grafted on parviflora the plants grow vigorously. They grow best in shady locations.

2. *Ixora williamsii*—Known also as I. TRINIDAD RED'. It was introduced to South Florida in about 1956 from the Panama Canal Zone by Mrs. Dora McGee of Miami. The flowers are the deepest of the reds, free flowering with very large blooms. Leaves are very large and dark green. It does best in southern exposures and benefits from severe trimming in late winter before new growth commences in the spring. Larger flowers and more vigorous growth are produced when grafted on parviflora.

3. *Ixora* 'SUPERKING' — A variety of *I. macrothyrsa* introduced to the South Florida trade in about 1950 by Swedroe but has been available in Florida since about 1932. It has brilliant red flowers, probably the most spectacular of the popular Ixoras. Flowers are very large and abundantly produced all year in South Florida. New leaves are usually pale green but turn dark green as they mature. Leaves are very large, becoming as much as ten inches long. It grows well on its own roots with moderate care on most soils. Grafting with parviflora has not been successful since they seem to be incompatible. It is well adapted to general landscape use and produces a very large bushy plant.

ACKNOWLEDGEMENT

Credit should be given to Albert Muzzell, Ornamental Horticulture Student at University of Florida 1964, who gave much time and effort to collect much of the information contained in this report.

PHILODENDRON IMPROVEMENT THROUGH HYBRIDIZATION

R. H. McCOLLEY[1] AND H. N. MILLER[2]

ABSTRACT

Philodendron hydridization has been conducted with the objectives of producing plants that have increased beauty through new forms, leaf shapes and coloration and to produce plants which show resistance to some of the more common diseases and have improved keeping qualities in transit and in the home. Data on philodendron flowering, collecting and storing of pollen, time of pollination for successful fertilization and compatability have been obtained. Hundreds of crosses have been made, and millions of seedlings screened. Some desirable selections have been made from inter-specific F_1 hybrids and a lesser number of multi-hybrid crosses.

INTRODUCTION

The use of foliage plants for indoor decoration and enjoyment goes back as far as history. However, the modern foliage plant industry began in earnest at the close of World War II. Prior to that time foliage was primarily ferns and sanseverias. As late as 1950 only two major nurseries in Florida were in volume production of large leaf Philodendron. Yet in this same year the question asked by every northern buyer was. "What do you have that is new and different?" This demand led to the introduction of many soft, worthless species and to the introduction of diseases not yet identified. It seems nature provided only two types of foliage plants, those that are tough but of little beauty and those that are beautiful but soft and susceptible to ills from climate and diseases.

It was about the beginning of the 20th century that improvement of agricultural crops began through hybridization. Today, hardly a single crop has not been radically changed through the process of cross pollination. These changes, in a way, were forced changes. With heavily increased production needed to prepare for the population explosion following the two world wars, it was necessary to produce strains which were resistant to diseases, gave increased yields and had better keeping qualities.

Hybridization to improve foliage plants, however, is in its infancy. It seems strange indeed that man has been satisfied with plants that were available even at the turn of the century. It was not until the early 1950's that any serious hybridization of philodendron was started. An Italian hybrid, *P. corsinianum* was made in Florence in 1887 (1). Manda in 1936 produced the

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first hybrid philodendron in the United States by crossing *P. hastatum* with *P. erubescens* (2).

The senior author began philodendron hybridization in 1951 at Bamboo Nurseries, Orlando, Florida. At that point the only definite knowledge was the projected goal of obtaining plants with increased beauty and desirability, good keeping qualities in transit and in the home and, if possible, resistance to some of the more troublesome diseases.

Methods and Procedure

One of the first attempts at philodendron hybridization was the crossing of *P. squamiferum* with *P. laciniatum*. There were two varieties of *P. squamiferum* in collectors' green houses at the time, one being more compact (short internodes) and bearing bright red bristles on the petioles. The other variety was stringy with weak coloring and smaller leaves. A strain of *P. laciniatum* was found to be cold resistant withstanding temperatures to approximately 27 degrees F.

