUSTRY TO ADOPT GRADES AND STANDARDS CANNOT BE JUSTIFIED AND WILL CONTINUE TO BE A MAJOR DETRIMENT TO IMPROVEMENT OF ORDERLY MARKETING AND PROFITS.

Quality measurement can be by either subjective or objective means. Flower and/or foliage color, fragrance, cleanliness, and form are measured subjectively, if at all, while flower diameter, leaf size, stem length, height, bulb circumference, and bunch weight are examples of objective measurements. Presently, container-grown foliage and flowering plants are mainly measured by container size, which is not a good measurement of total plant quality. On the other hand, attempts have been made to measure fresh flower quality using grades and standards based on parameters such as maturity, size, shape, and condition. Tables 4 and 5 present examples of floral grades and standards based on size only being used, if at all, on a voluntary basis in the U.S. while compulsory standards for fresh flowers being used in European Common Market are shown in Table 6.
TABLE 4. Size dimensions of tulip bulbs suggested by the American Association of Nurserymen

<table>
<thead>
<tr>
<th>Top size</th>
<th>Circumference</th>
<th>(cm)</th>
<th>(in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12 +</td>
<td>4-3/4 +</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td>11 - 12</td>
<td>4-3/8 - 4-3/4</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>10 - 11</td>
<td>4 - 4-3/8</td>
</tr>
<tr>
<td>Small</td>
<td></td>
<td>9 - 10</td>
<td>3-5/8 - 4</td>
</tr>
</tbody>
</table>

TABLE 5. Society of American Florists standards suggested for carnations, chrysanthemums, and roses in the U.S.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Blue</th>
<th>Red</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(cm)</td>
<td>(in)</td>
<td></td>
</tr>
<tr>
<td>Carnations</td>
<td>(cm)</td>
<td>(in)</td>
<td></td>
</tr>
<tr>
<td>1. Minimum flower diameter</td>
<td>7.0</td>
<td>2.75</td>
<td>5.7</td>
</tr>
<tr>
<td>2. Minimum overall length</td>
<td>56</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Chrysanthemums</td>
<td>1. Minimum flower diameter</td>
<td>14.0</td>
<td>5.5</td>
</tr>
<tr>
<td>2. Minimum overall length</td>
<td>76</td>
<td>30</td>
<td>76</td>
</tr>
<tr>
<td>Roses</td>
<td>1. Hybrid teas</td>
<td>56</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2. Sweethearts</td>
<td>36</td>
<td>14</td>
</tr>
</tbody>
</table>

TABLE 6. European Economic Community standards of fresh flowers

<table>
<thead>
<tr>
<th>Code</th>
<th>Stem Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5 or no stems</td>
</tr>
<tr>
<td>5</td>
<td>5 - 10</td>
</tr>
<tr>
<td>10</td>
<td>10 - 15</td>
</tr>
<tr>
<td>15</td>
<td>15 - 20</td>
</tr>
<tr>
<td>20</td>
<td>20 - 30</td>
</tr>
<tr>
<td>30</td>
<td>30 - 40</td>
</tr>
<tr>
<td>40</td>
<td>40 - 50</td>
</tr>
<tr>
<td>50</td>
<td>50 - 60</td>
</tr>
<tr>
<td>60</td>
<td>60 - 80</td>
</tr>
<tr>
<td>80</td>
<td>80 - 100</td>
</tr>
<tr>
<td>100</td>
<td>100 - 120</td>
</tr>
<tr>
<td>120</td>
<td>120 +</td>
</tr>
</tbody>
</table>
In addition to the size or measurement standards presented in Tables 4-6, often there are inspection or condition standards. Information presented in Table 7 exemplifies such standards. It should be noted that these standards are mainly determined using subjective measurements.

TABLE 7. Society of American Florists suggestions as to inspection standards for carnations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bright, clean, firm flowers and leaves.</td>
</tr>
<tr>
<td>2</td>
<td>Fairly tight--petals near center of flower are tight and unopened.</td>
</tr>
<tr>
<td>3</td>
<td>Symmetrical--flowers of shape characteristic of the variety.</td>
</tr>
<tr>
<td>4</td>
<td>No split calyx or mended splits--splits and mended splits shall not be included in any of the above grades. Designation is at the discretion of the grower, but splits shall not be marketed with the use of the SAF emblem.</td>
</tr>
<tr>
<td>5</td>
<td>No buds or suckers.</td>
</tr>
<tr>
<td>6</td>
<td>No decay or damage.</td>
</tr>
<tr>
<td>7</td>
<td>Essentially straight stems of normal growth.</td>
</tr>
</tbody>
</table>

*Similar standards are used in Europe.*

It is important to note that the potential lasting quality of floral crops has not been considered in determining grades and standards. Thus, it is very conceivable that floral crops graded highest using present parameters would have inferior lasting qualities compared to crops graded lower. For example, it will be explained subsequently in this publication that many floral crops grown in media containing luxuriant nutrient levels will not keep as well after harvest as ones grown with lesser amounts of nutrients, yet the former crop would probably be graded higher because of i.e., darker foliage, larger flowers, longer stems, etc. The same relationship can be true for container-grown plants. Within a given container size, larger diameter plants would probably be graded higher compared to smaller ones assuming that the heights were both acceptable. However, large plants resulting in high shoot/root ratios don't last as long after harvest because the root system is too small to maintain the rest of the plant (shoot) once removed from production areas and placed in the marketing channel. In summary, optimum grades and standards for floral crops must contain provisions for measuring potential lasting qualities.
While various grades and standards exist, the floral industry has not accepted them. Ignorance on this subject by many people in the floral industry is the primary reason for its unacceptance. For example, advisories state that such grades and standards would allow various governmental agencies to "take-over", lead to marketing orders, and reduced profits. They are also said to be unenforceable and too restrictive, resulting in "grading down", and would arbitrarily change depending on market supplies and demands.

To help overcome these "disadvantages", a better educational effort has to be developed to emphasize advantages like improved communications, marketing, buying, and selling which result in less shrinkage, more profits, and improved pricing structures. The technologies are presently available for the implementation of this concept, so why not do it?

Factors Affecting Quality

To help reduce the 20 percent shrinkage rate of floral commodities:

1) The producers must become more cognizant of pre-harvest factors that can influence post-harvest lasting qualities since approximately 70 percent of the post-harvest characteristics are predetermined at harvest; 2) absolute storage temperature control is a must; 3) ethylene sources must be eliminated or reduced; and 4) the importance of relative humidity control has to be understood and implemented.

Potentially, everything that is done by man and/or nature in the production, harvesting, and post-harvest handling of floral crops can influence crop quality and its consumer acceptance. While being a very complex subject area, emphasis will be placed on production, time of harvest, ethylene, pests and temperature, relative humidity, and light factors as they affect post-harvest quality of floral crops.

Production. When considering the factors that affect the lasting quality of floral crops, normally only post-harvest factors are considered, i.e., storage temperature, re-cutting stems, use of preservatives, etc. However, there are a number of pre-harvest and harvest factors that strongly influence the potential life of the product. In fact, it has been estimated that up to 70 percent of the potential lasting quality of many floral crops is predetermined at harvest. These pre-harvest factors are related to the production of the crops. Production factors can be categorized into inherent or genetic, environmental, and management factors.

Only grow species and/or cultivars known to have good post-harvest characteristics. It is obvious that different species of floral crops would have different potential lasting qualities because of their genetic make-up. Thus, chrysanthemums normally last longer than roses, and poinsettias last longer than Easter lilies, and philodendron tolerates less light indoors than aralia. However, the main discouraging aspect of this is that most people in the floral industry, including the breeders, usually do not develop, grow, sell, or buy crops based on their potential
lasting quality. Why not list in your own mind the reasons why the different species and/or cultivars of foliage plants, chrysanthemums, carnations, etc. are grown. How many of these reasons are related to post-harvest factors? A major exception to all of this is the rose industry. In order for them to survive, they had to become more aware of the post-harvest aspect of their crop. However, will producers and handlers of other floral crops be forced to do the same in order to survive . . . ?

Environmental factors, either controlled by nature or man, can significantly alter the quality of a product. For example, insufficient light levels from shaded greenhouses, environmental conditions, and/or too close spacing which result in a reduction in food being produced via photosynthesis often result in crops that have inferior lasting qualities. The vase-life of chrysanthemums flowered in November and December under full light conditions was only 2 days longer than flowers grown under 50 percent shade at the same time. However, these differences increased to 5 to 7 days when harvested in mid-summer. Also, while total production of chrysanthemums increased as spacing went from 24 to 15 sq. in. per stem, the quality of the flowers decreased. Thus, the more food present in the plant at harvest, the greater the potential lasting quality.

Too high a growing temperature can reduce post-harvest quality. For example, 3 varieties of roses were grown at 15, 18, 21, 24, and 27°C. The roses grown at 21°C had the longest vase-life. Also, roses grown at too high temperatures have decreased flower pigmentation. Finally, wet conditions at harvest can often provide environments (i.e., wet flowers and foliage) for pathogen growth after harvest, again reducing the quality of the crop.

A major production factor affecting quality is the management of the crops. While specific comments will be made for the major floral commodities in subsequent sections, a few general examples are presented here.

The use of growth retardants (i.e., B-Nine, Cycocel, A-Rest, and Phosfon) can often improve plant quality. When applied prior to harvest, these growth regulators can retard stem elongation, promote formation of yellow pigments in flowers, increase the green color of foliage, reduce visible injury caused by air pollutants such as ozone and sulfur dioxide, and can regulate flowering time and/or flower size with certain floral crops.

Pre-harvest sprays with other growth regulators have resulted in higher quality crops after harvest. For example, applications of N-6-Benzyladenine (not registered) on Anthurium andraeanum and stock flowers reduced chilling injury susceptibility and increased lasting quality, respectively. Also, pre-harvest sprays of gibberellins (not registered) on roses increased flower size and intensified flower pigmentation. Applications on foliage plants also indicated improved keeping quality.
FLORAL CROPS HAVING RELATIVELY LOW FOLIAR NUTRIENT AND/OR MEDIA SOLUBLE SALTS LEVELS AT HARVEST WILL EXHIBIT BETTER POST-HARVEST CHARACTERISTICS THAN THOSE HAVING HIGHER LEVELS. Over-fertilization can decrease the quality of many floral crops. In fact, within reasonable limits, there is often an inverse relationship between foliar nitrogen content and lasting quality viz. as nitrogen levels increase, lasting quality decreases. Table 8 lists some relationships between nutrient levels in the foliage of chrysanthemums and their keeping qualities.

Table 8. The management of nutrient levels in chrysanthemums as it relates to post-harvest quality

<table>
<thead>
<tr>
<th>Category</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stem diameter increases as potassium levels increase.</td>
</tr>
<tr>
<td>2.</td>
<td>High nitrogen levels may decrease bloom size.</td>
</tr>
<tr>
<td>3.</td>
<td>High nitrogen levels decrease vase-life.</td>
</tr>
<tr>
<td>4.</td>
<td>Post-harvest deterioration of leaves and stems by Botrytis cinerea Pers. ex Fr. is increased with increased nitrogen levels.</td>
</tr>
<tr>
<td>5.</td>
<td>Decreasing the soluble salts levels in media during the last 1/3 of the growing time improves root growth and lasting quality.</td>
</tr>
</tbody>
</table>

However, it must be noted that this inverse relationship does not always exist. For example, some studies have shown that soil nitrate levels had no effect on the life of carnations, chrysanthemums, and roses.

Excess fertilizer (high soluble salts) in media at the time many container-grown foliage plants are harvested can result in a rapid loss of plant quality. Approximately 10 percent or less of the nutrients required for optimum growth under greenhouse or outdoor production conditions are required by most foliage plants after being placed in the marketing channel. The problem, then, is what happens to a plant after it is removed from the production area where higher nutrition is necessary for growth to low light interiors where much lower levels are desired. Most commonly, on sensitive plants such as palms, dracaenas, schefflera, and other greenhouse-grown foliage plants, a rapid loss in quality occurs when excess fertilizer (high soluble salts) is permitted in the root zone when plants are moved indoors. Symptoms are general loss of healthy color, chlorosis, necrosis, defoliation, and in severe cases, plant death.

Nutritional acclimatization may take several forms, but the need and extent depends on how the plant was grown. The first question that may arise is fertilization rate, since some excess fertilizer may be applied without producing toxicity symptoms (hidden toxicity). Another

1Acclimatization, according to Webster, "is the climatic adaptation of an organism, especially a plant, that has been moved to a new environment."
consideration that enters the picture is the light intensity the plant was grown under, since more fertilizer is required to produce dark green plants under higher light intensities. The problem facing the purchaser is that unless plants are nutritionally acclimatized for low light levels there is a good chance damage or loss of plants may occur.

Research has shown that to acclimatize plants nutritionally, the producer should stop addition of fertilizer toward the end of the crop cycle and leach soil heavily with at least 6 inches of water prior to shipment. Although research has shown leaching and use of lower fertilizer levels are beneficial, the length of time before placement indoors following these nutritional adjustments has not been determined.

Under-fertilization can also reduce the post-harvest qualities of various floral crops. Low foliar levels of calcium and potassium can reduce the vase-life of carnations.

FOLIAGE PLANTS GROWN UNDER REDUCED LIGHT LEVELS LAST LONGER. Light acclimatization of foliage plants is essential and failure to do so can result in inferior plants. As an example, under high light levels the plant produces small thick leaves with stacked chloroplasts in many cells and vertical orientation of grana within chloroplasts. This is a protective mechanism which prevents injury to cell components from high light intensities, but reduces the ability of plants to produce carbohydrates (food) through photosynthesis under lower interior light levels. Although leaves developed under high light levels present no problem while the plant remains under high light, movement of the plant to the low light levels of an interior location present problems because of the plants compensation point. "Compensation Point" is that point at which energy (food) required by the plant during respiration is equal to the amount produced by photosynthesis. A plant grown under high light intensity has a higher compensation point than one grown under heavy shade due to the previously mentioned differences in leaf structure. Therefore, even though 100 foot-candles of light for 10 to 12 hours per day may be sufficient for a shade-grown plant, if the plant were grown in the sun, 200 foot-candles might not be sufficient. The effects of continuous light on foliage plants are not presently known.

Several problems have been noted with acclimatization of sun-grown foliage plants that influence consumer acceptance. Research has shown that some sun-grown leaves can be partially converted to shade leaves, but such leaves have lower efficiency. Observations to date indicate some conversion and production of new shade foliage combined with conversion of immature foliage on plants at time of placement under shade. After placement indoors, such plants drop most of the original sun-grown foliage within a few months, while foliage produced under shade remains on the plant. Shade-grown foliage is more efficient indoors, because leaves are thinner, larger, chloroplasts are dispersed within cells, and grana have a horizontal orientation. These mechanisms enable shade-grown leaves to absorb more of the incoming light energy, which allows them to photosynthesize more efficiently under low light conditions.
For example, *Ficus benjamina* plants often lose excessive amounts of foliage when brought directly from production to home environments. Research has shown that if these same plants had been placed under 80 percent shade for 5 weeks prior to harvest, leaf drop could have been reduced by 50 percent. Also, it has been shown that many foliage plants can be economically grown under much reduced light intensities for their entire production period and shipped directly to final consumers with no further acclimatization needed and no loss in quality.

Growing foliage plants under reduced light intensities can also help prevent high temperature-induced root losses, especially in very warm growing areas like Florida, Texas, and southern California. The problem arises when radiation from the sun comes in direct contact with growing containers for relatively long periods of time resulting in increased media temperatures. These higher media temperatures generally promote root desiccation and/or inhibit root development, especially on the side of the containers facing south. Thus, plants grown under these conditions have fewer roots which often results in reduced lasting quality after harvest.

The use of supplemental carbon dioxide in greenhouses to improve plant growth also has been shown to improve the lasting quality of various floral crops. For example, some rose cultivars exhibited increased lasting qualities when grown in environments containing 1000 or 2000 ppm CO₂ compared to normal levels of 300 ppm.

The location at which certain fresh flowers are harvested can influence potential vase-life. It has been shown that standard chrysanthemums harvested 25 cm above the soil line last longer than those harvested 5 cm above the soil line. The reason put forth explaining this phenomenon is that flowers harvested at the 5 cm position had older stem tissue at the basal end remaining of the harvested flower which reduced water uptake.

WITH CONTAINER-GROWN PLANTS, MEDIA SHOULD HAVE 20% AIR- AND 65% WATER-HOLDING CAPACITY BY VOLUME. Large numbers of healthy roots are synonymous with plants having good lasting qualities. Generally, more plants are killed by over-watering (insufficient oxygen) because of the poor growing media with improper soil-air-water balances. Don't mix small media particles with big ones. The small particles clog the mix.

One technique believed to improve drainage and, thus, provide for more oxygen in media is the addition of "crock" or gravel at the base of containers. In reality, what results is a decrease in water drainage, hence, less oxygen in the medium. This phenomenon occurs because capillary movement of water is decreased due to a shallower column of medium created by the presence of the crock or gravel.

