POSTHARVEST HANDLING OF TROPICAL ORNAMENTAL CUT CROPS IN HAWAII

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Hawaii has probably the most highly developed tropical floral industry in terms of production and export values. The wholesale value of all ornamental crops (cut and lei flowers, foliages, and rooted and potted ornamentals) produced in the State amounted to $4,484,000 (1971), $5,101,000 (1972), $6,341,000 (1973), and $8,211,000 (1974) (7). The total value of all ornamental crops exported was $2,719,000 (1971), $3,074,000 (1972), $3,678,000 (1973), and $4,359,000 (1974). Therefore nearly 60% of the total production was exported, mostly to the U.S. mainland and some to foreign countries. The cut and lei flowers and foliages which are the subjects of this presentation accounted for 89.2% (1971), 90.3% (1972), 86.0%, (1973), 92.0% (1974) of the total value of ornamentals exported. Various rooted and potted ornamentals made up the balance of the export value.

Nearly all Hawaiian ornamental crops are currently shipped by air. Some rooted plants, such as *Dracaena,* have been shipped by sea and attempts are being made to increase shipment of rooted bulky plants by this method.

Air shipments are made by air mail, air post, and air freight. In air mail shipment, the packaged flowers are handled like regular air mail through the postal system, or may be given special delivery with additional charge. Usually smaller packages and smaller shipments are carried by air mail. In air post shipment, usually utilized for larger packages and bulkier shipments, the packages are first shipped by air in bulk by a local handler from Hawaii to the U.S. mainland where they are deposited at a post office, nearest to the destination of the shipment, for delivery to consignee by surface transportation. Special delivery may also be utilized for faster delivery. Since air post uses air transport only partially, it is less expensive than air mail. However, air mail has faster delivery service. Air freight does not involve the postal system and is handled by airlines. Since only bulk shipments are carried by air freight, this is the least expensive method in air shipment of ornamentals. Undoubtedly, air shipment has been the impetus that has influenced most the development of the floral industry in Hawaii, but the ever-increasing cost of all methods of air shipment since the advent of the first shipment in quantity about 30 years ago, is becoming a major concern for shippers of Hawaiian ornamentals.

How much more in air shipment charges the floral industry can absorb and still maintain a profitable business remains to be seen. If the industry is forced to ship ornamental crops by surface transportation, which is less expensive than air transportation, the bulkier and hardier ornamentals, such as *Anthurium,* bird-of-paradise, and ti leaves, would fare better than the more delicate ones, such as the various orchids. The long shipping time (6–10 days including handling), as compared with 1–3 days by air, from Hawaii to the U.S. mainland, is the greatest obstacle to shipping ornamentals by surface transportation. Therefore, when that time comes, research must be directed toward the development of methods to maintain the quality of these ornamentals. Undoubtedly, the feasibility of using methods to preserve quality, such as controlled atmosphere storage and hypobaric storage, would be seriously investigated.

Anthurium andraeanum

Anthurium flowers make up the bulk of the ornamental crops exported from Hawaii. Out-of-state sales amounted to $1,530,000 (1971), $1,789,000 (1972), $2,036,000 (1973) and $2,306,000 (1974), which represent 53–58% of all ornamental crop exports (7). The shipment of this flower has steadily increased from 1965 to 1974 when 559,600 dozen were shipped, and greater volumes of shipment are projected for the current and ensuing years.

In one of the earliest methods of shipping *Anthurium,* the basal end of each flower stem was placed in a rubber balloon filled with water, and the balloon was securely tied to the flower stem with twine. This system assured a continuous supply of moisture to the flower in transit. In another method, a cotton wad, saturated with water and enclosed in wax paper, was placed at the tip of the flower stem and secured in place with twine. In either method, the flowers were then placed in a corrugated carton and fastened to the bottom of the carton with twine fastened to the flower stems, then extended out of the carton through holes, and finally tied outside the carton. This was to prevent the movement of flowers in the carton in transit. These methods were effective for preventing mechanical injury and desiccation of flowers, but they were time-consuming operations. In the meantime, more rapid methods of packing, such as placing the flowers in plastic bags before packing in cartons (12) and other methods of reducing moisture loss, such as dipping the spadix in melted paraffin (17), were found and recommended, but these have not been adopted by the industry.