As *P. squamiferum* was slow and would not stand winter shipment, and *P. laciniatum* lacked color, this looked like a good place to start. *P. squamiferum* was easy to flower, a healthy plant producing flowers the year around if the temperature was kept above 70 degrees F. *P. laciniatum* was very erratic in flower production. A disease free plant grown under favorable greenhouse conditions continued to produce foliage and only occasionally flowered in late spring unless shocked in some manner. As *P. squamiferum* usually had flowers, using fresh pollen from this to fertilize *P. laciniatum* flowers was no problem.

*auriculatum × imbe

*bipinnatifidum × selloum

*selloum × bipinnatifidum

deflexum × laciniatum

*giganteum × dubium

giganteum × imbe

hastatum × squamiferum

*hastatum × imbe

imbe × squamiferum

squamiferum × imbe

'seaside' × bipinnatifidum

*speciosum × selloum

stenophyllum × squamiferum

squamiferum × stenophyllum

**squamiferum × laciniatum
***(X Florida)

squamiferum × radiatum

**Species #8 X 'Tuffy'
***(X Emerald queen)

squamiferum × tripartitum

**squamiferum × quercifolium
***(X Florida compacta)

wendlandii × giganteum

*wendlandii × hastatum

**wendlandii × imbe
***(X wend-imbe)

wendlandii × laciniatum

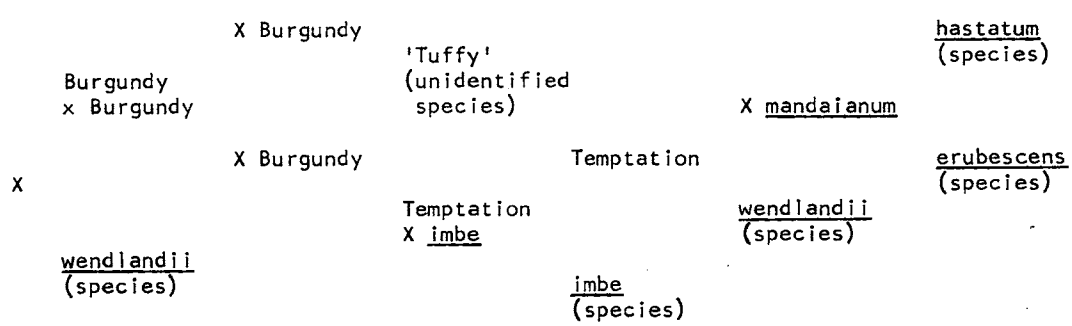
wendlandii × tripartitum

wendlandii × quercifolium

* Appeared on the market.

** Accepted by the trade and produced in large quantities.

*** Accepted trade names.



How could a plant that flowered in the spring be crossed with a plant flowering in the fall? Could pollen be stored? Could plants be forced to flower? By experimentation it was found that dry pollen of most varieties could be kept for six weeks by refrigerating at approximately 38 degrees F. There are exceptions to this in the less hardy species. Apparently, if the plant will not take 38 degrees F., neither will the pollen. Rather than solve the problems of pollen storage or forced flowering they were circumvented by crossing extremely soft species with tough species flowering at the same time and then re-crossing with desired species at a later date.

For flower production various philodendron were planted in the ground in a small greenhouse. Little control was exercised on disease or insects. Rain was produced in the greenhouse every twelve minutes for a period of ten seconds between the hours of 8 A.M. and 5 P.M. with the aid of time clocks and solenoids. By varying this rainfall and dropping night temperatures to 50 degrees F. for a few weeks in winter a heavy flowering season could be initiated in February that lasted until about June 1st.