During acclimatization of foliage plants, root system size can be improved by reducing nutrition and lengthening the interval between watering. This method reduces top growth while root growth continues
with a subsequent increase in root:shoot ratio. This practice will also harden foliage so it will be less likely to wilt under low relative humidity situations.

The size of root systems in relation to amount of foliage present (root:shoot ratio) is very important, since plants with large tops in relation to root systems may be damaged under low relative humidity conditions where roots cannot supply needed water. Therefore, producers should avoid shipping plants that are not properly established, or those with root systems damaged by disease or insect pests.

Soil type can also strongly influence interior functional life of foliage plants, especially when poorly aerated mixtures are used. Such potting soils will exclude oxygen and allow a build-up of CO₂, which will reduce the ability of the root system to transport water. If such soils are allowed to remain saturated with water, root death will occur which will further limit water absorption and usually result in plant death.

Producers are now becoming familiar with those production factors that influence the functional life of foliage plants and are rapidly changing production practices. These practices include growing all foliage plants under specified shade levels and on reduced fertilizer regimes, as well as paying closer attention to potting medium, watering methods, and pest control.

Another factor that may influence root growth is the use of growing containers that are light-colored enough to transmit light. Observations made in California revealed that poinsettia plants growing in light-colored containers had chlorotic foliage and poor, greenish-colored roots compared to healthy plants growing in dark-colored containers. Subsequent measurement of light transmission through the side-walls of various colored containers showed that white containers allowed 1050 foot-candles of light transmission compared to 0.1 foot-candles for dark green containers. Similar experiments conducted in Ohio resulted in plants of equal quality regardless of container type. No data are available for foliage plants.

The use of Viterra Hydrogel (cross-linked poly(ethyleneoxide)) as a growing media amendment in containerized floral crops can result in plants that will not wilt as rapidly as well as improve root growth and, thus, provide for a higher quality crop at the consumer level. This material is added to growing media during preparation prior to pasteurization. Upon coming in contact with water, it will swell to produce small particles of immobilized water of which 95 percent is available to plants. These particles can hold 20 to 25 times their weight in water. The end result is less shrinkage in the marketing channel, especially in the mass market retail outlets, because the plants do not wilt as rapidly compared to plants grown in media containing no Viterra Hydrogel. Also, the free pore space is increased providing for conditions conducive for root growth.
Time of harvest. The point in time at which a specific crop should be harvested depends on a number of factors including stage of maturity, time of day, distance to market, customer characteristics, consumer demands, and time of year. Each of these factors is discussed.

By definition, maturity is that point in time when a crop can be harvested and it will continue to grow and develop, if necessary, to reach maximum quality. For example, carnations can be harvested in the "bud" stage and, if handled properly, will reach maximum quality off the plant. Also, tulips or hyacinths in the "green-bud" stage and Easter lilies in the "white-puffy stage" can continue to develop to maximum quality after harvest. Examples of keeping qualities of certain fresh flowers harvested at different maturities are presented in Table 9. The proper time of harvest for each species will be discussed in the crop sections.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Harvest Maturity</th>
<th>Lasting Quality (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnation</td>
<td>Open</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>Bud-cut (calyx opening)</td>
<td>15.2</td>
</tr>
<tr>
<td>Chrysanthemums</td>
<td>Open</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Bud-cut (flower approx. 6 cm in dia.)</td>
<td>19</td>
</tr>
<tr>
<td>Tulips</td>
<td>Full color</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Green-bud stage</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Z No. of days in preservative solution to unacceptable quality.

Bud-harvested flowers have had problems in recent times. The problems seem to have occurred when producers harvested their crops (especially chrysanthemums, daffodils, stocks, and roses) too early even for bud-cut. This problem has been experienced mostly in Great Britain where the concept of bud-harvested flowers has been practiced by people in the entire marketing channel for years.

The time of day various fresh flowers can be harvested to maximize lasting qualities is that point at which the carbohydrate levels in the part(s) to be harvested are highest. Generally, crops harvested in mid to late afternoon have maximum stored carbohydrates due to photosynthates produced that day. For example, roses harvested at 4:30 p.m. lasted 11 percent longer than flowers harvested at 8:00 a.m. However, when commercial aspects are considered, it is normally impractical to harvest fresh flowers solely in the afternoon.
The distance floral crops have to be transported to markets can affect time of harvest. Fresh flowers being shipped dry in boxes long distances are often harvested at an earlier stage of development than those sold at a local market. One reason for this is that more flowers can be packed per box when harvested at an earlier stage of development because they are smaller than flowers harvested later.

If the customer that the producer is selling to has a greenhouse or similar facilities (i.e., retail florist with attached greenhouses), pre-finished container-grown stock may be supplied. Thus, poinsettias may be delivered in October or November and grown on for sales in mid-December.

The time at which a crop is harvested and sold is highly dependent on the level of consumer demand. For example, container-grown chrysanthemums being produced for the Easter market are often sold out much in advance of the holiday. If product demands continue to reach the producer, often other chrysanthemum crops, not yet mature enough for sale, are sold. What frequently results are flower heads so immature that they do not open properly in the marketing channel and, hence, inferior quality products are placed before ultimate consumers. A second classical example occurs with foliage plants. Under similar high consumer demand periods, many foliage plants reach the market place without adequate root systems. What happens is that cuttings are directly stuck in the final selling containers and not given sufficient time to develop. Again, lower quality crops reach the consumer.

At the other extreme, in slack periods of consumer demands, many floral crops are held back or stored for excessive time periods resulting in inferior quality products often sold at distressed prices. In fact, it has been determined that often more money is lost by holding the products and selling them at distressed prices compared to discarding the crop initially.

Research has shown that fresh flowers harvested at times of the year when light intensities are high have a longer vase-life than flowers grown under low light levels. The reason for this is that flowers grown under high light have higher amounts of stored carbohydrates which is directly related to keeping qualities. For example, certain cultivars of pompon chrysanthemums lasted twice as long when grown under high light periods in April or July compared to ones harvested in November or December.

Ethylene. Ethylene is a low molecular weight gas that is notorious for reducing the quality of floral crops. Common examples include carnations going to "sleep", shattering of snapdragon florets, shelling of calceolarias, dry sepal injury to orchids, and yellowing and/or abscission of foliage of container-grown plants. It is imperative that every step be taken to eliminate or reduce ethylene in areas where floral crops are being handled. Levels of 30 to 60 parts per billion may cause reduction in crop quality, especially of fresh flowers, while higher (approx. 1.0 ppm) levels are needed to injure foliage plants.
There are numerous sources of ethylene. The following briefly summarizes some of the major sources.

1) While not conclusively known with all species, it is most probable that all floral crops biosynthesize ethylene. As early as the 1930s and '40s it was shown that hollyhock, marigold, calla, gladiolus, peony, verbena, geranium, gardenia, lily-of-the-valley, petunia, tulip, calceolaria, and snapdragon produced ethylene and that with the latter two species, enough ethylene was produced autocatalytically to cause their own flower drop. Subsequent studies have shown that all floral crops investigated produce ethylene including rose, orchid, carnation, and chrysanthemum. Also, early studies indicated that certain flowers like carnations did not produce enough ethylene to cause self-inflicted problems like "sleepiness" and that ethylene is not detrimental if flowers are not confined. However, both of these conclusions have been shown to be incorrect. For example, senescence of carnations being stored in ethylene-free air that was exchanged frequently directly coincided with autocatalytic increases in ethylene production. A final example is that pollinated flowers often produce higher amounts of ethylene compared to flowers left intact and not pollinated. Probably the most dramatic example is that ethylene production rates 30 nL/g/hr have been measured for pollinated Vanda orchid blooms compared to undetectable levels for ones not pollinated.

2) As with floral crops, fruits and vegetables also produce ethylene. In fact, it was the early studies with these commodities showing ethylene production and ethylene-induced disorders that paved the way for similar research and findings with floral crops. It is an understatement to suggest that fruits and/or vegetables should not be stored with floral crops. Also, for example, foliage plants and citrus should not be shipped in the same truck.

3) Diseased and/or injured plants produce higher amounts of ethylene compared to healthy, damage-free plants. In the first place, pathogens themselves can produce ethylene. Of 228 species of fungi examined, 58 produced ethylene including common strains of Penicillium, Botrytis, and Alternaria. Secondly, damaged plant tissue either from insects, pathogens, viruses, and/or physically induced caused increases in ethylene production by the plant tissue itself.

4) Ethylene levels found in the ambient atmosphere can be high enough to induce disorders of some floral crops. For examples, ethylene levels from 40 to 700 parts per billion (ppb) have been measured in the atmosphere in the Washington, D.C., area.

5) Various types of internal combustion engines and petroleum-fired heaters are often major sources of ethylene and other low molecular weight hydrocarbons like propylene and methane. Of special concern are heaters in tightly constructed polyethylene or fiberglass greenhouses or snow and ice-covered glasshouses where air exchange is often minimal especially during night periods. What often results is an incomplete combustion of the fuel resulting in by-products like ethylene up to 100
pm being produced. Data presented in Table 10 exemplifies this condition. Also, the exhaust of internal combustion engines can contain ethylene levels up to approximately 200 ppm.

### TABLE 10. Ethylene levels in plastic greenhouses

<table>
<thead>
<tr>
<th>House Number</th>
<th>Heater Operation Before Sampling</th>
<th>Ethylene (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Burning</td>
<td>263.0[z]</td>
</tr>
<tr>
<td>2</td>
<td>Burning</td>
<td>34.1[y]</td>
</tr>
<tr>
<td>3</td>
<td>Not burning</td>
<td>16.3</td>
</tr>
<tr>
<td>4</td>
<td>Not burning</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>Not burning</td>
<td>16.3</td>
</tr>
</tbody>
</table>

\[z\] Heaters were not vented.
\[y\] Heaters were vented.

6) Ethylene-like disorders induced by gas leaks have become less important in recent years especially since illuminating gas which contains relatively high ethylene levels is not used anymore. However, it must be emphasized that other low molecular weight gases like propylene, carbon monoxide, acetylene, and other low molecular weight hydrocarbons can also induce ethylene-like disorders.

7) Under certain conditions, various types of electric motors and light fixtures can release ethylene. The problem occurs when petroleum-based products like wire coverings are heated with ethylene being evolved as a breakdown product.

**Pests.** The most common pests that can affect the quality of floral crops are fungi, bacteria, and insects. The following briefly describes some of the problems induced by these pests.

Earlier in this section the subject of fungi producing ethylene and the ethylene-induced problems were discussed and need not be duplicated here. However, fungi can reduce plant quality in numerous other ways.

**Root** and/or stem rots like Pythium and Rhizoctonia, if not causing death, can severely reduce post-harvest lasting qualities of flowering and foliage plants by decreasing the amounts of viable roots, especially under low relative humidity conditions. The concept of "latent pathogens" in this regard should be described. Most, if not all, floral crops are externally and/or internally inoculated with pathogens. Whether or not the pathogens create post-harvest problems depends on the condition of the host plants, the environment, and the conditions the pathogens and
plants are both subjected to prior to and/or after harvest. For example, assume a poinsettia plant has been properly grown under controlled environments with no visible disease symptoms at the time of harvest. It can be assumed that pathogens are present on and/or in the plant and/or in the growing media. However, the plant was healthy and the environment such as to not allow the pathogens to grow and cause problems. However, once out of the controlled environment and into the marketing channel, the plant may be put under stress and the environment such to allow the pathogens to grow, i.e., Pythium. The Pythium grows, causes root problems, and leaves begin to fall off. Thus, maybe we should consider "acclimatization of "northern"-grown plants as well as those grown in warmer locations.

Probably the most common post-harvest pathogenic fungus is various species of Botrytis. Botrytis can grow under all temperature ranges encountered in the production and handling of floral crops, even at temperatures as low as -2°C. Also, many post-harvest storage and shipping conditions, where high relative humidities are often encountered, are often ideal for Botrytis growth. Finally, damaged crops resulting in wounded tissue provide excellent environments for Botrytis and other fungi to grow.

Various types of microorganisms, especially bacteria, have been implicated as being primary agents in causing the phenomenon known as "stem-blockage" in harvested fresh flowers. Whether it is solely the bacteria and/or physiological disorder(s) causing the blockage or even if the blockage actually occurs is still open for discussion. It is known that various germicides can reduce stem blockage as measured by water conduction in xylem elements. However, reduction in water conduction has also been measured using "sterile" conditions.

Insects, especially aphids and spider mites, are often present on floral crops when they are in the marketing channel. Not only do the insects themselves by their presence reduce plant quality, but the damage they cause can often render the crop unsalable. For example, it has already been pointed out that plant injuries induced by feeding insects can cause increases in ethylene production which in turn can cause severe problems like premature senescence. Also, the resulting wounded tissues reduces the resistance of crops to invasion by pathogens like Botrytis.

Temperature, relative humidity, and light. What many believe to be the most important and for sure the most researched factor affecting quality of floral crops is temperature. Brief mention has been made on how production temperatures can affect lasting qualities. Presently only post-harvest temperatures will be discussed. Also, the effects of relative humidity and light as lasting qualities will be presented. It is important to note at the onset that it will be shown that changes in relative humidities can alter the lasting qualities of various crops often as much as changes in temperature.

Summarizing all of the research on floral crop lasting qualities as affected by post-harvest temperatures would result in many pages of
reading. An easier way to approach this subject is to understand the concept of temperature coefficients $Q_{10}$. When measuring the effects of temperatures on various biological processes like respiration, there is often a change in the rate of the process by a factor from 2 to 3 for every $10^\circ C$ change in temperature. This rate change is referred to the $Q_{10}$ for that particular process. For example, one of the primary objectives in maintaining plant and/or flower quality after harvest is the conservation of food sources like sugars and starches by reducing processes that utilize such compounds. The main process that utilizes sugars for energy production is respiration.

Since respiration rates are often inversely related to lasting qualities of floral crops, it is wise to store or display products at the lowest temperature possible without adversely affecting them. For example, carnations stored for 14 days at $0^\circ C$ had 7 days of vase-life upon removal compared to 2 days for ones stored at $5^\circ C$. Recommended storage temperatures for specific crops will be presented in the crop sections. It should be emphasized that "low" temperatures for crops like foliage plants may be 55 to 60°F.

Another important process already discussed that can affect lasting qualities is ethylene. Again, as with respiration rates, lower temperatures greatly reduce ethylene production which in turn can result in higher quality products that last longer. Also, assuming a constant level of ethylene, plants are less susceptible to ethylene-induced disorders at lower temperatures. For example, using opened carnation flowers, increasing the temperature from approximately 2 to $21^\circ C$ increased the effect of ethylene nearly $1000$ times.

Since the rates of metabolic processes of floral crops can be reduced by lowering temperatures, it is correct to assume that metabolic and physical activities of pests attacking floral crops is also reduced. Thus, pathogen growth and development is often reduced under reduced temperatures. Also, insects are not as active.

While the importance of maintaining proper relative humidities in the storage of fruits and vegetables has been well documented, very little information is available for floral crops. It is generally believed that high relative humidities can help extend lasting qualities of floral crops by conserving water loss via transpiration. Table 11 presents data showing the importance of high relative humidities on the vase-life of roses and carnations. It is especially important to note the extended vase-life of carnations at 98% vs. 80% relative humidity. Also, that carnations lasted equally well at $27^\circ C$ (room temperature) and 98% relative humidity compared to those stored at $10^\circ C$ and 15% relative humidity.
TABLE 11. Vase-life (days) of rose and carnation flowers as affected by temperature and relative humidity

<table>
<thead>
<tr>
<th>Relative Humidity (%)</th>
<th>Temperature (°C)</th>
<th>27</th>
<th>15</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rose</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>3.5</td>
<td>3.5</td>
<td>9.0</td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>4.0</td>
<td>4.5</td>
<td>11.0</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>4.0</td>
<td>6.0</td>
<td>8.5</td>
</tr>
<tr>
<td>98+</td>
<td></td>
<td>4.0</td>
<td>7.5</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Carnation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1.5</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>2.8</td>
<td>3.0</td>
<td>4.3</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>3.0</td>
<td>5.5</td>
<td>8.8</td>
</tr>
<tr>
<td>98+</td>
<td></td>
<td>4.0</td>
<td>10.5</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Another advantage of having relatively high relative humidity is in rooms where bud-harvested chrysanthemums are being opened viz. sucrose-induced phytotoxicity of leaves generally did not occur when flowers were stored at high (35 to 60%) relative humidities compared to frequent leaf desiccation at humidities lower than 30%.

While lacking in documented examples with floral crops, the importance of relative humidity can be demonstrated by having an understanding of vapor-pressure deficits (VPD).