Currently, the flowers are packed in corrugated cartons of various sizes (21.6 x 50.8 x 91.4 cm, 27.9 x 43.2 x 101.6 cm, etc.) to accommodate varying number of flowers per carton. Ten dozen or more flowers are placed in these cartons for commercial bulk shipments. A polyethylene sheet lining is first placed inside the carton. Then several layers of newspaper are placed on the lining. The flowers are then individually placed in the carton with the spadix down. In the finished pack, half of the flowers will have their spathes on one end of the carton and the other half will have theirs on the opposite end of the carton. Moistened shredded newspaper is used to nestle the flowers and to maintain a high humidity within the carton. Some shippers use a piece of newspaper to separate the spathes from each other. Water is sprinkled on the flowers and packing material, and the layers of newspaper first, and then the polyethylene lining, are folded over the pack. The carton is finally covered and securely tied with twine for shipping. Since the carton is fairly tightly packed, shifting of the flowers within the carton is minimized, but the flowers become slightly flaccid due to temporary partial wilt. Turgidity is readily regained if a short segment of the flower stem end is severed and the flower immersed in water for about an hour after being removed from the shipping carton.

There are minimum grade requirements for Hawaiian export *Anthurium* flowers (5). Although some flowers are cut too mature for maximum vase life (11), the grade requirements specify that at least one-third of the length of the spadix must have true flowers open (5). Other requirements are that the "neck" (portion of flower stem immediately below the spathe) be firm to touch and that the flower stem itself be of certain length depending on the size of the spathe (5). In general, the shorter the flower stem, the greater the vase life; however, for esthetic value, it should not be too short (2). Therefore, the final stem length should be determined after esthetic consideration, which affects price, the grade requirement for export flowers, the desirable vase life, and the size of the shipping carton.

Currently, *Anthurium* flowers are held in storage no more than 2 days at prevailing temperatures before shipping. If it becomes necessary to hold them in storage for longer periods, certain commercial floral preservatives and chemicals can be used prior to shipping to prolong the eventual vase life (3). Cold storage is ineffective for vase life extension (10).

Vanda cv. Miss Agnes Joaquim

Although the out-of-state sales value of flowers of this orchid has fluctuated during the last few years, it is still second only to that of *Anthurium* flowers (7). After declining from 1971-1973, the sales value of shipped flowers, including some flowers of other *Vanda* species and hybrids, increased from $273,000 in 1973 to $318,000 in 1974.

The blossoms of *Vanda* are shipped as intact flowers or as leis. The small intact flowers are packaged in corrugated cartons of varying sizes for shipment. A polyethylene liner is first placed in the bottom of the carton for retention of moisture within the carton, then the flowers, which had been previously sprinkled with water, are placed in layers in the carton. The liner is folded over the top layer of flowers and the carton sealed for shipment. As many as 500 or more flowers may be shipped in a single carton.

There are two kinds of *Vanda* leis: the ordinary type and the "Mauna Loa" type. In the ordinary type, whole blossoms are strung into a lei, but in the "Mauna Loa" type, only the lips with throat (lower modified petals) are used in the lei. The leis are shipped in cartons with provisions for retention of high humidity within the container.

In the shipment of *Vanda* flowers, premature facing is the major problem. These blossoms normally fade in senescence, but they

prematurely fade when pollinated, when the pollinia are disturbed, or when exposed to certain noxious gases such as illuminating gas, automobile exhaust fumes, and tobacco smoke, all of which contain C_2H_4 (ethylene). Exposure of flowers to emanations of ripening fruits, at as low loevel as 0.05 ppm of C_2H_4, also causes fading.