Before discussing the procedure of pollinating or cross pollinating it should be pointed out that the philodendron genus can be divided into three apparently compatible groups. The first group is the aborescent or tree like plants, i.e. *P. selloum.* These have erroneously been called "self-headers." The second group consists of the majority of the vines and true "self-headers," such as *P. wendlandii.* Plants within each of these two groups cross freely. However, after hundreds of attempts, no successful cross has been made between plants of one group and the other. The chromosome numbers of the plants within these groups are not known. The third group consists of plants (all vine types) that have not been successfully crossed with any type. A few of these have refused their own pollen, suggesting they are sterile and are hybrids from outcrossing in nature. A good example of this is *P. panduraeforme.* A red hybrid with the *pandraeforme* shaped leaf but with no *panduraeforme* parentage has been produced.

Philodendron oxycardium (commercial *cordatum*) can be readily self pollinated. However, it has not been possible to cross it with other species. A cross between *P. hastatum* x *P. cordatum* has been listed. However, the appearance of the plant would suggest that it is a cross between *P. hastatum* and true *P. cordatum, a* spindly plant with hastate leaves.

The philodrendon has a typical aroid flower. It has a spadix enclosed in a rather thickened spathe. (Fig. 1). The timing of pollination is important if successful fertilization is to be obtained. Having selected the species to be used, and after the flower buds are well formed, it is necessary to start checking each evening before 6 P.M. to see if the spathe is starting to open. If so, the female parts of the flower will be ready to pollinate within 12 hours, the usual time being 4 to 5 hours. The time for pollination can be determined two ways. One being to check the temperature of the spadix. There is a definite temperature rise in the male flowers of these plants as the flowers open. This temperature rise above air temperature may be only a few degrees to as much as 15 degrees F. or more. The female flowers, i.e., lower portion of the spadix, should be checked to see if they are covered with a sticky substance that will disperse the dry pollen when it is applied. At this point the spathe is cut away from the flower, exposing the flower parts (Fig. 2). Pollen from storage or from a flower that had opened 24 hours previously should be applied to the surface of the stigmas with the aid of a small camel-hair brush or by the finger tips. In using either method, the brush or finger tips should be moistned first in the solution covering the stig-

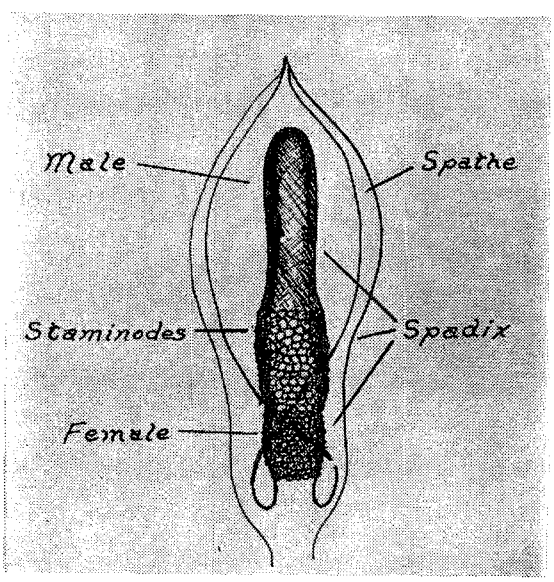


Figure 1.—Line drawing of philodendron flower showing flower parts.