Water vapor, like other gases, moves from a region of high concentration to a region of lower concentration. Since the internal relative humidity of floral crops normally approaches 100% and the external relative humidity is usually less than 100%, water vapor will move out of the plants mainly via transpiration. Hence, the drier the surrounding air, the more water will be lost, and, thus, reduced lasting quality often results. The difference between the water vapor pressure in the product and the water vapor pressure in the air is called vapor-pressure deficit. Table 12 shows the relationship of temperature and relative humidity to the vapor pressure of water and VPD.
TABLE 12. Relation of temperature and relative humidity to the vapor-pressure of water and the VPD

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Vapor Pressure (mm Hg)</th>
<th>VPD (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>4.58</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>4.12</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>3.21</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2.29</td>
<td>2.29</td>
</tr>
<tr>
<td>2.2</td>
<td>100</td>
<td>5.37</td>
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<td>4.83</td>
<td>0.54</td>
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<td></td>
<td>70</td>
<td>3.76</td>
<td>1.61</td>
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<td></td>
<td>50</td>
<td>2.68</td>
<td>2.69</td>
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<tr>
<td>4.4</td>
<td>100</td>
<td>6.27</td>
<td>0</td>
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<tr>
<td></td>
<td>90</td>
<td>5.64</td>
<td>0.63</td>
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<tr>
<td></td>
<td>70</td>
<td>4.39</td>
<td>1.88</td>
</tr>
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<td></td>
<td>50</td>
<td>3.13</td>
<td>3.14</td>
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<td>10</td>
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<td>9.21</td>
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<td>4.61</td>
</tr>
<tr>
<td>21</td>
<td>100</td>
<td>18.76</td>
<td>0</td>
</tr>
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<td>90</td>
<td>16.88</td>
<td>1.88</td>
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<td>70</td>
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</tr>
<tr>
<td></td>
<td>50</td>
<td>9.38</td>
<td>9.38</td>
</tr>
</tbody>
</table>

For example, 0.46 = 4.58 - 4.12.

Using the VPD in Table 12, assume a floral crop is being held at 10°C at 90 or 50% relative humidity. The VPD at 50% relative humidity (4.61) is approximately 5 times as high as at 90% (0.92). Thus, water will be lost from the product stored at 50% relative humidity 5 times as fast as products at 90%. Thus, floral crops at 50% relative humidity will wilt faster resulting in lower quality crops.

Careful consideration of the data in Table 12 will also show that changes in relative humidities can often be as important as changes in temperature. For example, storage of a floral crop at 2.2°C and 50% relative humidity (VPD = 2.69) will loose approximately equal amounts of water compared to storage at 10°C and 70% relative humidity (VPD = 2.76).

The final factor to be discussed as influencing quality is light. It has been previously stated that high light conditions prior to harvesting fresh flowers and/or flowering plants can often result in longer lasting qualities after harvest because of relatively high carbohydrate levels. Also, various qualities of light can change the appearance, hence quality, of floral crops.
For example, red roses or poinsettias displayed under common fluorescent lamps may look off-colored because these light sources "bring out" the blue colors in the flowers. To bring out the red colors, lamps (i.e., incandescent) have to be used in addition to the common fluorescent sources. Finally, light acclimatization of foliage plants prior to harvest improves lasting qualities. But what effects do various light intensities during post-harvest operations have on the quality of floral crops?

At the extreme when no light is present after harvest for extended periods of time, numerous adverse effects often are noted viz. chlorophyll loss (yellowing); leaf, fruit, and/or flower abscission; and even death. Many foliage plants will start to lose foliage after 7 days of such treatment.

The more common situation is where various low light intensities are available to floral crops after harvest. While specific recommended light intensities for foliage and flowering plants will be presented in the respective commodity sections, information presented now concerns only fresh flowers.

Harvested fresh flowers are thought to have no photosynthetic (food producing) capacity by many in the floral industry. Thus, very little, if any, consideration is given to the storage of these flowers as related to light conditions. However, research has shown that harvested fresh flowers can photosynthesize, and many such flowers stored in areas where light intensities greater than 50 foot-candles have longer lasting qualities.

In another series of experiments, it was shown that harvested gladiolus flowers exhibited less geotropism (curving upwards) when stored horizontally in light (6 feet below a 200-watt lamp) than when stored in complete darkness. This observation was especially noteworthy at a temperature of 27°C while being less pronounced at 9°C.

With harvested snapdragons, however, flowers lasted 9.3 days in the dark and only 7.7 days in 200 foot-candles of light when held in water. When snapdragons were placed under similar light and dark conditions in floral preservative, both treatments lasted approximately 19 days. Thus, the presence of floral preservative was more important than light conditions.

Maintaining Quality After Harvest

FOLLOWING HARVEST, FLORAL CROPS MUST BE COOLED TO THEIR PROPER STORAGE TEMPERATURE AS FAST AS POSSIBLE. With some floral crops, delays of 30 minutes can substantially reduce lasting qualities.

Storage temperature should not deviate more than ± 1°C from the recommended temperature. Deviations greater than + 1°C can greatly increase water loss, respiration, and ethylene sensitivity of floral crops, thus, reducing lasting qualities. For example, the vase-life of
carnations stored for 14 days at 3°C over recommended (0°C) was reduced by 80%. At the other extreme, lower than recommended temperatures often promote freezing or chilling injuries since recommended temperatures are at the lower end to begin with. A number of tropical foliage plants are injured when subjected to cool (40 to 45°F) temperatures or watered with cold water. Plants particularly susceptible to low temperatures are *Aglaonema*, *Dieffenbachia*, *Fittonia*, and *Scindapsus*. Some other foliage plants that develop spots on foliage from cold water are *Philodendron*, *Syngonium*, and *Sansevieria*. Often foliage plants are permanently injured during transportation or when loading and unloading when subjected to freezing or even cool temperatures. Freezing damage will be obvious, but cold damage from exposure to cool but not freezing injury often is not. Such plants, however, will often have severely decreased functional life indoors.

Comfortable temperature levels for humans are adequate for most foliage plants. However, care should be taken to prevent temperatures around foliage plants from falling below 60°F as this will check growth. Temperatures below 45°F will permanently damage many foliage plants, so special care should be exercised during winter months when loading, unloading, or transporting foliage plants, and when selecting interior locations.

PLACE THERMOMETERS OR THERMOCOUPLES AT THE LEVELS THE CROPS ARE BEING STORED AND NOT JUST AT A LEVEL CONVENIENT FOR HUMANS TO READ. In some storages, it is common for temperatures to vary 5°C from ground to eye level.

Relative Humidity. UNLESS OTHERWISE NOTED, STORE ALL FLORAL CROPS AT 90 to 92% RELATIVE HUMIDITY. As with temperature control, small deviations (5 to 10%) in relative humidity can reduce crop quality. When the relative humidity is consistently less than 25% surrounding foliage plants, it is imperative to install humidifiers to aid in quality maintenance, but at least 50% relative humidity is suggested where possible.

Psychrometers, instruments to measure relative humidity, should be as common in floral storages as thermometers. If relative humidity is to be controlled, it has to be measured.

Light. DISPLAY FLORAL CROPS UNDER PROPER LIGHTS TO PROMOTE MAXIMUM COLOR EFFECTIVENESS. Mixtures of blue (fluorescent) and red (incandescent) light is required for flowering plants and fresh flowers while only fluorescent lamps are sufficient for foliage plants. Some fluorescent lamps have sufficient red light and no incandescent lamps are required when displaying flowering plants and/or fresh flowers.

STORAGE OF MOST FLORAL CROPS IN LIGHT EXTENDS POST-HARVEST LASTING QUALITIES. Storage of floral crops in the dark for relatively brief periods of time (1 to 3 days) generally does not reduce subsequent lasting qualities. It is suggested, however, that some light be provided in storages whenever possible. Light levels of 150 to 200 foot-candles have proven to be beneficial for crops like chrysanthemums and snapdragons.
In fact, light is an absolute requirement for the opening of bud-harvested chrysanthemums. In some cases, light levels do not have to be so high as to approach maximum photosynthetic rates. Low light levels of 5 to 10 foot-candles may be sufficient to reduce problems like leaf chlorosis and/or abscission.

**FOLIAGE PLANTS SHOULD BE ACCLIMATIZED.** Unless a greenhouse is available, the quantity of light available will be lower than the location in which the foliage plant was grown. However, foliage plants will not deteriorate rapidly unless light levels are below 75 foot-candles. Desirable lighting for foliage plants varies but should be in the range of 150 to 200 foot-candles for 10 to 12 hours a day in wholesale and retail establishments, and 75 to 150 foot-candles for consumer uses. A reduction in light intensity of up to 25% is usually acceptable, provided light is supplied for longer periods. Once plants become acclimatized to the use location, light intensity can be reduced to the recommended level or allowed to remain as originally supplied.

Light quality is less important for foliage plants than those grown primarily for their flowers. Light sources may be fluorescent, incandescent, or combination of the two types. Foliage plants look best under fluorescent lighting, which is a highly efficient light source. Excessively low light levels cause chlorophyll degradation (foliar yellowing), utilization of carbohydrate (food) reserves, and formation of hormones which influence leaf loss; any of which reduce quality of foliage plants.

**Watering Container-grown Plants.** OVER-WATERING AND NOT UNDER-WATERING IS THE MAIN PROBLEM. A proper soil mixture is absolutely necessary for plant and root growth and prevention of root damage from soluble salts which may be present in the soil medium. A soluble salts level in moist soil of up to 1200 parts per million (based on a 1:2 soil to water ratio) will not cause injury to most plants if the soil is moist, but if the soil is allowed to become dry, plants may be severely injured because the level may double or triple the original figure. This occurs because the level of soluble salts depends on the amount of free water present in the soil medium, and salts levels double each time there is a 50% reduction in soil moisture. Resulting higher soluble salts levels often severely damage root systems which prevents absorption of nutrients and water and may predispose them to disease organisms. Symptoms of injury from high soluble salts on plants may appear as marginal leaf chlorosis or necrosis of newer leaves, yellowing and dropping of older foliage, and retarded root growth. High levels of salts may be reduced by leaching the soil medium with good quality water.

Application of excessive water to container-grown plants also creates problems, but saturated soil conditions may be prevented by allowing excessive water to drain from containers with provision for drainage, tipping small containers without drainage on their sides until excessive water is removed, and using a dipstick technique on large planters and containers without drainage. Two rules to remember for proper watering
techniques are never allow the entire soil medium to become dry (top 1/2 to 1 inch is acceptable) and never allow plants to stand in water.

**Fertilizing Container-grown Plants.** FERTILIZING CONTAINER-GROWN FLORAL COMMODITIES AFTER HARVEST CAN BE DETRIMENTAL FOR FLOWERING PLANTS AND SHOULD ONLY BE DONE SPARINGLY FOR FOLIAGE PLANTS. Additions of fertilizer to foliage plants for the first few months after moving to interior locations are unnecessary. Nutritional levels supplied by growers are adequate under reduced interior light levels for up to three months, and fertilizer added by wholesalers, retailers, or consumers increases the probability of soluble salts damage to roots. Therefore, wholesalers and retailers should not only resist the temptation to add fertilizer, but should caution consumers about the practice. A general rule of thumb is that the interior fertilizer requirement is only 1/10 the required production level.

Some wholesalers, retailers, and even consumers immediately add fertilizer because the plant is not of the desired dark-green color. However, in most cases this is unnecessary and even undesirable, as foliage plants will develop a darker green color under reduced light intensities found indoors.

**Ethylene.** IT HAS BEEN ESTIMATED THAT 30% OF FLORAL CROPS DIE PREMATURELY BECAUSE OF ETHYLENE-INDUCED DISORDERS. The importance of maintaining low ethylene levels in areas where floral crops are displayed, handled, and/or stored cannot be overemphasized. The following are major factors that potentially can reduce post-harvest ethylene levels and/or reduce ethylene-induced disorders: proper aeration, use of ethylene filters, removal of damaged and/or diseased plants, proper storage temperatures, proper storage mix, and post-harvest sprays and/or dips.

Continuous exchange of air surrounding floral crops after harvest with air containing non-harmful ethylene levels can extend flower and/or plant longevity. This is especially critical in coolers or packaged floral crops that are closed or sealed for extended periods of time. Also, grading and/or storage areas near petroleum-fueled heaters and/or vehicle exhaust fumes should always be well ventilated.

The use of filters containing brominated-activated charcoal (BAC), or formulations of potassium permanganate, can reduce ethylene levels. The BAC filters are relatively efficient but can be short-lived in the presence of water, thus, are often limited under practical conditions. Also, because of its hydrophylic nature, significant amounts of water can be removed from floral packages containing BAC to the point of causing the floral crops to wilt. Because of this inherent problem with BAC, the use of potassium permanganate is recommended.

It has been well documented that damaged and/or diseased plant tissue produce higher amounts of ethylene than healthy tissue. Thus, it is critical to remove non-healthy plants and/or flowers at all stages in the marketing channel since damages induced mechanically and/or by pests indirectly or directly can result in increased ethylene levels.
Both ethylene production and ethylene-induced disorders are decreased at lower temperatures. At a given ethylene concentration, the higher the temperature the more problems associated with ethylene. As previously noted, increasing temperatures from 1.7°C to 21°C increased the effect of ethylene nearly 1000 times on opened carnation blooms. For example, carnations stored at 21°C in the presence of 1.0 ppm ethylene for 10 hours and subsequently placed in a preservative solution lasted approximately one day compared to a normal vase-life of flowers stored under similar conditions except at 1.7°C.

Do not store floral species that are ethylene sensitive with species, whether fruit, vegetable, or ornamentals, that produce high amounts of ethylene. The most common example is apples with carnations. Also, do not store "old" specimens with freshly harvested crops even of the same species. For example, carnations that are "old" can autocatalytically produce high amounts of ethylene that in turn can hasten senescence of the freshly harvested flowers.

Two major constituents of floral preservatives have been shown to reduce and/or delay ethylene production. Increasing sucrose levels from 2 to 16% delayed the onset of ethylene production by carnations up to 14 days while increasing lasting qualities by 10 days. A second major constituent, 8-hydroxyquinoline sulfate (8-HQS), suppressed ethylene production by rose stamens in both sterile and non-sterile conditions. The results obtained for non-sterile conditions was expected since 8-HQS is a germicide, and the microorganisms killed or inhibited themselves may have had the capacity to produce ethylene. The reduction of ethylene production under sterile conditions suggests that 8-HQS itself can directly interfere with ethylene biosynthesis. Preservatives. USING FRESH FLOWER PRESERVATIVE SOLUTIONS THROUGHOUT THE ENTIRE MARKETING CHANNEL CAN INCREASE PROFITS AND CONSUMER SATISFACTION. In general, successful preservative solutions have contained an energy source like sucrose and/or chemicals that have germistatal or germicidal properties. Presently, the most common preservative solutions contain various amounts of sucrose (1 to 4%) and 8-HQS (50 to 200 ppm) along with other constituents. Research has demonstrated that the longer fresh flowers are held in preservative solutions, the longer the flower longevity.

With an understanding of what floral preservative solutions are and what they can do in lengthening the longevity of fresh flowers, it is now important to know how to use them. The following is a list of factors that can influence the effectiveness of preservative solutions:

1) Water salinity influences lasting qualities. De-ionized and/or distilled water is best either with or without preservatives. For example, carnations stored in distilled water alone lasted 10.3 days compared to 5.8 days in tap water. With the addition of preservatives, flowers in distilled water treatments lasted 11.5 days while the ones in tap water lasted 10.5 days. Again, ones in tap water did not last as long. The same held true for roses: those held in tap water lasted 4.2 days compared to 9.8 days in distilled water.
High salts in water supplies can be removed using commercial de-ionization or reverse osmosis equipment. However, if steam boilers are available, condensate (distilled) water can be obtained. This water has been shown to have 90% of the salts removed. If condensate water is to be used, it must be drawn off before it reaches the makeup tank since new (high salinity) water is introduced there.

2) Fluoride levels of 1.0 ppm or greater can reduce lasting qualities of floral crops, especially gladioli. Levels of 1.0 ppm fluoride approximate those found in fluoridated water systems.

3) If pre-transport immersions using silver nitrate are employed, then subsequent re-cutting of the stems in the marketing channel will reduce lasting qualities.

4) Non-metallic containers should be used for holding the preservative solutions. If metal containers are used, there is a chance that some preservative constituents (i.e., AgNO₃, 8-HQC) could be rendered inactive by the metal ions. Also, non-metallic (i.e., plastic) containers normally last longer.

5) With most floral crops, the depth of stem submersion into the preservative solutions seems to make little difference as long as sufficient solution covers the cut end. Specifically with gladioli spikes, submersion to 7.5 cm was sufficient and higher levels were even slightly detrimental.

6) The length of time preservative solutions remain potent (useful) depends on numerous factors like temperature, degree of microorganism inoculation, and concentrations and types of preservatives used. Therefore, no definite recommendation can be made. However, cloudiness of the solution indicates the presence of microorganisms which probably means the solution should be discarded.

7) Re-cutting of stems not previously treated with silver nitrate can be beneficial. Cutting on an angle offers little or no advantage.