As the *Vanda* flower fades, it produces C_2H_4, and the production of this gas is phenomenal (ca 3,400 µl/kg/hr) in that it is several times greater than that of some of the highest producers (fruits) (1). If a flower in a sealed carton begins to fade in transit, it will produce enough C_2H_4 to cause the others to fade also in a few hours. Therefore, it is imperative that only sound flowers (unfaded, unpollinated, pollinia intact) be packaged in a clean atmosphere devoid of C_2H_4 or C_2H_4-producing gases. However, no matter how exacting the packing operation may be, human errors are not always avoidable. Thus if a flower that is beginning to fade or destined to fade soon after being packaged, is accidentally included among normal flowers, and the liberated C_2H_4 is not inactivated or eliminated, all the flowers in the package will fade in transit or shortly thereafter.

Brominated activated charcoal is effective for inactivating the liberated C_2H_4 and thus preventing the normal flowers from fading in the presence of one or more fading flowers (4), but because of the stringent requirements of its use (exactly measured quantities of charcoal and water to be used per given number of flowers in a package), shippers have not adopted the method. To make the use of the brominated charcoal more practical, the charcoal particles were compressed into discs and pellets, or packed in a paper tube (cigarette-like), or adhered to the surface of paper and inner walls of rubber and plastic tubings, and these were placed in the flower package. All were impractical, because the adsorptive surface area of the particles was reduced by the process, and excessive amounts of the prepared materials were required to inactivate the C_2H_4.

Use of $KMnO_4$ (about 2%) as a solution or impregnated in paper, cloth, "Vermiculite", or "Perlite" is effective for inactivating C_2H_4 in packages of *Vanda*. "Purafil" (commercial preparation impregnated with $KMnO_4$) is also effective, but in all of these, the problem is to keep the materials separated from the delicate flowers in the package, because contact with the chemical causes injury ("bronzing") to the flowers. In stationary storage, the flowers can readily be kept separated from the chemical. In transit this would be difficult, because even if permanganate-impregnated materials are used, the chemical will become a freely flowing solution by the absorption of moisture added to the package to keep the flowers turgid.

Packaging flowers in modified atmospheres created by using reduced pressures, N_2, or CO_2 is also effective for preventing fading of normal flowers in the presence of C_2H_4-liberating flowers. During the 1–3 day period required for handling and shipping by air, atmospheric pressures of 125–190 mm Hg (3.45–5.25% O_2), 3% O_2 in air modified with N_2, or 3% CO_2 in air prevented fading during simulated transit and holding conditions after removal from the modified atmospheres. In the two cases in which the O_2 concn were reduced to low levels, the production of C_2H_4, as well as the rate of fading of the C_2H_4-liberating flowers was reduced so that the normal flowers were not affected during the short periods in the modified atmospheres. Under a low concn of CO_2, the C_2H_4-liberating flowers completely faded in one day, but the C_2H_4 produced was inactivated by the CO_2 and the normal flowers were not affected. This gas has also inactivated C_2H_4 produced by other flower species (13, 14, 15). For shipping under modified atmospheres, the packaging materials would have to be gas impervious and sufficiently durable to withstand any "ballooning" effect due to decrease in atmospheric pressures in flight.

Other orchids

The out-of-state sales value of *Cattleya, Cymbidium,* and *Dendrobium* has increased in recent years with *Cymbidium* contributing most to the increase. The total value of these orchids was $138,000 in 1971, $294,000 in 1972, $365,000 in 1973, and $454,000 in 1974 (7). They are packed in cartons of various sizes for shipment with provisions for maintaining turgidity of the flowers and prevention of injury in transit. There are no special problems in the shipping of these orchids.

Bird of paradise (*Strelitzia*), *Heliconia,* and Ginger

Flowers of various types of bird-of-paradise (*Strelitzia*), *Heliconia,* and ginger are among the bulkiest of all flowers exported from Hawaii. The value of out-of-state shipment for bird-of-paradise has increased from $47,000 in 1971 to $85,000 in 1972 to $90,000 in 1973, and to $115,000 in 1974, but that of ginger has decreased from $71,000 to $64,000 to $61,000 during the same 3 years, then increased to $65,000 in 1974 (7). No data are available for the shipment value of *Heliconia.*

Because of the size and weight of bird-of-paradise and *Helioconia,* they are packed in large containers and securely fastened to the container to prevent shifting of the flowers in transit. They are packed with moistened shredded newspaper to prevent bruising of the flowers and to maintain high humidity within the carton. The flowers are readily shipped and apparently their vase life is not impaired by the handling in shipment.