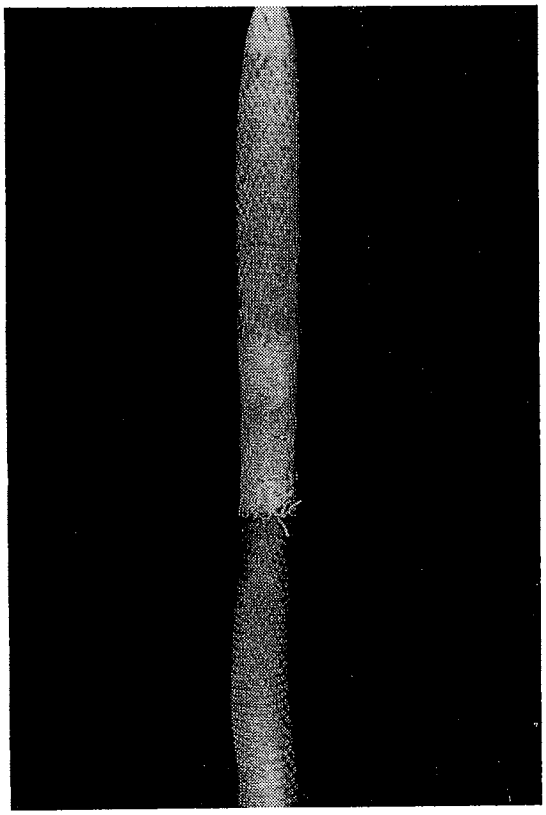


Figure 2.—Cannifolium flower with spathe cut away. Top—staminate flowers, center—sterile portion, bottom—pistillate flowers.

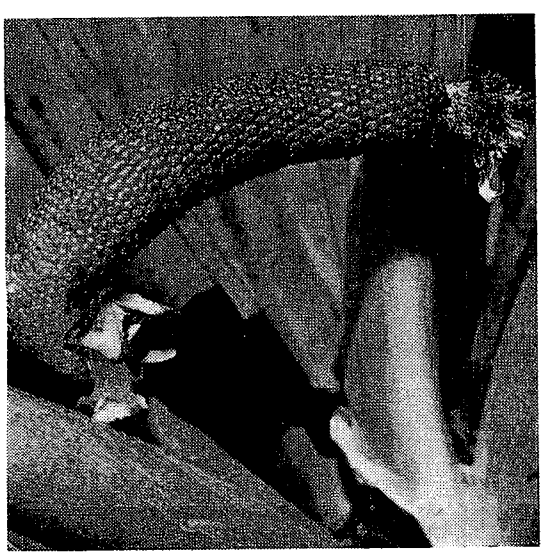


Figure 3.—Mature fruit of P. cannifolium.

mas and then dipped into the pollen. The pollen when applied to the stigmas should be allowed to disperse and then be spread evenly over the entire surface of the female flower portion of the spadix. This is extremely important, because if only a small portion of the ovaries are fertilized, the fruit will not develop to maturity.

If fertilization is successful, the cluster of ovaries turn green and start enlarging. The upper portion or pollen bearing part of the spadix dries and in time will drop off (Fig. 3). The fruit continues to enlarge and in a period of two to six months, according to the species, will grow to 8 to 10 times its original size (Fig. 3). As the fruits ripen they change color, usually becoming white, yellow or orange. A few fruits such as *P. cannifolium* remain green. Regardless of color change, the general appearance of the fruit will clearly indicate its ripeness. The balance of the spathe not cut away during the pollination process will soften and curl back (Fig. 3), looking very much like a banana peeling when it is partially peeled back, exposing the fruit. When this happens, the fruit is ready for picking.

The fruit contains a hard core not unlike the core in the center of a pineapple. The seeds are encased in a thin sac filled with fluid. Each sac contains one or two seed to as many as a hundred or more as in *P. melinoni*. Some of the arborescent types have seed the approximate size of poppy seed (Fig. 4), while others like *P. melinoni* and *P. squamiferum* have seed so small a hundred could be picked up on the end of a pencil.

The fruit can be stored at 38 to 40 degrees F. and kept for several weeks, or the seed can be planted directly. Fruit from plants that will not tolerate 38 degrees F. should not be stored at this temperature. The seed will be damaged.

Tests were conducted to determine the best time for planting seed after the fruits are harvested. Ten lots of 500 seed each from single fruits were used. One seed lot was planted the day of harvest and one each week for 10 succeeding weeks. Approximately 95 percent germination was obtained for all seed lots. However, 21 days were required for the seedlings to become visible to the naked eye for the first day of planting, and only 17 days were required for the 10th weeks planting.