Storages. PROPER AIR CIRCULATION PATTERNS AND COMMODITY SPACING CAN BE AS CRITICAL AS TEMPERATURE AND RELATIVE HUMIDITY. Circulation fans should be positioned to "pull" the air throughout the storage versus "pushing" it through. The latter often results in dead spaces where little or no air movement exists. Also, high rates of air movement (i.e., 100+ linear f.p.m.) are only necessary during peak periods when relatively large amounts of heat have to be removed quickly. Otherwise, 50 to 75 linear f.p.m. is adequate with higher rates often being detrimental. Finally, the commodities being stored, whether packaged or not, should be so stacked as to have at least one surface exposed to freely circulating air. If this is not done, heat build-up may occur.
A new type of storage unit, called low pressure or hypobaric storage, is now being introduced commercially. Hypobaric storage provides environments where the atmospheric pressure is reduced and, hence, the products are stored in a vacuum. Table 13 presents data comparing the storage life of certain floral crops under normal and hypobaric conditions. It is strongly suggested that producers, wholesalers, and retailers of floral crops keep abreast of this new technology.

**TABLE 13. Storage life of certain floral crops under normal or hypobaric conditions**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Normal</th>
<th>Hypobaric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh flowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carnation (bud-cut)</td>
<td>10</td>
<td>90+</td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>6 to 8</td>
<td>21 to 28</td>
</tr>
<tr>
<td>Snapdragon</td>
<td>14</td>
<td>42 to 56</td>
</tr>
<tr>
<td>Gladiolus</td>
<td>5 to 7</td>
<td>30</td>
</tr>
<tr>
<td>Rose</td>
<td>7 to 14</td>
<td>56</td>
</tr>
<tr>
<td>Flowering plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>7</td>
<td>28 to 35</td>
</tr>
<tr>
<td>Easter Lily</td>
<td>14</td>
<td>42</td>
</tr>
</tbody>
</table>

*No. of days in storage with subsequent shelf-life equal to or better than freshly harvested crops.

**Packaging.** PACKAGE ONLY PRE-COOLED PRODUCTS AND DO NOT ALLOW THE PRODUCTS TO COME IN DIRECT CONTACT WITH THE CONTAINER ITSELF. Substantially more time is required to cool floral crops if they have been packed directly after harvest prior to bringing them to their optimum storage temperature. Also, plant tissue in direct contact with containers will have greater fluctuation in temperature and, thus, are more susceptible to injury.
There are many technological improvements that can reduce post-harvest shrinkage and help maintain quality for fresh flowers, flowering plants, and foliage plants. Some involve more precise control of storage and handling conditions such as air circulation, temperature, and relative humidity while others involve utilizing relatively old technologies such as precooling never adopted by the industry. More attention given to pre-harvest factors, air- and water-holding capacity of soil mixes for containerized plants, and maturity of the flowers at harvest are all important areas that need more precise industry management. However, the most critical areas requiring immediate industry change that already are restricting industry expansion involve the effective utilization of grades and standards, floral preservatives throughout the market channel, and better acclimatized foliage plants as well as consumer information regarding their purchasing and placement. Efforts in all of these areas will dictate if the industry is to technologically innovate and hopefully improve its competitive position with the consumer by providing a relatively lower cost, longer lasting, and higher quality product.

MORE FLORICULTURAL BUSINESSES NEED TO REINVEST RETAINED EARNINGS INTO IMPROVING AND ADVERTISING PRODUCT QUALITY AS A PROFITABLE PATH FOR MARKET EXPANSION.

Individual firms involved in producing, shipping, wholesaling, and retailing floral commodities need to evaluate available technologies for implementation in their operations. Too often businesses in floriculture have built more physical facilities avoiding consideration of how they can build the firm's productive capacity through reducing shrinkage, improving space utilization, and selling a higher quality product. Most of the technologies in this report involve a relatively small capital and labor investment, yet, offer rather substantial possibilities of improving the firm's competitive position by making the business more efficient and increasing product differentiation in the market in which the seller operates.

For example, the use of floral preservative and some consumer information on care and handling will cost the retailer as little as 6 cents per arrangement but will guarantee the arrangement to last over 50% longer in the home. Obviously, the investment is small relative to the value of the technology as a selling tool.

Just adopting a few of these technologies throughout the industry will mean an improving of the economic position of floriculture. It has been shown that without a doubt industries must continuously innovate and technologically progress in order to remain economically viable. The historical record for floriculture based on the failure to use available technology is in doubt. The consequences often result in (1) a decline in consumer purchasing, (2) low or nonexistent return on investment, and (3) an out-flow of capital from the industry. While the rapidly expanding consumer purchasing of bedding and foliage plants has allowed some alternatives to fresh flowers, in the long run the industry will have to reduce shrinkage because of its damaging effect.
Introduction

The following pages contain detailed information for the improvement of post-harvest characteristics of the major fresh flowers, flowering plants, and foliage plants utilized in the U.S. The major emphasis is to present information on various pre- and post-harvest factors that can influence the quality of these floral crops after harvest. Regarding foliage and flowering plants, information on handling these products generally cannot be substantiated in the literature. However, considerable general knowledge has been obtained at the Agricultural Research Center, Apopka, and the Department of Horticulture, The Ohio State University, Columbus, regarding foliage and flowering plants, respectively.

Also presented are the common, botanical, and family names for each crop as well as botanical phonetics and a list of related plant species. The reasons for including this type of information is now presented.

Because plants do have various common names throughout the U.S., it is extremely important to have a common language and a single name for each plant species, especially since more and more plant species are being introduced, thus increasing the chance of confusion. The botanical name is the universal name for a plant that unequivocally distinguishes that plant species from all others. Botanical names consist of two words: the genus and the specific epithet. The genus is always capitalized while the specific epithet is not, and both are italicized to indicate they are Latinized. Together, they are referred to as the botanical, scientific, Latin, or species name. The second word or specific epithet is not the species name. For example, Gypsophila paniculata is the botanical name for common Baby's Breath. The genus is Gypsophila and the specific epithet is paniculata. Often there is a third word or group of words associated with the botanical name. Generally this is either the cultivar (cv.) or sub-species name. An example of a cv. name is 'Nob Hill' in Chrysanthemum morifolium cv. Nob Hill while a sub-species name may be compacta as in Gypsophila paniculata compacta. Cultivar names are capitalized and in English while sub-species names are Latin and not capitalized.

Not only should the botanical name be known, but one must be able to pronounce it correctly to effectively communicate. A method of phonetically writing the botanical names is presented for each species.

Knowing the Latin, and/or common family name(s) of a plant can help a person understand more about that particular plant. For example, both Dianthus caryophyllus (carnation) and Gypsophila paniculata are in the same family Caryophyllaceae (pinks). By definition, since both of these plants are in the same family, they have similar flower characteristics.

As another way of assisting people in learning more about plants, important family and/or generic relatives are presented. This is useful information that can benefit consumers. For example, stating that sweet
peas, redbud, wisteria, clover, lupine, and goldenchain tree are in the same family and, thus, have similar flower structures, can help some consumers relate the crop they are purchasing (sweet peas) to other common plants.
Fresh Flowers

Anthurium

Anthurium andraeanum (An-THUR-ee-um an-dree-AH-num)

Araceae (Arum family) (Air-AY-see-ee)

Related plants—Philodendron, Aglaonema, Dieffenbachia, Monstera, Scindapsus aureus (Pathos), Caladium, and Calla.

Mostly Hawaiian-grown, anthuriums should be harvested when three-fourths developed and allowed to stand in water over night prior to air shipment to the mainland. Flowers can be stored up to 3 to 4 weeks in water at 55 to 56°F with little or no loss in subsequent vase-life. Exposure to temperatures below 55 to 56°F (i.e., 45°F for 48 hours) results in chilling injury as indicated by darkening of the flower color. Respiration can be decreased, vase-life increased, and susceptibility to chilling injury decreased when a post-harvest dip of 10 ppm N-6-Benzyladenine (not registered) is used. The use of preservative solutions is very beneficial, especially for the 'Nitta' cultivar.

Babysbreath

Gypsophila paniculata (Jip-SOPH-ill-lah pan-ick-u-LAH-tah)

Caryophyllaceae (Pink family) (Care-ee-oh-fill-AY-see-ee)

Related plants—(see Dianthus).

The inflorescence (spray) of babysbreath is a multi-branched type with individual flowers not opening simultaneously. Thus, the tip of spray opens first and must be harvested separately before the entire inflorescence opens. Flowering stems are normally cut 10 to 14 inches long and graded into 6- to 10-ounce bunches with 5 to 25 stems per bunch.

A major problem with this crop is that it dries out very rapidly. Therefore, harvested flowers last longest when placed in water or in low water-stress conditions (i.e., high relative humidities and low temperatures) when stored dry. Even under ideal conditions, storing dry for more than 2 to 3 days can greatly reduce lasting qualities. The best storage temperature is reported to be 40°F. Overnight conditioning prior to shipment of normally harvested flowers in 5 to 10% sugar and 25 ppm silver nitrate (not registered) can improve subsequent lasting qualities.

The best way to maximize lasting qualities is to harvest the flowers in the bud stage and subsequently open them in solutions like 200 ppm 8-HQC and 2% sugar or 25 ppm silver nitrate (not registered) and from 5 to 10% sugar. When done this way, flowers lasted 3 to 4 times longer compared to water alone and all flowers opened. In fact, the flowers developed better off the plant in opening solutions than they did still attached to the plants. The sugar and silver nitrate solutions
generally resulted in whiter flowers and less phototoxicity compared to 8-HQC and sugar, Everbloom, and a modified Cornell solution. Sodium benzoate (not registered) at 100 ppm also proved to be beneficial when used with 8-HQC and sucrose.

Carnation, Clove Pink, Picotee, Grenadine

*Dianthus caryophyllus* (Die-AN-thus care-ee-OH-fill-us)

*Caryophyllaceae* (Pink family) (Care-ee-oh-fill-AY-see-ee)

Related plants--*Arenaria* (Sandwort), *Cerastium tomentosum* (Snow-in-summer), *C. vulgatum* (Mouse-ear Chickweed), *Lychnis*, and *Gypsophila paniculata* (Babysbreath).

Within reasonable limits, various levels of nutrients supplied to growing carnations do not alter subsequent keeping qualities. However, unusually low potassium and calcium can reduce lasting qualities. As with many fresh flower crops, carnations grown under relatively high light intensities last longer than those grown under lower intensities often encountered in winter months. Carnations grown at 75°F have larger flowers and stronger stems but shorter lasting qualities compared to those grown at 60°F where the opposite occurs.

It is recommended that carnations be harvested in the bud stage when the flowers are approximately 3/4 to 1 inch in diameter and subsequently opened using any good preservative (opening) solution. Opening them in light (150 foot-candles) often results in slightly larger flowers. Flowers harvested this way are more easily handled, less susceptible to mechanical damages, unit transportation costs are reduced, and most importantly last longer. This latter advantage is especially significant with low light intensity-grown carnations that normally are lacking in carbohydrates. By harvesting these flowers in the bud and supplementing the carbohydrates within the cut flowers with sucrose, the flowers last longer. Reported disadvantages include grading problems, uneven opening, failure to open, and *Botrytis* problems.

Regardless of harvest maturity, flowers must be cooled rapidly to 31 to 32°F, the optimum storage temperature. Relatively short delays in cooling can reduce lasting qualities. Also, flowers stored at 31 to 32°F are less susceptible to ethylene-induced disorders like sleepiness. Under ideal conditions including high relative humidities (90%), low temperature (31°F), and vertical positioning of the flowers, carnations can be stored for 6 to 8 weeks. Under commercial conditions, storage of 2 weeks is more common.

Use of preservative solutions at all stages of the marketing channel is a must. Good solutions include 200 ppm 8-HQC and 3% sucrose; 400 ppm 8-HQC, 500 ppm B-Nine (not registered), and 5% sucrose; and 10% sugar and 25 ppm silver nitrate (not registered). Preservatives containing aluminum may be phytotoxic. Pre-shipment conditioning treatments
of a 1200 ppm silver nitrate (not registered) dip for 10 minutes is very beneficial as long as all wounds, including wounds caused by foliage removal, are covered and that the stems not be recut during the marketing operations. Other conditioning treatments include an entire dip for a few seconds in a 4-ounce per gallon solution of Benlate (not registered) or an overnight stem dip in 10% sucrose plus 200 ppm 8-HQC. The latter may increase Botrytis problems. Regardless of the solution utilized, use water containing soluble salts lower than 600 ppm. De-ionized water is best.

Shipping containers must be well-insulated and should have a vapor barrier like polyethylene to help maintain high relative humidities. Boxes should never be placed directly in the sunlight and should be under refrigeration at all times. High carbon dioxide levels (i.e., 10%) often existing in such containers can be beneficial as long as the oxygen level is adequate to prevent anaerobic conditions. High carbon dioxide storage (CA) per se is presently not economically feasible.

Statements that red and pink cultivars do not last as long as white cultivars cannot be documented in the literature when preservatives are used. Also, unsubstantiated is the claim that tinted carnations last longer.

A major problem with carnations is ethylene gas. Remember, ethylene is approximately 1000 times more active in inducing problems at 65°F compared to 35°F. Also, ethylene levels frequently encountered (approximately 50 ppb) are completely ineffective at 31°F but extremely effective at 38°F. Therefore, a major way to reduce ethylene problems is to maintain proper low temperatures (31 to 32°F). The use of ethylene "scrubbers" is a very good insurance policy to help improve product quality. While not always needed or effective, additional 2 days in vase-life have been measured using such scrubbers. Finally, if low pressure (hypobaric) storage becomes a commercial reality, then ethylene-induced problems with carnations can be essentially eliminated.

Chrysanthemum, Florist Chrysanthemum, Pompon

Chrysanthemum morifolium (Chris-AN-thee-mum more-i-FOH-lee-um

Compositae (Aster family) (Com-POZ-i-tee)

Related plants--Taraxacum (Dandelion), Lactuca (Lettuce), Gerbera jamesonii (Transvaal Daisy), Chrysanthemum maximum (Shasta Daisy), Achillea (Yarrow), Artemisia, Helianthus (Sunflower), Cosmos, Dahlia, Zinnia, Callistephus chinensis (China Aster), Aster, Tagetes (Marigold), Centaurea cyanus (Bachelors-Button), and Chrysanthemum frutescens (Paris or Marguerite Daisy).
Excessive nitrogen fertilization of chrysanthemums resulting in foliar nitrogen levels of 3.5% and higher can reduce lasting qualities and increase Botrytis susceptibility after harvest. During the first two-thirds of the growing season, normal fertilization should be practiced resulting in N:K ratios of approximately 1:1. However, the N:K ratio during the last one-third of the growing season should be reduced to approximately 1:2 by reducing or eliminating nitrogen fertilization. Also, ammonia-type nitrogen should not be used during reduced light intensity growing periods (e.g., winter months) to help ensure adequate lasting qualities.

Proper insect control is a must. Insects proliferating after harvest can reduce lasting qualities (i.e., stimulate ethylene production) as well as product appeal. Post-harvest stem dips with 600 ppm Azodrin (not registered) for one-half hour have been effective. Proper pre-harvest insecticide programs are the best preventive procedures presently being used commercially.

Even though chrysanthemums are considered to have a relatively long vase-life, proper cultivar selection is still an important way to increase their longevity. For example, 'Fred Shoesmith' lasts approximately 15% longer than 'May Shoesmith'.

Chrysanthemums, both standard and pompon, are generally harvested commercially when the (majority of) flowers are nearly completely opened. Subsequent vase-life is enhanced when they are stored under lights (50 to 100 foot-candles) at 31 to 33°F. Storage at higher temperatures can enhance Botrytis development.

Flowers can also be harvested in the bud stage. While no general recommendation for pompons can be made, standards are harvested when the flower diameter is approximately 2 to 2 1/2 inches. Compared to normally harvested chrysanthemums, bud-cut flowers can be generally stored dry equally well, are less susceptible to mechanical damage, easier handled, have equal or superior lasting qualities, and more stems can be placed in shipping containers. Subsequent opening of these flowers should be at warm (65 to 74°F) temperatures under approximately 75 foot-candles of light, and the use of opening (preservative) solutions is a must. However, flowers harvested too tight can result in flowers that won't store as long and will not open properly.

Regardless of the harvest maturity, flowers should be cut above the original height of the planted cutting. Cutting in the "old" (cutting) portion of the stem can result in reduced water uptake and, thus, reduced lasting qualities.

The type of preservative or opening solution used is critical. Commercially available solutions generally contain sugar and 8-HQC among other constituents. Levels of 8-HQC over 150 to 200 ppm can promote excessive stem discoloration and sucrose levels of approximately 1 to 3% and above can promote foliar necrosis and/or chlorosis, especially when bud-cut flowers are used. For this reason, bud-harvesting of chrysanthemum...
cannot be fully recommended at this time. Stem dips for 10 seconds in 1200 ppm silver nitrate (not registered) is advantageous since no phytotoxicity occurs. The water used should be low in soluble salts since every 100 ppm in salts can reduce flower longevity by approximately one-half a day.

The ultimate 3-dimensional shape of the flower can be influenced by post-harvest conditions. Continuous use of opening solutions with bud-cut flowers will increase the height of the flower heads. Using opening solutions for only the first 3 to 7 days after harvest can result in "flat" flowers. Also, excessive storage of chrysanthemums can result in "flat" flowers.