The red ginger (*Alpinia purpurata*) is the main type exported from Hawaii. The method of packing red ginger for export is similar to that of bird-of-paradise and *Heliconia,* and it is readily shipped without any impairment to their keeping quality. However, since the leaves wilt very rapidly once the flower stem is cut, red ginger is shipped devoid of leaves. If a method is found to prevent the wilting, the value of the flowers may be enhanced.

Protea

The growing of *Protea* in Hawaii has increased over the past few years, and currently some out-of-state shipments are being made. They are packed and shipped like other bulky flowers. The problem, however, is the rapid darkening of the leaves of some species of *Protea* and other species of related genera (8). Elsewhere certain chemical treatments are reported to be effective for preventing the darkening of the leaves (6), and gamma rays accelerated leaf darkening (9). Research on the prevention of leaf darkening of Hawaiian *Protea* has just been initiated at the University of Hawaii.

Lei flowers

The chief lei flowers of Hawaii are *Plumeria, Vanda Miss Agnes Joaquim,* and pikake (*Jasminum sambac*). *Vanda* has already been discussed above. Flowers of *Plumeria* and pikake are exported mostly as leis with some exported as loose flowers. In 1973, the out-of-state sales value of *Plumeria* was $23,000, which increased to $31,000 in 1974, and that of pikake was $3,000, which decreased to $2,000 in 1974 (7). They are packaged in corrugated cartons with provision for retention of moisture in transit. *Plumeria* blossoms are short-lived (1 – 3 days under refrigeration) and floral preservatives are ineffective for vase life extension (16). Pikake blossoms are also short-lived, turning brown rapidly. The need of some treatment to be applied prior to shipment or during transit that would extend the life of *Plumeria* and pikake flowers is obvious.

Dried wood rose (*Ipomoea tuberosa*)

The demand for Hawaiian dried wood rose for dry arrangements and other ornamental uses overseas increased up to 1973 when the sales value of exported flowers amounted to $79,000, but it decreased to $56,000 in 1974 (7). Wood roses are packed in corrugated cartons in such a way that the dry flowers with attached stems are not crushed in transit.

Foliages

Among the ornamental foliages exported from Hawaii, leaves of ti (*Cordyline terminalis*) make up the bulk. The out-of-state sales value of this foliage was $197,000 in 1974, an increase of 49% from the previous year (7). Leaves of various types of crotons (*Codiaeum variegatum*) and *Monstera* are also shipped. These are readily shipped in corrugated cartons with moisture provided by wrappers of moistened newspaper. Heat of respiration of the leaves rapidly increases the temperature within the container under prevailing temperatures. Therefore, it is necessary to store the packaged foliages under refrigeration (10–12.8°C) if they must be held for any length of time before shipping. This, in general, applies to all packaged floral crops intended for shipment from Hawaii.

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POSTHARVEST HANDLING OF ROOTED AND UNROOTED CUTTINGS OF TROPICAL ORNAMENTALS[1]

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Cuttings of tropical foliage plants for interior use compose the bulk of all ornamental cuttings moving in international commerce. Records of the USDA plant quarantine division in Miami, Florida for October 1974 show that of the 4.3 million cuttings imported through that entry point, 99.8% could be classified as tropical foliage plants. Major plant genera involved included *Aglaonema, Aphelandra, Araucaria, Codiaeum, Cordyline, Dieffenbachia, Dracaena, Ficus, Peperomia, Philodendron, Scindapsus* and *Syngonium*.

The most recent statistical information for 1974 shows 1467 acres of tropical foliage plants in production in the top 23 producing states in the U.S. with a wholesale value of slightly over $111 million (1). Large increases in foliage plant stock production are occurring in the American tropics and were estimated at nearly 400 acres in 1974 (8). Major stock producing countries include British Honduras, Costa Rica, Dominican Republic, Honduras, Guatemala, Jamaica and the Commonwealth of Puerto Rico.