In general the seed were planted the day the fruit was harvested, while they were still moist. The seed were mixed with dry builders sand and shaken from a glass jar with holes punched in

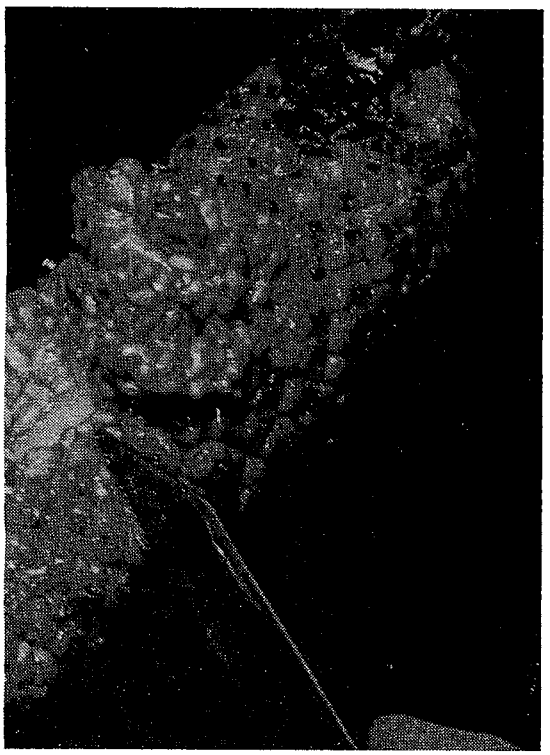


Figure 4.—Portion of P. selloum fruit. Note size of seed. Photo by F.S.N.B.

the lid onto a flat or tray filled with about 3" of sterilized German peat. Mixing sand with the seed assured a more uniform distribution of the seed. The seeds are so small the young plant has trouble emerging if covered with soil. Several methods of covering the seed have been tried, including sphagnum dust, but covering the tray with a pane of glass has proved most satisfactory. The seed should never be allowed to become dry. Once germination has started, the trays need to be inspected daily for signs of "damp off" and bacterial "soft rot." Most Philodendron seedlings are extremely susceptible to both.

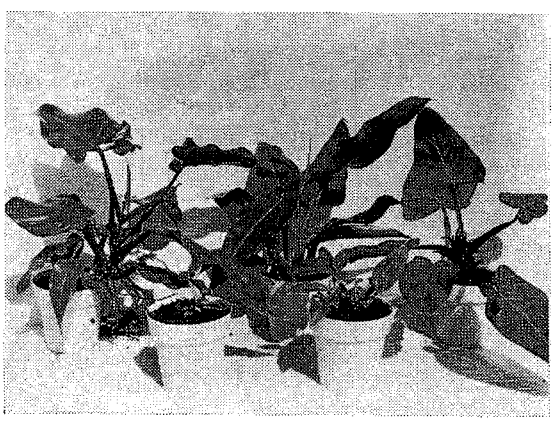


Figure 5.—Five seedlings from a single fruit of a multi-cross philodendron hybrid. Note, cholrotic, deformed plants in foreground and at right, compared with acceptable plants.

When plants are ¼" to ½" tall, they are fed a weak solution of soluble fertilizer and maintained in a healthy, growing condition.

When the seedlings are ready for transplanting, selecting desirable types for growing off is of primary consideration. If the cross is an F_1, 25 seedlings are transplanted for growing off. The other seedlings in the tray can be held back for use if needed by keeping the tray relatively dry and witholding fertilizer. If the progeny resulted from multi-crosses, there is no easy way out. All the seedlings have to be grown off for observation. Extreme variations in plant types and growth response occur among seedlings from a single fruit (Fig. 5). There is one exception to this. If coloration in the final plant is being sought, the transplants may be culled. Any plant which will show color in the mature form will have red root tips as a tiny transplant.

During the first three or four months after transplanting from the trays to an open bed optimum conditions for plant growth are maintained. Temperatures ranging from 70 degrees F. at night to 90 degrees F. in the daytime appear best. A fertility level of approximately 25-5-20 ppm soil test has been satisfactory. The soil is kept constantly moist. Plant foliage is allowed to dry off before night.