Partial shading in the growing areas of certain cultivars when they show color can help intensify the ultimate flower color. It is unknown what effect this has on lasting qualities. It is also unknown what effect the common practice of crushing the lower portion of the stem has on flower longevity.

Daffodil

Narcissus pseudo-narcissus (Nar-SISS-us SUE-do nar-SISS-us)

Liliaceae (Lily family) (Lily-AY-see-ee)

Related plants--Liriope (Lily-Turf), Hosta (Plantain-Lily), Hemerocallis (Day-Lily), Convallaria majalis (Lily-of-the-Valley), Tulipa (Tulip), Lilium (Lily), Scilla (Squill), Hyacinthus orientalis (Hyacinth), Muscari (Grape Hyacinth), Dracaena, and Chionodoxa (Glory-of-the-Snow).

Large-cupped daffodils should be harvested in the "goose-neck" stage, namely, when the flower angle to the stem is approximately 120° measured from the stem up. Under certain conditions, earlier harvests, while not recommended, can sometimes be successful as long as flower color is showing. Under no circumstance should daffodils be harvested past the goose-neck stage.

Recommended storage temperatures of 32 to 33°F result in storage life up to 3 weeks with no loss in subsequent keeping qualities have been reported but without supporting data. However, data were reported showing that goose-neck flowers lasted 1 to 3 days longer in preservative solutions compared to ones held in water. The preservative solutions should not contain 8-HQC over 150 ppm or else phytotoxicity can occur. However, the presence of sugar causes very significant ovary growth resulting in abnormally shaped flowers.

Techniques to remove the exuding sap from the cut stems did not increase lasting qualities. This same sap, however, can promote senescence of harvested tulips if stored in the same solution.
While not used commercially, the daffodil is one type of flower that has been successfully stored in the absence of oxygen. Flowers stored at 40°F in 100% nitrogen for as long as 3 weeks had a display life equal to that of freshly harvested flowers.

If excessive height is a problem resulting in weaker stems, a soil drench of 960 ppm ethephon (Florel) (not registered) when growth is approximately 6 inches high is effective in reducing subsequent elongation. The use of ethephon does not affect flowering date, flower size, or vase-life.

Gerbera. Transvaal Daisy, Barberton Daisy

Gerbera jamesonii (Jer-BEER-ah jame-i-SOH-neye)

Compositae (Aster family) (Com-POZ-i-tee)

Related plants--(see Chrysanthemum)

Gerberas are often harvested using a sideward push near the base of the flower stem leaving a relatively small area for water uptake. Therefore, it is imperative for the stem to be cut early after harvest. In fact, gerberas respond favorably to recutting at all stages of the marketing channel regardless of the handling and storage techniques used. Most cultivars should be harvested when the outer two rows of disc florets are perpendicular to the flower stem while even later harvesting is suggested for those cultivars that close at night.

Gerberas can only be stored at 35°F for short periods of time. Even after only one week of storage, subsequent vase-life can be reduced by 40%. Storage in preservative solutions is better than storage dry, in water, or in plastic bags.

The use of preservatives can double the lasting quality. As with most fresh flowers, immediate use of floral preservatives after harvest is better than a one-day delay in water. However, 1 ppm fluoride is phytotoxic and preservatives will not prevent this from happening.

The flower stems of gerberas often elongate substantially after harvest when placed in preservative solutions like sugar and 8-HQC. However, a 10-minute dip in 1000 ppm silver nitrate (not registered) or 600 ppm sodium hypochlorite shortly after harvest can improve the lasting qualities without accompanying stem elongation.

A final but very significant factor influencing post-harvest characteristics of gerberas is the cultivar being grown. Producers should become aware of the cultivars that last the longest.
Gladiolus

Gladiolus sp. (Glad-ee-OH-lus or Glad-EYE-oh-lus)

Iridaceae (Iris family) (Ear-i-DAY-see-ee)

Related plants--Iris, Crocus, and Freesia.

Gladioli are normally harvested when the lower 1 or 2 florets show color. Flowers harvested in the afternoon last longer than those harvested in the morning. To help ensure proper opening, floral preservatives must be used. Presently, the best solution consists of 600 ppm 8-HQC and 4% sucrose. As with most flowers, the earlier gladioli spikes are placed into and the longer they are held in preservative solutions, the longer the spikes will last with more florets opening of good color and size. Conditioning of spikes immediately after harvest in 20% sucrose or even plain water can also improve the opening and size of florets and increases flower longevity. The best temperature for opening gladioli spikes, regardless of preservative treatment, is from 68 to 77°F. Warm water (approximately 100°F) is also advantageous. However, submersion of the stem to a depth greater than 3 inches is of no value.

A major problem with the shipment of gladioli spikes is that they respond negatively to gravity by bending upwards when placed horizontally, similar to snapdragons. Numerous treatments have been tried to prevent this curvature but without substantial success. For example, storing the spikes in light can partially reduce this response. Thus, gladioli spikes must be transported vertically to avoid tip curvature.

Numerous types of packaging techniques have been tested using gladioli. Generally, those techniques that help maintain high relative humidity without promoting Botrytis growth are desirable. Venting of the containers is of no advantage while covering spikes with moisture-proof wrapping or stored in containers lined with similar wrapping materials is better than paper-lined containers.

The proper storage temperature is between 35 to 40°F with lower temperatures frequently promoting chilling injury. Recutting the stems during all phases of the marketing channel is advantageous.

Atmospheric fluoride or fluoride as low as one ppm in holding solutions is phytotoxic. The latter level is frequently encountered in fluoridated drinking water.

Gladiolus spikes can exhibit a post-harvest disorder called "topple". The main symptom of topple is the breaking-over of spikes as they open in vases. This is associated with insufficient calcium levels during growth in the field.
A final point is that only cultivars that exhibit good post-harvest characteristics should be grown. Some cultivars that exhibit good characteristics include 'Spic and Span', 'Traveler', 'White Friendship', and 'Wild Rose'. At the other extreme, some bad-lasting cultivars include 'Orange Gold', 'Tequendama', and 'Hopman's Glory'.

Iris, Bulbous Iris

*Iris* *hollandica* (represents crosses between *I. xiphium* x *I. tingitana*)

(*EYE-rih* hah-LAND-ih-cah)

*Iridaceae* (Iris family) (*Ee-ri-DAY-see-ee*)

Related plants--(see Gladiolus)

It has been reported (no data) that bulbous iris can be stored dry at 31 to 32°F for 2 to 4 weeks with little loss in subsequent vase-life. This author's experiences (no data) indicate that only in rare situations would iris flowers last that long. However, storage in water is recommended over dry storage.

It is known that 'Wedgewood' iris should be harvested when the flowers show color but just prior to the outer tepals (falls) reflexing or bending down. With 'Blue Ribbon' iris, allow the falls to reflex before harvesting to help ensure proper development off the plant. Also, with both cultivars, the basal-plate must be removed to allow better water conductance. Finally, immediately after harvest but before shipping, flowers should be conditioned in warm water or preservative solutions, the latter resulting in improved flower color and somewhat increasing the flower longevity. One of the better preservatives consists of 200 ppm 8-HQC, 50 ppm silver nitrate (not registered), and 5% sucrose. A second preservative that does a good job is Chrysal (components unknown).

Often growers of bulbous iris notice that certain bulbs flower substantially earlier than others in the same scheduled flowering time. Not only do these bulbs flower early, but also they often exhibit reflexed, twisting leaves. Examining the entire plant carefully usually reveals that the bulbs were infested with disease with results in increased ethylene production and, hence, the problem. These flowers are normally of inferior quality and should be discarded.

Orchid

*Cymbidium* sp. and *Cattleya* sp. (*Sim-BID-ee-um* and *CAT-lee-ah*)

*Orchidaceae* (Orchid family) (*Orchid-AY-see-ee*)

Related plants--*Vanilla fragrans* (Common Vanilla), *Dendrobium*, *Cypripedium*, *Oncidium*, *Vanda*, and *Phalaenopsis*. 
It would be very difficult, if not impossible, to make general recommendations for improving post-harvest characteristics for all of the orchid species and/or cultivars grown commercially. A case-in-point now follows:

It has been conclusively shown that most orchids store best at temperatures between 40 and 45°F (Vanda orchids store best at 55°F). Temperatures lower than this often produce "chilling" injury symptoms. This injury is manifested by a darkening of the column which later spreads to the labellum (lip) and then to the sepals and petals. At 40 to 45°F temperature conditions, most orchids can be stored for a period of approximately 2 weeks. However, there are certain species and/or cultivars (i.e., certain types of Cymbidium) that can be successfully stored at 31°F with no chilling injury exhibited and with subsequent excellent lasting qualities.

Flower development at harvest differs greatly. Some species can be harvested in the bud stage while others have to be essentially opened. Harvesting the latter type too early will result in a decrease in quality because, regardless what is done, they will not completely open.

It is often foolish for growers to store harvested flowers for extended periods of time because many orchids last much better on the plant. For example, members of the Cymbidium and Paphiopedilum genera often last 6 to 7 weeks on the plant and only 2 to 3 weeks once harvested. Hardening in 80°F water at 40°F for 24 hours is recommended prior to dry storage.

Depending on the species, storage of flower spikes versus individual flowers can be beneficial. For example, spikes of Phalaenopsis flowers do not wilt as rapidly compared to individual flowers when stored at 31 or 40°F.

Orchid flowers are very sensitive to ethylene, especially at the time the sepals begin to split apart. Levels of just 0.002 ppm can promote "dry sepal injury" which is characterized by a progressive drying and bleaching of the sepals. Not only are external ethylene sources problems, but also the promotion of extremely high ethylene production rates by orchids is encountered as a result of pollination or, in some cases, after emasculation (pollen removal). The use of ethylene "scrubbers" like potassium permanganate or activated charcoal has proven to be very useful. When using the latter type, care must be taken that the charcoal not remove too much moisture as to promote wilting.
Rose, Hybrid Tea Rose, and Sweetheart Rose

\textit{Rosa x hybrida} (ROH-sah HY-brid-ah)

\textit{Rosaceae} (Rose family) (Rose-AY-see-ee)

Related plants--Spiraea, Cotoneaster, Pyracantha (Firethorn), Crataegus (Hawthorn), Pyrus (Pear), Malus (Apple), Fragaria (Strawberry), and Prunus (stone fruits).

Growing conditions can influence the lasting qualities of roses. Temperatures above or below approximately 68°F can reduce subsequent longevity. Temperatures above 70 to 75°F can also result in flowers having decreased pigmentation and increased flower blueing. While lower temperatures increase pigmentation and flower size, it can also increase the occurrence of "bent necks". While supplemental carbon dioxide can increase flower pigmentation especially during low light conditions in the greenhouse, very little if any added flower longevity is added. The presence of insects like aphids and/or spider mites and diseases like powdery mildew and/or Botrytis can also reduce lasting qualities. Within reasonable limits, various levels of nitrogen and/or potassium do not alter lasting qualities. Thus, most conditions that result in a lowering of photosynthate production (i.e., low light intensities) and/or increased ethylene production (i.e., insect or disease damage) can reduce subsequent flower longevity.

Most rose cultivars should be harvested when the calyx reflexes. Harvesting at earlier stages often results in "bent necks" and/or failure of buds to open, while harvesting at a more mature stage reduces longevity. Flowers harvested in the afternoon generally last longer. Flowers harvested with older wood or "hooks" present do not have reduced lasting quality.

There are two main ways roses can be handled after harvest. For longer storage periods up to approximately 2 weeks, flowers should be placed immediately into moisture-proof containers at 32°F. It is important to allow the field heat to be removed prior to sealing the containers. Placing the flowers in water prior to dry storing will reduce flower longevity and increase flower blueing. Upon removal, stems should be recut and placed in preservative solutions for a minimum of 4 to 6 hours prior to shipping. This conditioning period is an absolute requirement.

The more common storage procedure, which is effective for 4 to 5 days, is to store roses in preservative solutions at 32 to 35°F. Immediately after harvest, roses are placed in preservative solutions at 32 to 35°F for a minimum of 3 to 4 hours prior to shipping. Again, as with dry-packed roses, this is an absolute requirement. Then, the roses can be graded, packaged, and shipped or placed back into the cooler. If being shipped short distances, shipping in preservative solutions is recommended.
If handled and conditioned properly prior to shipping, recutting upon receiving may be of no benefit. However, expect less than ideal conditions prior to receiving and recut the stems as well as conditioning again in preservative solutions for 4 to 6 hours prior to using them in arrangements or selling them. Removal of bottom leaves and/or thorns does not alter flower longevity as long as the bark is not injured. Crushing the stems will reduce lasting qualities by as much as 3 days. Cutting the stem on an angle is of no value. As with most floral crops, it goes without saying that flowers should be unpacked immediately upon arrival and placed in the proper environment. Clean containers should be used, and avoid excessive handling to reduce mechanical damages.

There is no doubt that the single most important factor in maintaining rose quality after harvest is the use of preservative solutions. Flower life can easily be doubled when preservatives are used. This is especially true for the grower who must condition the flower in such solutions prior to shipping. By doing so, the grower adds approximately one day of vase-life regardless of what the wholesaler and/or retailer does.

Most solutions contain 1 to 3% sucrose and 100 to 200 ppm 8-HQC plus other constituents. "Pulsing" the flower immediately after harvest with 10% sucrose solutions has also been shown to be beneficial. The use of Alar (not registered) at 500 ppm in addition to the 8-HQC and sucrose has also resulted in even greater flower longevity. Using preservatives reduces flower blueing and "bent neck". For maximum benefits, use floral preservative solutions throughout the marketing channel. Warm (approximately 110°F) solutions are often beneficial.

High soluble salts reduces flower longevity. Fluoride levels of 1.0 ppm can produce moderate toxicity while levels of 3.0 ppm result in severe toxicity.

Other post-harvest treatments like CA (high carbon dioxide) storage and the use of ethylene oxide to promote flower longevity have not proven to be useful and/or feasible.

Snapdragon

Antirrhinum majus (An-ti-RY-num MAY-jus)

Scrophulariaceae (Figwort family) (Scroh-few-lair-ee-AY-see-ee)

Related plants--Calceolaria, Veronica (Speedwell), Digitalis (Foxglove), and Nemesia.

Snapdragons should be harvested when a maximum of one-third of the florets have opened. If floral preservatives are used, as few as 1 or 2 opened florets are all that is needed with many cultivars to help ensure successful development of the remaining florets.
Recommended storage temperatures vary from 31 to 35°C. The freezing temperature is approximately 30.3°F. Snapdragons can be stored dry plus or minus paper wrapping for 3 to 4 days with no loss in subsequent lasting qualities and can be stored slightly longer when held in water. When stored in water containing no preservative, flowers last longer under dark versus light (200 foot-candles) conditions. However, light has no detrimental effect when flowers are stored in preservative solutions.

A major problem associated with snapdragons is their bending upwards in response to gravity (geotropism). In a matter of minutes, freshly harvested flowers placed horizontally will permanently bend upwards, thus reducing quality. Because of this, snapdragons are not often transported great distances, or if they are shipped, should be packaged in the vertical position. One chemical, N-1-naphthylphthalamate (NP), which is not registered has been shown to greatly reduce or eliminate this problem. For best results, 30 ppm NP should be used immediately after harvest as a 2-hour stem dip. It must be emphasized that flowers should not be held horizontally prior to this dip or stored vertically but must be given a sufficient amount of time after grading before the NP treatment to help assure success.

Snapdragon flowers respond very favorably to preservative solutions. On the average, a 2 to 3 times increase in flower longevity can be realized using mixtures of 300 ppm 8-HQC and 1.5% sucrose or similar solutions. Also, from 10 to 50 ppm n-dimethyl amino succinamic acid (Alar, B-Nine) or 50 to 100 ppm 2-chloroethyltrimethyl ammonium chloride (CCC) (both not registered) added to 8-HQC and sucrose solutions adds even more longevity.

Snapdragons are very susceptible to ethylene. The flowers themselves produce large quantities. Regardless of the source, "shelling" or "shattering" is the common result. Therefore, store in areas containing very low ethylene levels. A substituted benzothiadiazole (TH6241) (not registered) when sprayed on snapdragon flowers at 5 x 10^-4 M prevented shattering of the florets exposed to 500 ppb ethylene. Presently, plant breeders are developing lines more resistant to ethylene-induced disorders.

Snapdragons seem to be very tolerant to post-harvest water sources. Soluble salts up to 1000 ppm in the vase water seem to promote no loss in keeping qualities. Also, the level of fluoride has to be greater than 3.0 ppm before the flowers are injured.

Stock, Gilli-Flower

*Matthiola incana* (Math-EYE-oh-lah in-KAY-nah)

*Cruciferae* (Mustard family) (Crew-SIF-er-ee)
Related plants—Brassica (Mustards, i.e., Cabbage, Broccoli, and Cauliflower), Raphanus sativus (Radish), Iberis (Candytuft), Lobularia maritima (Alyssum), and Arabis (Rock-Cress).