Enormous changes have occurred in the tropical foliage industry during the last 5 years (7, 26). Wholesale value of plants sold in Florida have increased from $15.9 million in 1970 to nearly $50 million in 1974. The future of the foliage industry seems bright, and is projected to increase in Florida to over $150 million at wholesale by 1985 (2). Unless import restrictions are imposed on movement of tropical foliage cuttings into the United States, most stock expansion is expected to occur in the Caribbean and Central and South America.

Production of tropical foliage stock

Requirements for production of tropical foliage stock plants have been established (3, 5, 9, 10, 23, 24) and this information has generally proven applicable in temperate as well as tropical areas. Major cultural factors important in foliage plant production include reduction of light intensity for most genera, soil amendments to provide proper aeration, water holding and cation exchange capacities, proper fertilization levels and adequate growing temperatures. Because tropical foliage stock plants are grown under high humidity and temperature and in the same soil for several years, disease, insect and nematode control are of major importance. Programs have been developed to control most pests (12, 13, 15, 16, 17, 18) but problems still exist. Some of the most serious cultural mistakes include production under too little or excessive light, higher than optimal fertilizer levels and poor control of disease causing organisms and mites.

Keeping quality of tropical foliage cuttings can be strongly influenced by cultural procedures in the production area. This problem is most troublesome when cuttings are packed for periods of up to a week or longer.

Information on harvesting, packing, shipping and receiving is generally absent from published research literature. Therefore, information on these factors discussed here has been largely obtained from the foliage industry.

Selection of proper cutting material is important when handling and shipping both rooted and unrooted cuttings. Large cuttings are prone to desiccation and physical damage during shipping, especially when long shipping periods often occurring with export are involved. Where cuttings are taken and stuck within a short period at the same location, larger cuttings may be taken. Best quality, non-vining plants, are usually produced from tip cuttings with 4 to 6 inches of stem at time of harvest. Vining genera such as *Philodendron* and *Scindapsus* are usually cut as a single eye with leaf and 1 to 2 inches of stem (4).

Growers have observed that climatic factors which exist during harvesting can strongly influence rooting success, especially if cuttings are to be shipped. These problem areas include desiccation after cutting and prior to packing, from low humidity, high light or temperature; low food reserves because of low light levels and high day and night temperatures (32 to 38°C days and 24 to 27°C nights) and high disease incidence in stock (especially bacterial) because of frequent rains. During high temperature and rainfall periods, growers frequently do not ship genera such as *Dracaena, Philodendron, Scindapsus* and *Syngonium* because of losses due to disease.

Reduction of holding time between harvest and sticking or packing will reduce desiccation. Wherever possible, growers should pack or stick cuttings within 4 hours of harvest. Cuttings should always be held in the shade and misted to prevent water loss. Temperature should be maintained below 30°C.

Packing unrooted cuttings

Many more unrooted cuttings than rooted cuttings move in the export market, since they are less likely to have pest problems. Prior to packing, unrooted cuttings are washed primarily by dipping in water that may or may not contain a pesticide. Most commonly the dip solution contains a fungicide such as Captan or Dithane M-45 and a bactericide such as streptomycin (Agrimycin 17 or Agri-Strep). Less commonly, an insecticide such as Morstan is used on plants where mites may be a problem. Cut surfaces of cuttings are often treated with a 5% Captan dust. Unrooted cuttings used within the producers own operation generally do not receive a chemical treatment prior to sticking, but at times are dusted with Captan or dipped in a solution composed of Captan and streptomycin (18).

Rooted cuttings produced and sold within the U.S. are normally pulled, packed and shipped with soil medium attached. Rooted cuttings imported into the U.S. from other countries must have all original rooting medium removed prior to shipment and then packed in a clean packing material. This requires that roots be washed under pressure in a stream of water which frequently causes injury. After washing, cuttings are frequently dipped in one of the chemical solutions discussed for unrooted cuttings.

Cuttings transported within the borders of the U.S. and other countries are usually packed in cardboard cartons containing a waxed tray or in a waxed carton. Packing systems are relatively crude because cutting sizes are so variable. Generally, cuttings are wrapped in

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