By the fourth month most seedlings are large enough to start culling. After selecting and pulling desirable types, their treatment is just the opposite from the above. They are allowed to lay bare root 24 to 48 hours and then reset and given more space in an open bed. Fertilizer is withheld for several weeks; then nutritional levels are doubled or tripled those generally used for satisfactory plant growth. The plants are kept very dry and then very wet. Plants that become chlorotic, or show excess rotting or any other ills are immediately discarded. However, ones that withstand this treatment are able to stand the same mistreatment at the hands of any grower or wholesaler and should be able to endure the less than ideal conditions of the home.

After culling is finished and after the mis-

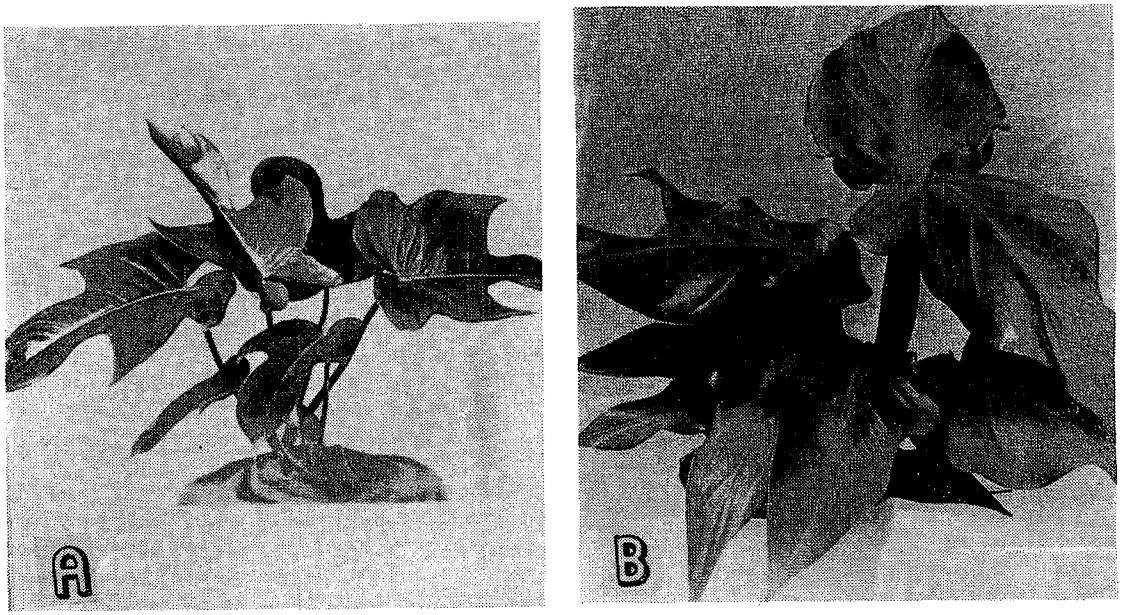


Figure 6.—A -P. X Florida F_1 from inter-specific cross. B - selected plant from multi-species cross.

treatment, growing conditions are brought back to normal. If some particular clone appears to be promising (Fig. 6), it is again transplanted; but this time it is tipped, and both tip and base are labeled and planted. If it to be a vine, some single eye cuttings are also planted. When these cuttings develop, and if the plant still looks desirable, other tests may be conducted. The plants are subjected to the environment of air conditioned buildings. They are sealed in air tight boxes for a week to see if they will withstand long shipments. If the plants have passed these tests, one more big decision must be made—are they better than anything similar on the market? If not, they are discarded.

Figure 7.—Red, rosette type of philodendron plant selected from multi-hybrid crosses.

Results and Discussion

The senior author has made hundreds of crosses to date. As many as 1,000,000 seed, 800 trays, have been planted per year; yet the really good hybrids can be counted on the fingers. A partial list of the F_1 hybrids that have been made is given below.