It has been stated, but no data reported, that stock should be harvested when 1/2 to 2/3 of the florets are opened and should be stored at 40°F. Also, no data were located supporting the practices of crushing or smashing the stems and/or completely dipping the harvested flowers in water. Therefore, the handler of stock flowers must determine the validity of these practices.

It is known that preservative solutions like 300 to 400 ppm 8-HQC and 1 to 8% sucrose plus or minus 10 to 50 ppm Alar (not registered) increases lasting qualities from approximately 3.5 days to 7.5 days. Stock flowers freeze at approximately 30.5°F. Also, a pre-harvest spray of gibberellin (not registered) at 100 to 200 ppm when the lower florets begin to show color results in larger and more showy flowers.

Finally, a spray of from 25 to 50 ppm \(N^6\)benzylaminopurine (not registered) 2 hours before harvesting results in flowers having lower respiration rates, longer lasting qualities, and darker green foliage. Also, post-harvest stalk elongation was inhibited by this chemical regardless of whether the stems were held in the light or dark. Regardless if \(N^6\)benzylaminopurine is used, store stock in the light to prevent this elongation resulting in a strung-out appearance.

Tulip

*Tulipa gesneriana* (TOO-lip-ah jez-near-ee-AH-nah)

*Liliaceae* (Lily family) (Lily-AY-see-ee)

Related plants—(see daffodil)

Proper cultivar selection, stage of harvest, and storage temperature are the three most important factors influencing the lasting quality of tulip flowers.

By selecting the proper cultivars, tulip flower longevity can be increased by over 100%. Notoriously poor lasting tulips include most of the Darwin hybrids like 'Apeldorn', 'General Eisenhower', 'Gudoshnik', 'London', 'Oxford', and 'President Kennedy'. These cultivars last on the average only 3 to 4 days at 75°F while 5 to 6 days is considered to be the minimum standard for good post-harvest longevity. A complete cultivar listing of tulip flower longevity is available from The Netherlands Flower-Bulb Institute, 5 World Trade Center, Suite 6217, New York, NY 10048.

Tulips must be harvested in the green-bud stage which is when the upper one-half portion of the flower is showing color. Flowers harvested at this stage last longer, are less susceptible to mechanical
injury, and can be stored for longer periods of time. The time of day or weather conditions at harvest do not influence subsequent lasting quality nor does the angle at which the stem is cut.

Successful storage of tulip flowers for 52 days has been achieved using certain cultivars under highly controlled conditions including various packaging materials and modified atmospheres. However, a maximum storage life of 2 to 3 weeks is all that can be expected using commercially available technologies. Maximum storage life (i.e., 2 to 3 weeks) is achieved when the flowers are harvested in the green-bud stage with the bulb attached and stored dry in the vertical position at 31 to 32°F. Flowers harvested at the same maturity but without the bulbs attached can be stored for approximately one week at 31 to 32°F in the horizontal position. Storage temperatures of 35°F and over are too warm for both harvest techniques. Also, regardless of storage technique, flowers should be wrapped in newspaper or similar materials to provide added strength and to aid in subsequent conditioning of the flowers. However, if wrapped in materials that will not allow sufficient air exchange, conditions conducive for pathogen growth may occur. Storage of tulips in water for over 1 to 2 days is not recommended if for no other reason than extensive stem elongation can occur. Storage of tulips in containers with narcissus will materially reduce the keeping quality of the tulips.

When removed from storage, stems should be recut (or cut in the case when the bulbs are attached) and placed still wrapped in warm water and conditioned for 2 to 4 hours prior to putting them in arrangements or being sold to the ultimate consumer. It is important that the flowers be in the vertical position to reduce any permanent bending induced by gravity (geotropism), thus the reason for keeping them wrapped. This conditioning not only can improve longevity, but also flowers so treated are less susceptible to severe delivery conditions. The use of preservative solutions has produced variable results at best and for sure has not resulted in 50 to 100% increases in longevity as noted with many other flower species.

A major problem with tulip flowers is the post-harvest elongation of the stems. Although producing stronger stems, the use of preservatives can actually increase this stem elongation. Preliminary research using ethephon (not registered) has resulted in a reduction of stem elongation.

The greatest amount of water uptake with tulip flowers occurs during the first 24 hours after being placed into the water or preservative solution. For this reason, special emphasis must be made to educate consumers receiving tulip flower arrangements to replenish the water soon upon arrival.
Flowering Potted Plants

Sales of flowering potted plants may depend not only on the quality of the product, but also proper care in the sales outlet and artistic staging of the plants for maximum yet pleasing display. Keeping the plants in good condition by attention to watering, removal of yellow or dead leaves or broken flowers and stems as well as over-ripe or nearly dead plants, and preventing the area from becoming "trashy" will present an attractive facade to the prospective buyer. Inattention to these important details is often commonplace particularly in mass market sales areas, and is a contributing factor to the failure of many such outlets to fully capitalize on the market potential.

Relatively little research has been done on a number of the practices concerned with the handling of flowering potted plants from the time they leave the area of production until they are placed on display for sale. Much of which follows is based on experience and observation of what takes place as the plants are handled in the trade.

To produce a plant with substance, the grower should finish the crop at a temperature several degrees lower than that at which the plants were grown. This causes an accumulation of carbohydrates which adds substance to the plant. Such a practice generally intensifies the color of the flowers also.

Plants are normally boxed, several to a cardboard container, for ease of handling and protection. The plants should not be placed in the container and left in the greenhouse where the temperature in the box may rise considerably causing a loss of quality. Furthermore, keeping the plants in the boxes for prolonged periods is conducive to quality loss in that in the absence of light, the chlorophyll or green pigment in the leaves breaks down so that yellowing and dropping of the foliage will be very evident. It is generally believed that 4 days is the very maximum that most flowering plants should be boxed. The high relative humidity in the box is also conducive to development of the fungus Botrytis or gray mold which infects leaves and petals causing them to become watersoaked in appearance and turn brown. The quicker the plants can be removed from the boxes and put on display, the better. At the least, the boxes should be opened so the plants will get some light, no matter how poor, and the relative humidity will be reduced.

It is known with some cut flower crops that near the end of their production, reducing the nitrogen applied to the soil medium will add to their keeping quality and the same is probably true with many flowering potted plants. Those types of plants that can be grown on, however, such as Rieger Begonias, fuchsias, hanging baskets, and to some extent poinsettias, should have fertilization continued to the point of sale in order to insure success with the plant on the part of the ultimate purchaser. Slow-release fertilizers are very useful in this instance. There is no excuse for producers to use so little fertilizer that the plants have yellow lower leaves or otherwise light green and starved. Buyers should look elsewhere for their stock if this situation exists.
Nothing is more detracting than a display of flowering potted plants that is wilted. If allowed to go too far, the wilted plants will not recover and will have to be removed, not marked down in price to encourage unwary buyers. In the dry atmosphere of the retail flower shop or mass market outlet, loss of water vapor from the leaves and flowers is considerable to say nothing of evaporation from the soil or through the walls of a porous container in which they grew. Water should be applied when the first indication of "flagging" or slight wilting is evident, and the amount of water should be sufficient to thoroughly wet all of the soil medium and run out the drain holes at the bottom or side of the container. The above is most important! Do not apply just enough water to wet the soil surface or penetrate only part way into the soil—the wilting may be less evident but the lower roots usually die from dehydration. Water thoroughly again when the soil medium surface is quite dry to the touch or incipient wilting becomes evident. Soil in plastic or non-porous containers dries more slowly than if in a clay container. Be careful not to water too often or apply too much if there is a pot wrap that has no drainage—aluminum foil, etc. Roots of plants standing in water will be killed from lack of oxygen.

In the home, watering of plants that are excessively dry can be accomplished by removing the decorative pot wrap if one is present. Then submerge the pot in water in a pail or sink to a depth to cover the medium until bubbles cease rising through the soil. This thoroughly and uniformly wets the medium. When the pot is removed from the water and dripping ceases, the pot wrap can be replaced. This method is especially useful where large proportions of peat moss are used in the medium because once it becomes dry, it is very difficult to re-wet by overhead watering.

Bright indirect light is best for the plants, but most sales outlets may not have such ideal conditions. In a retail flower shop rotation of plants from darker areas to lighter locations is possible. Mass marketers should rely on fast turnover so the plants are not in the store any longer than necessary, although most supermarkets, etc., are now well-lighted using fluorescent lamps.

Staking and/or tying of some plants may be necessary to prevent entanglement of stems and flowers which will break when the plants are handled. These operations should be done by the grower, but if necessary, several light bamboo stakes placed equidistantly around the pot and green waxed string tied to one stake and placed around the plant looping it around the other stakes will save what would otherwise become a broken or damaged plant.

Sleeves are usually placed around the plants prior to boxing and delivery. If the turnover of plants is rapid, the sleeves need not be removed, but otherwise they can be taken off by tearing down the glued overlap. Some protection will be needed for all plants in cold weather since the weakest link in the marketing and sales chain could be from the point of sale to the customer's vehicle. This is one reason for not removing sleeves on all plants on display.
The art or technique of displaying the plants is one that is often overlooked. Plants with flowers facing up, such as chrysanthemums and poinsettias, should be staged low enough so customers can see the plant from above, certainly not above eye level. Plants with pendant or drooping flowers, such as fuchsia or Christmas Cactus, should be displayed high enough so customers can look at the flowers without undue stooping.

Crowding the plants in the display area is a sure way to reduce sales. Plants jammed together so their individual characteristics and beauty cannot be seen won't sell as well as those artfully displayed so that the customer can easily select what he desires. Removal of a plant from a too-crowded display generally results in breakage or damage of adjacent plants.

Proper lighting in the display area is often overlooked. Fluorescent lamps emit very little red radiation, hence flowers or leaves with red pigment may look faded or even bluish because there is so little red reflected from them to the eye. Using a few spotlights or incandescent lamps which are naturally rich in red radiation will "spruce up" an otherwise drab display due to improved wave lengths of light.

Needless to say, the presence of insects and allied pests detract from sales. If these are not discovered until the customers have taken them home, they have a right to be irate and demand exchange or their money back. There is an adequate selection of registered insecticides that growers can use to prevent and/or control the pests before the plants are sold, and buyers should advise their suppliers of past insect problems and if unheeded, buy elsewhere.

Care tags are available and growers should put these on plants sold to mass market outlets since store clerks often know less than the customers about plant care. Retail florists can imprint their shop name on a care card as advertising. A satisfied customer is one that will come back to buy again, and care cards can provide useful information for cultural practices to be followed.

African Violet
Saintpaulia ionantha (Saint-PAUL-ee-ah eye-oh-NAN-thah)
Gesneriaceae (Gesneria family) (Jes-nare-ee-AY-see-ee)
Related plants--Achimines, Aeschynanthus, Columnea, Episcia, Gloxinia (Sinningia), Streptocarpus.

The African Violet is a most satisfactory plant for the home, since it will grow and flower well at relatively low light levels (1200 foot-candles of natural light and 400 foot-candles for 18 to 24 hours per day from fluorescent sources). Plants do not store well, and if in
complete darkness for several days, flowers will drop. Ethylene gas in the air or pollination which causes self-generation of ethylene will cause rapid flower drop.

Cold water on the leaves will cause development of yellowish blotches on the foliage within 72 hours due to destruction of the chlorophyll or green pigment in the leaves and from which there is no recovery. Water temperature as warm as the room or up to 100°F can be used without causing trouble.

Thrips which cause pollination, mealybugs which are under the white cottony masses on the underside of leaves, and cyclamen mites which dwarf the new growth are the major pests. Since the tissue is succulent it easily rots if damaged, and crown rot is caused from water standing in the crown of the plant overnight. Powdery mildew can be a problem if the air temperature is below 60°F for prolonged periods.

The African Violet does not tolerate temperatures below 55°F. New leaves will curl downward and new growth will be checked from exposure to cool temperature. Slow-release fertilizers are very useful with this plant.

Azalea (Ah-ZALE-ee-ah)

*Rhododendron obtusum* (Roh-doh-DEN-dron ob-TOO-sum)

Other species are known to have contributed to the numerous cultivars of azaleas now in the trade. These are *R. indicum*, *lineari-folium*, *mucronatum*, *pulchrum*, *scabrum*, *simsii*, *tschonoski*, and *yedoense poukhanense*.

*Ericaceae* (Heath family) (Air-i-CAY-see-ee)

Related plants--*Calluna* (Heather), *Erica* (Heath), *Kalmia* (Mountain Laurel), *Pieris* (Andromeda), and *Vaccinium* (Blueberry and Cranberry).

These colorful plants with red, pink, white, lavender, or bi-colored flowers will last up to 6 weeks in the home if properly cared for. Most azaleas are produced in peat moss or a medium consisting largely of peat and when it becomes somewhat dry it is very difficult to wet. Plunging the pot in water as described earlier in the introduction to this section is suggested. Azaleas should be given bright indirect light for longest life in the home.

Azaleas will drop leaves readily if kept in the dark, and furthermore are very subject to foliage drop from the presence of ethylene. Plants should not be placed in the proximity of fruits, particularly apples which are notorious for their production of this gas.

Most greenhouse azaleas are not hardy except in more southerly climates, hence it is generally useless to plant the specimen outside in hopes it will live.
Calceolaria, Pocketbook Plant

**Calceolaria x hybrida** (Cal-see-oh-LAIR-ee-ah HY-brid-ah)

**Scrophulariaceae** (Figwort family) (Scroh-few-lair-ee-AY-see-ee)

Related plants--(see snapdragon, fresh flowers)

A colorful, flowering plant with rather poor keeping quality since it does best at temperatures around 55°F. Flowers are like small balloons and are spotted yellow, orange, or red. Under warm conditions, 60°F or higher, the plants and flowers quickly degenerate. This is a rather unsatisfactory plant for most people unless they have a cool room with adequate indirect light or a home greenhouse.

Christmas Cactus and Easter Cactus

**Schlumbergera bridgesi**--Christmas (Schlum-BER-jer-ah BRIDGES-eye)

**Schlumbergera gaertneri**--Easter (Schlum-BER-jer-ah GAIRT-ner-eye)

**Cactaceae** (Cactus family) (Cac-TAY-see-ee)

Related plants--Crab or Christmas Cactus (Zygocactus), Night-Blooming Cereus (Hylocereus or Nyctocereus), Prickly-Pear (Opuntia).

Much confusion exists in the identification of these plants because they are short-day types and both can be flowered any day of the year. The decorative red or orange-red flowers are borne at the end of flattened stems and hang downward.

Display these high enough so the flowers can be seen near eye level. The soil medium can become quite dry without undue harm, and overwatering will quickly kill the roots. The plant will do well under conditions of bright indirect sunlight and will last many years in the home if properly cared for. When the plants are kept in a room where there is light at night, this provides a long-day condition so the plants will grow vegetatively and not flower. However, if the plants are placed in a location where there is no light at night yet given bright indirect light during the day, they will form flower buds and approximately 12 weeks after the start of such treatment they will produce flowers at the tips of the flattened stems.

Chrysanthemum

**Chrysanthemum morifolium** (Kris-AN-thee-mum more-i-FOH-lee-um)

**Compositae** (Aster family) (Com-POZ-i-tee)

Related plants--(see Chrysanthemum, fresh flowers)
The potted chrysanthemum is one of the most satisfactory flowering plants because it is colorful and has excellent keeping quality under rather unfavorable conditions. Many growers sell their plants when the flowers are not developed to at least one-third open, and under dark conditions in the home, they will not open. Allowing the flowers to be half open prior to sale will permit full development of the flower even under rather adverse conditions. When the center of the flower turns dark, it is indicative that the plant doesn't have enough food to develop the inner florets.

Bright indirect light or at least one-half day of full sun is suggested, and the watering should be thorough to wet all of the medium in which it is growing. The plant should last at least 2 weeks and perhaps as long as a month if it is of good quality to begin with and receives proper care. Unless the cultivar is a garden type that will grow and flower outside, there is no need to apply fertilizer. After the garden-type cultivars have flowered, cut them back to within several inches of the ground, knock the soil ball out of the pot, separate the individual plants, and set them in the garden after danger of frost or freezing is past.

Their longevity and wide range of flower color and forms makes the pot mum a popular plant. It lasts well even in warm temperatures, such as in hospitals, but if kept at 55 to 60°F each night, will last even longer. High nitrogen or high salts level in the soil at the time of sale reduces ultimate lasting quality. A good root system is an important factor in long keeping quality in the home.

Plants should not remain in boxes for more than a few days since lack of light will cause the flowers to deteriorate, especially the centers which may not open when placed in a favorable environment. Plants displayed for sale should be on a low shelf or staging so they can be viewed from above to show off the flowers to fullest advantage. Crowding the plants on display will cause stems and flowers to entangle, and many flower heads and stems will be broken when customers attempt to remove a plant. Also, a proper mixture of light quality will enhance flower color.

Potted mums should be about three times the height of the pot in which they are growing (including the pot) and a spread of not over three times the width of the pot. Many plants offered for sale are too narrow for their height caused by the producer growing them too close. One cutting (not potted specimen) should be given one-fourth square foot on the bench in order to permit adequate development. A pot consisting of 5 cuttings per 6-inch pot should have 1.25 square feet of space which is a center to center spacing of individual pots at 12 x 15 inches. If the plants have to be staked and tied, it generally indicates poor culture on the part of the producer.
Cineraria

Senecio cruentus (Sen-EE-she-oh crew-EN-tus)

Compositae (Aster family) (Com-POZ-i-tee)

Related plants--(see Chrysanthemum)

This colorful flowering plant is generally available in the winter and early spring months, and when well-grown will attract considerable attention because it will be covered with daisy-like flowers with petals that are red, lavender, or white with a red or lavender edge. However, it has very poor lasting quality under normal indoor environments because it should be kept cool--not over 55°F.

Watering will be a problem on display or in the home as the large leaves cause great water loss and the plants wilt readily. If the roots are killed, the plant will wilt even when the soil mixture is moist. The dry, warm air in places of sale and the home are not conducive to long life of the plants.

Cyclamen

Cyclamen persicum giganteum (SIGH-clah-men PER-sick-um jy-GAN-tee-um)

Primulaceae (Primrose family) (Prim-u-LAY-see-ee)

Related plants--Lysimachia, Primula (Primrose), Shooting Star (Dodecatheon)

The flowers on this plant face downward, but the reflexed petals are relatively broad and long making it very attractive. Colors are red, pink, dark red, white, and some bicolors, and occasionally doubles, frilled, or rococo types are seen.

Unfortunately, the plant does not tolerate warm conditions, and unless it can be kept in a cool room (55 to 60°F), it will degenerate from excessive wilting and failure of the flower buds to develop. It should be placed in bright indirect light for longest life in the home.

Easter Lily

Lilium longiflorum (LILL-ee-um lon-ji-FLOR-um)

Liliaceae (Lily family) (Lily-AY-see-ee)

Related plants--(see daffodil)
Easter lilies are in greatest demand as potted plants just prior to Easter, and because there is no market for them after this holiday, they must be produced and marketed for this rather short period.

A good quality lily has dark green leaves down to or near the top of the pot. Crowding on the bench or insufficient nitrogen will cause yellowing or browning of lower leaves indicating poor culture. In the greenhouse plants in 5 1/2-inch pots can be spaced 6 x 7 inches whereas those in 6-inch pots should be grown no closer than 3 per square foot (6 x 8 inches) to avoid loss of lower leaves and stretching. Lily plants over 22 inches high, including the pot, are considered too tall unless produced for some special use.

Removal of the anthers or pollen-bearing organs in the flower before the pollen sheds keeps the interior of the flower or trumpet clean, but apparently has little effect on longevity of the flower.

There are several cultivars available. The 'Croft' is seldom grown, even though it has large flowers because of root rot and leaf-scorch problems. 'Ace' is the most popular type followed closely by 'Nellie White'. 'Ace' has narrow dark green leaves with a light stripe on the mid-vein whereas 'Nellie White' has wider, somewhat lighter green leaves and the plant is usually a little shorter than 'Ace'. Both have flowers of excellent keeping quality. Individual flowers of 'Georgia' or 'Arai', the latter a Japanese-grown 'Georgia', only last about two-thirds as long or approximately 7 days as those of 'Ace' or 'Nellie White' which are good for 10 days in the home under proper conditions.

Plants can be stored in the dark at 35°F when the flower buds are in the white puffy stage (not open). Flowers that are open will look satisfactory during cool storage but quickly degenerate when brought into room temperature. Plants should not be kept more than 4 days in the dark or buds may deteriorate or get Botrytis and lower leaves may turn yellow.

Since the bulbs are infected with one or more virus diseases, it is not suggested they be planted in the garden because they will infect other lilies (Lilium). If there are no other lilies, and they are planted outside, a new shoot will grow and flower in the fall. Usually, the summer temperatures are too warm for ideal bulb growth, and they will split into smaller bulbs after several years which won't flower.

Fuchsia, Ladies Teardrop

*Fuchsia x hybrida* (FEW-shee-ah HY-brid-ah)

Onagraceae (Evening-Primrose family) (Oh-nah-GRAY-see-ee)

Related plants--Clarkia, Evening-Primrose (*Oenothera*), Godetia, Water-Chestnut (*Trapa*).
In the spring this plant with pendant flowers of red, pink, purple, lavender, white, and combinations of these colors is an attractive addition to a line of potted plants. The flowers will drop quickly if the environment is not favorable and darkness or too heavy a shade can be a problem although the plants will not tolerate full sun. Because of the commonly experienced flower drop, this plant is not recommended for most indoor environments, but the trailing types make striking hanging baskets for patios, etc.

Plants should be displayed near eye level in order to best view the hanging flowers.

Gloxinia

*Sinningia speciosa* (Sin-NIN-gee-ah spee-she-OH-sah)

Gesneriaceae (Gesneria family) (Jes-nare-ee-AY-see-ee)

Related plants--(see African Violet)

These large-leaved plants with showy, tubular red, purple, or bicolor flowers are low growing, and they can be purchased year round in many parts of the country.

The plants do best in bright indirect light, but full sunlight generally will burn the foliage. They do well under fluorescent lights at twice the intensity suggested for African Violets.

If water stays on the crown or center of the plant overnight, rot generally follows so care must be exercised to water the soil, not the foliage. Water spots or yellowish blotches on the leaves can be caused on some gloxinias from very cold water--similar to that described for African Violets.

The cause of failure of the small buds to continue to develop is insufficient light. The plant can be rested after flowering has ceased by gradually reducing the water as the leaves turn yellow. The fleshy corm can be repotted in fresh soil and started again.

Hyacinth

*Hyacinthus orientalis* (Hy-ah-SIN-thus ore-ee-en-TAL-is)

*Liliaceae* (Lily family) (Lily-AY-see-ee)

Related plants--(see daffodil, fresh flowers)

Plants should be purchased by the retailer or mass market buyer when they are just showing color since they will grow very rapidly in the warm conditions of the sales outlet. If purchased when quite well
developed, they will soon deteriorate since many Dutch bulbs are not known for longevity of their flowers.

Oftentimes, hyacinths are seen which are very tall indicating they were kept at too warm a temperature in storage or in the greenhouse, and they stretched necessitating staking and tying. Such plants are generally ungainly in their appearance and lack sales appeal.

Hyacinths must be kept cool at night (50 to 55°F) for longest life. When the flowers are no longer decorative, keep watering as needed until the leaves turn yellow and die. Plant the bulbs in the garden when danger of frost is past, and next year and thereafter they should flower.

Hydrangea

**Hydrangea macrophylla** (Hy-DRAN-gee-ah mac-roh-FILL-ah)

**Caprifoliaceae** (Honeysuckle family) (Cap-ri-foh-lee-AY-see-ee)

Related plants—Elderberry (*Sambucus*), Honeysuckle (*Lonicera*), *Viburnum*, and *Weigela*.

Hydrangeas are very striking plants because of their large, colorful heads composed of many bracts, the true flowers being hidden underneath. Unusually large or tall specimens will need to be staked to prevent breakage.

The greatest problem with hydrangeas is that their large leaf and bract (flower) area looses quantities of water, and the plants wilt very rapidly under the warm and dry air conditions of most sales outlets. Watering must be thorough and frequent to prevent wilting. In the home, the submersion of the pot as indicated in the introduction to this section is the most satisfactory method of irrigation.

Bright indirect light is best, and if in sunlight the leaves and flowers may burn or scald. Rot of the heads is common if the producer did not space the plants to prevent the heads from touching or the plants were in a box too long. Under proper conditions the plants may last for up to 6 weeks in the home.

Because the plant is woody, many people plant it outside, and even though the plant itself is hardy, the flower buds are generally killed each winter except in more southerly climates.

Jerusalem Cherry, Cleveland Cherry

**Solanum pseudocapsicum** (So-LAIN-um sue-do-CAP-sick-um)

**Solanaceae** (Nightshade family) (So-lan-AY-see-ee)
Related plants--Browallia, Chinese Lantern-Plant (Physalis), Jimson Weed (Datura), Nightshade (Solanum), Petunia, Red Pepper (Capsicum), Tobacco (Nicotiana), Tomato (Lycopersicon).

One of the few fruiting plants produced by florists. It is generally sold from Christmas through Valentine's Day where its orange-red fruit about one inch or less in diameter make it an attractive plant that is quite different. The fruit is not poisonous as is widely believed, but has a bland, unappetizing taste, and the mouth is often puckered for a short time after ingestion.

Kalanchoe

Kalanchoe x blossfeldiana (Kale-an-KOH-ee bloss-feld-ee-AH-nah)

Crassulaceae (Orpine family) (Crass-u-LAY-see-ee)

Related plants--Crassula, Hen and Chickens (Echeveria), Houseleek or Live Forever (Sempervivum), Stonecrop (Sedum).

The older cultivars that were low growing or dwarf (Tom Thumb) are giving way to newer, more robust hybrids characterized by larger leaves and flowers with flower colors of orange-red, red, yellow, cream, and violet.

The kalanchoe is a short-day plant and can be flowered any day of the year as with potted chrysanthemums. Though the flowers are relatively small, they are produced in such profusion that a mass of color is obtained. The flowers have excellent keeping quality, and the plant under good culture in the home, etc., should last at least one month and often up to 6 weeks. Full light or bright indirect light is needed.

In shipment, the plants should not remain in closed boxes more than several days because they grow in full light naturally and do not tolerate shaded or dark situations.

Pepper, Ornamental Pepper

Capsicum annuum (CAP-sick-um ANN-u-um)

Solanaceae (Nightshade family) (So-lan-AY-see-ee)

Related plants--(see Jerusalem Cherry)

A plant used around Christmas for its elongated, decorative red fruits which are usually very "hot" if bitten into. However, they are not poisonous, though if hot, it is doubtful that many could be eaten. A rather short-lived plant in the home because of intolerance to warm temperatures.
Poinsettia

*Euphorbia pulcherrima* (You-FOR-bee-ah pul-CARE-i-mah)

*Euphorbiaceae* (Spurge family) (You-for-BEE-AY-see-ee)

Related plants--Castor-Bean (*Ricinus*), Chenille plant (*Acalypha*), Croton (*Codiaeum*), Euphorbia, Redbird Slipperflower (*Pedilanthus*), Rubber Tree (*Hevea*), Tapioca (*Manihot*).

The new, long-lasting cultivars retain their leaves and bracts (flowers) for many weeks when given a favorable environment in the home, and in fact, the plants may be discarded long before they have become unsightly. Many of the newer cultivars self-branch at the base and branch profusely when pinched (top portion of stem removed), making it possible to produce a multflowered plant using only one cutting per pot. Because of their ability to withstand handling and a rigorous environment, many poinsettias are now sold in the mass market though they must be protected from cold temperature by a sleeve closed at the top, between the point of sale and the customer's vehicle.

When one cutting is produced in a 5 1/2- or 6-inch pot, the finishing spacing in the greenhouse should be approximately 1 to 1 1/4 square feet per pot in order to provide a plant with sufficient spread to be in proportion to the pot. Crowding the plants in the greenhouse will make them tall with long internodes, and no amount of growth retardant will correct a lanky, thin appearance.

Poinsettias do not tolerate being in the dark, so plants should be taken out of the shipping boxes as soon as possible after receipt. Bracts may droop, curl, or twist if kept dark too long, and lower leaves will turn yellow and drop. They will tolerate temperatures of 55°F despite the fact they are tropical plants, but lower temperatures may induce excessive leafdrop when plants are placed on display in a warm location.

Most cultivars are red, though there are pink, white, and marbled types. Fluorescent lights do not bring out the red color, and the use of some incandescent lamps will show the true red color that is evident when the plants are in natural light.

Poinsettias are available from Thanksgiving or very early December on to Christmas, but after this latter date they find no demand. Buyers should make sure plants purchased for sales just prior to Christmas have not been in flower since early December, because the red color of the bracts gets "dusty" as the tissue ages.

Customers can save their plants and re-flower them, but in most instances the plants are unsightly. Information on how to do this is available from almost any county agricultural extension agent's office.
Because the plant is a short-day type, it can be flowered any day of the year, but until the buying public can be convinced that the poinsettia is not just a plant for Christmas, it will not find any demand at other seasons.

A great myth exists that the leaves and bracts of this flower are poisonous. This, however, is false, and there is little or no danger of individuals becoming ill from ingesting the tissue. The taste is rather unpalatable which would discourage any appreciable quantity being eaten.

Rieger Begonia (REE-ger)

*Begonia* x *elatior* (Bee-GO-nee-ah ee-LATE-ee-or)

*Begoniaceae* (Begonia family) (Bee-go-nee-AY-see-ee)

Related plants—No common types.

The Rieger Begonia will flower under any daylength though it does so more rapidly in short days so it should keep on flowering on new growth if properly cared for. The plant is highly susceptible to powdery mildew which makes the foliage and flowers unsightly. Periodic applications of plant shine materials are often effective in controlling this fungus disease.

Very bright indirect light or full sun for at least one-half day is recommended for the plant when placed inside, but filtered light from trees, etc., is suggested when plants are grown on a patio or similar situation. Slow-release fertilizers are useful in providing uniform, long-lasting nutrition. Watering should be thorough and since the plants are usually grown in a highly organic, well-drained soil, do not allow the medium to become "bone-dry" or it may be very difficult to re-wet.

Because the Rieger Begonia is a rather "loose" plant, it should be staked and tied to prevent undue breakage of leaves, stems, and flowers.

Rose

*Rosa* x *hybrida* (ROH-sah HY-brid-ah)

*Rosaceae* (Rose family) (Rose-AY-see-ee)

Related plants—(see Rose, flowering plants)

The potted rose plant is offered for sale principally from Easter to Mother's Day by the retail florist though some mass market outlets may also carry small numbers of these plants. Generally, the cultivars are the smaller-flowered types which are known as sweetheart roses,
polyanthas, grandifloras, or baby ramblers, but occasionally hybrid-tea
types that have long stems with large flowers are produced.

The rose is a plant that grows in full sun so it will not
tolerate being boxed for prolonged periods nor will it look good if
kept in a dark sales outlet. Fast turnover of stock is important.

In the home the plant should be given full light or very bright
indirect light. When the weather is favorable, the plant can be
placed in the garden where it will continue to grow and produce flowers
if properly cared for. Some states require a nursery license for a
retail outlet to sell garden roses.

Tulip

Tulipa gesneriana (TOO-lip-ah jes-near-ee-AH-nah)

Liliaceae (Lily family) (Lily-AY-see-ee)

Related plants--(see daffodil, flowering plants)

Tulip plants should be delivered to the retail outlet when the
color at the tip of the petals is just sufficient to ascertain what the
color of the plant will be. In the warm temperature of the retail
outlet or home, the flowers will develop rapidly. If the plant is in
full flower at the time of purchase by the ultimate customer, it is
really too late, because it probably won't last many days thereafter.

The plants should be in sunlight or bright indirect light in the
home so the color of the flower will be most intense. After the petals
have fallen, the soil can be watered as needed till the leaves turn
yellow at which time watering can cease and the bulbs planted in the
garden when the weather is suitable.
Foliage Plants

Common names--Aglaonema, Chinese Evergreen, Silver King, Silver Queen, Painted Droptongue, Francher Evergreen, etc.

Botanical names

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<th>Name</th>
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<tr>
<td><em>Aglaonema commutatum</em></td>
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<td><em>Aglaonema treubi</em></td>
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</table>

Family name--*Araceae* (Air-AY-see-ee)--mostly tropical herbs with fleshy or woody stems, others rootclimbers; variable leaf forms.

Related plants--(see Anthurium)

Cultivars--Several new cultivars are available that are as good or better than the original species. These include 'Francher', 'White Rajah', 'Silver Queen', 'Silver King', and 'Snow Queen'.

Harvest factors--Roots of this genus grow slowly, so extra care should be taken to be sure plants are well established at harvest, with white roots showing on the outside of the soil ball. *Aglaonema* will tolerate soluble salts quite well, but levels should be below 1500 ppm at harvest.

Storage temperature--65°F ± 5°F.

Storage relative humidity--75% ± 10%.

Storage life--Most species and cultivars will tolerate periods of 10 days in storage without light and maintain quality. After 14 days, considerable foliage loss will occur. Plants can be stored indefinitely at 50 foot-candles or more.

Storage conditions--*Aglaonema* is very intolerant of low storage temperatures (below 50°F). Plants subjected to such treatment will lose lower foliage and develop a dull off-color.

Pathogens, insects, and physiological disorders--No serious foliar pests are known, but at times root rots may occur on *A. commutatum* and *A. modestum* if soil is kept too wet.

Common names--Umbrella Tree, Schefflera.