It is in the subsequent crosses that progressive results show up. Below is the pedigree of a plant that is one of the best at this stage of its development.

Here it should be evident a red, rosette type plant was desired. This has been produced (Fig. 7), but many combinations of parent characteristics occurred in the process. In the final cross the male parent contains all the best qualities of X Burgundy plus having a shorter petiole and wide blade but is quite unique in that both male and female are fertile and the plant flowers over a long period of time.

The offspring of this cross are now up to flowering size, and several plants have been selected.

Each shows resistance to "shot gun fungus," (sensitivity to temperature and moisture fluctuations), has wide upright blades with very short petioles, and has both red and green plants.

Philodendron hydridization now stands at the threshhold of opportunity. Years of painstaking detail are behind. From the multicrosses now on hand and with knowledge of other crops that have been hybridized to seeming perfection, surprising results can be expected in the future.

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PHOTOSYNTHESIS IN CHRYSANTHEMUM CUT-FLOWERS[1]

S. S. WOLTZ[2]

ABSTRACT

It was demonstrated that the photosynthetic activity in *Chrysanthemum morifolium* Ram. cut-flowers may be of considerable importance in extending vase-life. Light intensities in the range 50 to 400 foot candles were beneficial in terms of keeping leaves green and functioning. Blossoms were benefited, but to a lesser degree. Light preserved photosynthetic capacity, chlorophyll content and the supply of metabolites in leaves that were lighted compared to those in the dark. The implications of photosynthesis by chrysanthemum cut-flowers are discussed.

INTRODUCTION

Cut-flowers are not generally credited with the capacity for manufacturing food when lighted or of benefiting from illumination. Consequently, those who handle cut-flowers (growers, wholesalers, florists and users) do not usually make provisions to take advantage of any benefit that might result from lighting where feasible.

Aarts (1) investigated the effect of lighting 12 hours a day with light of 2000 lumen intensity on the performance of *Mathiola incana, Dianthus Caryophyllus* and *Tulipa sp.* Mathiola cut-flowers lasted 20 days in the light but only 13 in darkness. Dianthus lasted approximately as long in light as in darkness; however, the stems were weaker and bent in darkness. Tulipa was not benefited by light. An effort was made to estimate the effect of lighting *Chrysanthemum morifolium* by comparing the keeping quality of manually defoliated cut-flowers with control cut-flowers, both being lighted. The object was to remove the photosynthetic effect by defoliation. While the control flowers out-lasted the defoliated flowers, this is not considered a valid measure of the effect of light on keeping quality, since the process of defoliation not only stops photosynthesis but also removes a source of chemical compounds important in metabolism.

The present investigation was undertaken to measure the effects of light upon the vase-life of cut chrysanthemum flowers. A secondary objective was to determine the basic effects in terms of the metabolism and biochemical constituents of leaves and flowers.

METHODS AND MATERIALS

Bluechip variety (*Chrysanthemum morifolium* Ram.) was harvested immediately prior to each experiment and placed in water after cutting. Flowers were illuminated in the laboratory using cool white fluorescent tubes. The desired range of light intensities was obtained by placing the flowers at various distances from the lights and by shading with saran screen as required. Light intensity was measured with a General Electric light meter model No. 80W40X16 calibrated in foot-candles. Light intensities were measured at the average height of leaves on the stem.

Measurements of photosynthesis and respiration by leaf disks were carried out in the manner described in a previous publication (5). Chlorophyll was determined by the method of Arnon (2). Anthocyanin was extracted from petals with ethanol containing 1% HCl, a modification of the method of Block, *et al.* (3) and measured spectrophotometrically at 505 mu, the wavelength of greatest light extinction. Sugars, amino acids and oxalic acid were determined semi-quantitatively by paper chromatography (3).

Three experiments were performed in December, 1964 and January 1965 studying the effect of

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