<table>
<thead>
<tr>
<th>Name</th>
<th>Phonetics</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Brassaia actinophylla</em></td>
<td>Braa-SAY-ee-ah ac-tin-oh-FILL-ah</td>
</tr>
<tr>
<td><em>Brassaia arboracola</em></td>
<td>Braa-SAY-ee-ah ar-bor-a-COLA</td>
</tr>
</tbody>
</table>
Family name—Araliaceae (Air-ail-ee-AY-see-ee)—mostly tropical, some temperate trees, shrubs, or vines; sometimes with aromatic foliage.

Related plants—Aralia, Dizygotheca, Kalopanax, Fatsia, and Hedera (ivy).

Cultivars—None known at present. B. arboracola is semi-dwarf compared to B. actinophylla and not as common.

Harvest factors—Root systems should be checked carefully at harvest, since root loss is common with this genus. Be sure root systems are extensive and healthy, or severe leaf drop will occur. Soluble salts levels in the potting medium should be below 1000 ppm.

Storage temperature—60°F ± 5°F.

Storage relative humidity—75% ± 10%.

Storage life—Brassaia will not tolerate storage without light for more than 7 days without loss of quality. However, storage with light at 150 foot-candles or higher is indefinite.

Storage conditions—Allowing soil to dry out in storage can cause root death and subsequent loss of foliage. Severity of root loss will depend on soluble salts level.

Pathogens, insects, and physiological disorders—Brassaia can be severely injured by the fungal pathogen Alternaria. Severity of attack is increased by moisture on foliage and high relative humidity. Therefore, plants should not be stored with wet foliage. Spider mites are also a severe pest of this plant, and their presence can quickly reduce quality.

Common names—Palm, Parlor Palm, Areca Palm, Miniature Date Palm, Bamboo Palm, Reed Palm, Kentia Palm, etc.

<table>
<thead>
<tr>
<th>Botanical names</th>
<th>Phonetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamaedorea elegans</td>
<td>Sham-ee-DOOR-ee-ah ELL-ee-gans</td>
</tr>
<tr>
<td>Chamaedorea erumpens</td>
<td>Sham-ee-DOOR-ee-ah ee-RUMP-enz</td>
</tr>
<tr>
<td>Chrysalidocarpus lutescens</td>
<td>Chris-sal-i-DOH-car-pus loo-TESS-ens</td>
</tr>
<tr>
<td>Howea forsteriana</td>
<td>HOW-ee-ah forster-ee-AY-nah</td>
</tr>
<tr>
<td>Phoenix roebelenii</td>
<td>FEE-nix roh-bell-LEN-eye</td>
</tr>
</tbody>
</table>

Family name—Palmaceae (Palm-AY-see-ee)—palms are mostly tropical evergrowing woody plants, tree-like, some single-trunked, some multiple, with fan- or feather-shaped leaves.

Related plants—Cocos (coconut) and Elaeis (oil palm).
Cultivars—Many palm genera exist, only the most common and best for interior use are listed.

Harvest factors—Palms should be well established at time of sale, because root growth is slow. Be sure roots are extensive along the outside of the soil ball. The soluble salts levels should be below 1000 ppm.

Storage temperature—60°F ± 10°F.

Storage relative humidity—65% ± 10%.

Storage life—Palms are able to tolerate dark storage for 10 days without injury, and some genera will not lose quality even after 2 weeks. Will store indefinitely under 150 foot-candles.

Storage conditions—Allowing soil to dry out in storage can seriously injure root systems, especially if soluble salts are high.

Pathogens, insects, and physiological disorders—Spider mites can be a severe pest of palms under low relative humidity interior conditions, but other pests are relatively uncommon. Be sure to leach soil periodically to prevent soluble salts accumulation.

Common name—Dumbcane, Dieffenbachia, Giant Dumbcane, Exotic Dumbcane, Golden Dumbcane, etc.

Botanical names

| Dieffenbachia amoena | Deef-en-BOCK-ee-ah am-MO-ee-nah |
| Dieffenbachia picta  | Deef-en-BOCK-ee-ah PICK-tah |

Phonetics

Family name—Araceae (Air-AY-see-ee)—largely tropical herbs with fleshy or woody stems, others rootclimbers; variable leaf forms.

Related plants—(see Anthurium).

Cultivars—There are several cultivars and hybrids of Dieffenbachia that are quite excellent. These include: Dieffenbachia x 'Bausei', Dieffenbachia x 'Exotica', Dieffenbachia x 'Perfection', Dieffenbachia x 'Tropic Snow', Dieffenbachia picta 'Golden Snow', and Dieffenbachia picta 'Rudolph Roehrs'.

Harvest factors—Plants should be well established in pots at time of sale, with roots showing on the outside of the soil ball. Also, plants should not have high soluble salts levels in the potting medium at time of sale (in most cases should be below 1500 ppm).

Storage temperature—60°F ± 5°F. This group of plants can be seriously damaged if allowed to drop below 55°F. They are one of the least cold-tolerant groups and can be easily damaged.
Storage relative humidity--75% ± 10%.

Storage life--Dieffenbachia store poorly when excluded from light for more than 5 to 7 days. Symptoms of excessive light exclusion are yellow bottom leaves.

Storage conditions--Dumbcane must be stored at 60°F or higher to prevent foliar damage. Also, soil must be moist or severe leaf crop can occur. Brown edges may also occur on plants from spider mite damage.

Pathogens, insects, and physiological disorders--Bacterial stem rot may severely damage dumbcane if it is stressed, because of lack of light, low temperature, or excess soil moisture. Spider mite feeding along edges of foliage will cause browning, which may appear to be a disease. All dumbcane contain a virus which at times causes foliage distortion, usually during winter months.

Common names--Dracena, Corn Plant, Red Edge Dracena, Dragon Tree, Florida Beauty Dracena, etc.

Botanical names

| Dracaena deremensis | Drah-SEE-nah dare-ee-MEN-sis |
| Dracaena fragrans | Drah-SEE-nah FRAY-grans |
| Dracaena godseffiana | Drah-SEE-nah god-seff-ee-AH-nah |
| Dracaena marginata | Drah-SEE-nah mar-gin-AH-tah |
| Dracaena sanderiana | Drah-SEE-nah san-deer-ee-AH-nah |

Phonetics

Family name--Liliaceae (Lily-AY-see-ee)--herbs, many of them bulbous, sometimes tree-like; parallel-veined leaves.

Related plants--(see Narcissus)

Cultivars--The cultivars available of D. deremensis are 'Janet Craig' and 'Warneckii', of D. fragrans is 'Massangeana', and D. godseffiana is 'Florida Beauty'. All of these are better forms than the species.

Harvest factors--Plants should be well established in pots at time of sale with an extensive, healthy root system. Soluble salts levels in the potting medium should be below 1200 ppm.

Storage temperature--65°F ± 5°F.

Storage relative humidity--75% ± 10%.

Storage life--Most dracenas will tolerate periods of up to 7 days of light exclusion without lower leaves turning yellow.
Storage conditions--Plants subjected to low temperature (below 45°F) and low humidity frequently develop severe tissue necrosis along leaf margin.

Pathogens, insects, and physiological disorders--Few insects or diseases affect dracaena, but this group is very sensitive to fluoride in the air or potting medium. Yellow spots on leaves which later turn brown, and tip necrosis are indications of this problem.

Common name--Rubbertree, Weeping Fig, Fig, Ficus, Fiddle-leaf Fig, Laurel Fig, Mistletoe Fig, Creeping Fig, etc.

Botanical names

<table>
<thead>
<tr>
<th>Ficus benjamina</th>
<th>FY-cuss ben-jah-MY-nah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ficus diversifolia</td>
<td>FY-cuss di-VERSE-i-folia</td>
</tr>
<tr>
<td>Ficus lyrata</td>
<td>FY-cuss lie-RAH-tah</td>
</tr>
<tr>
<td>Ficus pumila</td>
<td>FY-cuss PH EW-mill-ah</td>
</tr>
<tr>
<td>Ficus retusa nitida</td>
<td>FY-cuss re-TWO-sa NIT-i-dah</td>
</tr>
<tr>
<td>Ficus elastica</td>
<td>FY-cuss ee-LAST-i-cah</td>
</tr>
</tbody>
</table>

Phonetics

Family name--Moraceae (More-AY-see-ee)--trees, shrubs, and vines, often with milky juice and alternate, simple leaves.

Related plants--Morus (mulberry), Maclura (osage-orange), Cannabis (marijuana), and Humulus (hop).

Cultivars--There are several cultivars of *Ficus elastica* that have different foliage colors--these include 'Decora', 'Hondura', 'Robusta', and 'Doescheri'. The *elastica* group can tolerate low light, while the others need medium or high interior levels.

Harvest factors--Plants should be well established in pots at time of sale, with roots showing on the outside of the soil ball. Also, plants should not have high levels of soluble salts in the potting medium at time of sale (in most cases should be below 1200 ppm). *Ficus elastica* cultivars can be grown in high light and even full sun, and subsequently moved indoors. However, other *Ficus* species do poorly indoors unless they are acclimatized to lower light levels or grown under 40 to 60% shade.

Storage temperature--60°F ± 5°F. This group of plants can tolerate temperatures as low as 40°F in shipment without damage.

Storage relative humidity--65% ± 20%.

Storage life--*Ficus* vary in their reaction to storage without light, but severe leaf crop can occur on some species if light is excluded for more than 7 days. Severe leaf drop can also occur on *Ficus benjamina* and *Ficus retusa nitida* if soil is allowed to dry out.
Storage conditions--Beware of ethylene levels above 2 ppm as leaf drop can result.

Pathogens, insects, and physiological disorders--Ficus have few pest problems, but thrips on Ficus retusa nitida can cause severe leaf curling.

Common names--Ferns, Boston Fern, Table Fern, Fluffy Ruffles Fern, Florida Ruffles Fern, Sword Fern, Maidenhair Fern, Birdnest Fern, etc.

<table>
<thead>
<tr>
<th>Botanical names</th>
<th>Phonetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nephrolepis exaltata</td>
<td>Nee-FROLL-eh-pis ex-all-TAH-tah</td>
</tr>
<tr>
<td>Pteris ensiformis</td>
<td>TEER-1s en-si-FOR-mis</td>
</tr>
<tr>
<td>Adiantum hispidulum</td>
<td>A-dee-AN-tum hiss-PID-u-lum</td>
</tr>
<tr>
<td>Asplenium nidus</td>
<td>Ass-PLEE-nee-um NID-us</td>
</tr>
</tbody>
</table>

Family name--Polypodiaceae (Polly-poh-dee-AY-see-ee)—almost all common ferns without trunks; non-flowering plants propagated from spores.

Related plants--Polystichum and Dryopteris.

Cultivars--There are many cultivars of genera listed, as well as many other fern genera in the market place. Some common N. exaltata cultivars are 'Fluffy Ruffles', 'Florida Ruffle', 'Rooseveltii', 'Bostoniensis', etc.

Harvest factors--Ferns should be well established in pots at time of harvest. As roots are difficult to see, this can be determined by pulling on the plant. Ferns are fairly tolerant of soluble salts in the soil, but levels above 1000 ppm are to be avoided at harvest.

Storage temperature--65°F ± 5°F.

Storage relative humidity--75% ± 10%. Low humidity (below 50%) will cause leaflet browning.

Storage life--Ferns do not store well in the dark, therefore, storage periods longer than 7 days are to be avoided to prevent leaflet loss.

Storage conditions--Ethylene levels above 1 ppm will cause serious leaflet loss.

Pathogens, insects, and physiological disorders--Ferns are easily injured by applications of pesticides. However, when foliage is kept dry there are no disease problems, and insect pests are not too common.
Common names--Peperomia, Satin Peperomia, Emerald Ripple Peperomia, Variegated Peperomia, Watermelon Peperomia, etc.

Botanical names

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Phonetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peperomia bicolor</td>
<td><em>Peperomia bicolor</em></td>
<td>Pepper-OH-mee-ah bi-COLOR</td>
</tr>
<tr>
<td>Peperomia caperata</td>
<td><em>Peperomia caperata</em></td>
<td>Pepper-OH-mee-ah cap-er-AH-ah</td>
</tr>
<tr>
<td>Peperomia metallica</td>
<td><em>Peperomia metallica</em></td>
<td>Pepper-OH-mee-ah met-TAL-i-cah</td>
</tr>
<tr>
<td>Peperomia obtusifolia</td>
<td><em>Peperomia obtusifolia</em></td>
<td>Pepper-OH-mee-ah ob-TOOS-i-folia</td>
</tr>
<tr>
<td>Peperomia sandersi</td>
<td><em>Peperomia sandersi</em></td>
<td>Pepper-OH-mee-ah SAN-ders-eye</td>
</tr>
<tr>
<td>Peperomia scandens</td>
<td><em>Peperomia scandens</em></td>
<td>Pepper-OH-mee-ah SCAN-dens</td>
</tr>
</tbody>
</table>

Family name--Piperaceae (Piper-AY-see-ee)--mostly tropical herbs and vines common to jungle floors.

Related plant--Piper (pepper).

Cultivars--Over 500 forms of peperomias exist, and many of them are excellent indoors. Few cultivars exist, except as variegated sports of green forms.

Harvest factors--Plants should be well established in pots at time of harvest, with healthy roots covering most of the soil ball. Soluble salts levels should be below 1000 ppm.

Storage temperature--65°F ± 5°F.

Storage relative humidity--75% ± 10%.

Storage life--The genera are so variable that it is impossible to give complete information. In general all will tolerate up to 7 days exclusion from light in storage, but most will have a severe loss in quality after 10 days. Plants can be stored indefinitely under 100 foot-candles.

Storage conditions--Storage with wet, saturated soil should be avoided because of possible root rots.

Pathogens, insects, and physiological disorders--Peperomias frequently develop root rot if soil is kept too wet. They are also very intolerant of ethylene, and will drop foliage if more than 1 ppm is present.

Common names--Philodendron, Heartleaf Philodendron, Fiddleleaf Philodendron, Red Duchess Philodendron, Cordatum, Tree Philodendron, etc.
Botanical names

<table>
<thead>
<tr>
<th>Philodendron domesticum</th>
<th>Fill-o-DEN-dron</th>
<th>doh-MESS-tick-um</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philodendron micans</td>
<td>Fill-o-DEN-dron</td>
<td>MY-cans</td>
</tr>
<tr>
<td>Philodendron panduraeforme</td>
<td>Fill-o-DEN-dron</td>
<td>pan-dur-ee-FOR-me</td>
</tr>
<tr>
<td>Philodendron oxycardium</td>
<td>Fill-o-DEN-dron</td>
<td>ox-ee-CAR-dee-um</td>
</tr>
<tr>
<td>Philodendron selloum</td>
<td>Fill-o-DEN-dron</td>
<td>sell-OH-um</td>
</tr>
</tbody>
</table>

Family name—**Araceae** (Air-AY-see-ee)—largely tropical herbs with fleshy or woody stems, others rootclimbers; variable leaf forms.

Related plants—(see Anthurium)

Cultivars—Several new patented cultivars have good interior lasting quality as well as new colors. These include 'Red Princess', 'Prince Dubonnet', 'Emerald King', 'Emerald Duke', and others.

Harvest factors—Plants should be well established in pots at time of sale, with roots showing on the outside of the soil ball. Also, plants should not have high soluble salts levels in the potting medium at time of sale (in most cases should be below 1500 ppm).

Storage temperature—$65^\circ F \pm 5^\circ F$.

Storage relative humidity—75% ± 10%.

Storage life—Most species and cultivars will tolerate dark periods of 7 days without loss of quality and up to 10 days with only minor loss of quality.

Storage conditions—When possibility of bacterial diseases exist, plants should not be shipped or stored with wet foliage. Leaves may turn grey-green or yellow and appear wilted if ethylene levels are above 2 ppm.

Pathogens, insects, and physiological disorders—Several bacterial diseases affect philodendron foliage, but these will cease to be a problem if foliage is kept dry, however, all existing damage will remain. Root rot may occur if soil is kept too wet, but usually is not a severe problem with these species.

Common names—Devil's Ivy, Pothos, Golden Pothos, Marble Queen Pothos, etc.

Phonetics

| Scindapsus aureus | Sin-DAPP-sus | ORE-ee-us |

Family name—**Araceae** (Air-AY-see-ee)—largely tropical herbs with fleshy or woody stems, others rootclimbers; variable leaf forms.

Related plants—(see Anthurium).
Cultivars--The only cultivar is 'Marble Queen', which is green and white, rather than green and yellow. This form is not quite as good a grower.

Harvest factors--Plants should be well established in pots at time of sale with an extensive healthy root system. Soluble salts levels in the potting medium should be below 1500 ppm.

Storage temperature--65°F ± 5°F.

Storage relative humidity--75% ± 10%.

Storage life--Pothos will tolerate periods of 7 days without light in storage without loss of quality. After 10 days without light, serious leaf loss will occur.

Storage conditions--When possibility of fungal or bacterial diseases exist, plants should not be shipped or stored with wet foliage. Leaves may turn off-color if ethylene levels are above 2 ppm.

Pathogens, insects, and physiological disorders--Pythium root rot is common on devil's ivy, and care should be taken to prevent overwatering. Plants should not be allowed to stand in water.