SOME USES OF PLASTIC FILMS IN THE PROPAGATION AND GROWTH OF CERTAIN HORTICULTURAL PLANTS

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SOME USES OF PLASTIC FILMS IN THE PROPAGATION AND GROWTH OF CERTAIN HORTICULTURAL PLANTS

by

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INTRODUCTION

During the last five years the air-layering method of propagating stiffly-erect, or difficult-to-root plants, has been stimulated by the use of certain plastic films which prevent the loss of moisture when the films are used as wrappers around the rooting media. Polyethylene and polyvinyl type films were used successfully in this work. The "rubber plastic" film was used in the air-layering of the Lychee (Litchi chinensis) by Grove in 1947 (10). He received a patent in 1951 for this method of propagation. Air-layering with polyethylene film was reported by Creech in 1950 (4) and by Wyman in 1952 (15).

Wyman experienced difficulty in getting some of the new plants to continue growth once they were rooted and removed from the parent, although he considered this operation beyond the scope of his experiment. He suggested that a study should be made to determine the proper time to remove the air-layer for further development of the new plant.

Accordingly with this difficulty in mind, an attempt was made to determine the proper time to remove the air-layer for continued growth of the new plant, as shown in the preliminary trials; and also to investigate the possibility of using plastic films in the rooting of cuttings. Furthermore, the program was broadened to include the use of plastic films in the propagation and growth of certain horticultural plants.

REVIEW OF THE LITERATURE

Articles were written on vegetative propagation over 2,000 years ago. Theophrastus, as reviewed by Avery et al (1), considered that trees could be propagated by cuttings and layers, and Pliny described methods of propagating many plants by suckers, cuttings, and layers. For many centuries the Chinese practiced air-layering, a method of reproducing the stiffly-erect or difficult-to-root, woody plants. Probably this method was introduced into the United States by early settlers from China.

Essentially these methods have remained unchanged throughout the years, although much has been learned, especially during the last 25 years, to improve the techniques of propagation. About the middle of the eighteenth century Duhamel du Monceau (7), after careful experimentation, suggested that plants may contain a substance capable of initiating callus and root growth.

Darwin (5) localized a response to light and gravity in roots and grass seedlings. The response occurred several millimeters below the tip of the organ which received the stimulus. He suggested that the transmitted stimulus may have brought about this phenomenon.

The theory of Sachs, as reviewed by Went and Thimann (14), that specific chemical substances from one part of the plant moved to other parts, influencing organ development, was speculated upon by many investigators from 1880 to 1910. It was generally concluded that the bending of shoots to unilateral light and the response of roots to gravity were due to a transmission of stimulus from one part of the plant to another part where the curving occurred.

Animal physiologists in 1905 coined the word "hormone", a Greek word meaning "activity arouser", a specific substance which was produced in one part of the body and carried by the blood stream to another region where the response would take place. Botanists began to use the work to describe unknown materials thought to be present in minute quantities within the plant and which were responsible for plant development.

The fact that leaves manufactured the carbohydrates and other nutrient substances caused confusion among many workers. Van der Lek, according to Went and Thimann (14), concluded root formation was dependent somewhat upon the presence of sprouting buds, although some roots could be formed without buds present. He assumed that a hormone-like material was produced in the buds and transported downward in the phloem tissue to the basal portion of the cutting.

Much work was done to correlate the internal physiological conditions of plants with the ability to root. Many chemical substances were tested but the results were not significant. The advantage of using them was slight.

Zimmerman, Crocker, and Hitchcock (16) were the first to find a specific chemical that definitely aided rooting. When carbon monoxide gas was used on the stems of some plants, rooting occurred. Because of the toxicity of the gas to workers, it could not be used commercially.

The discovery that indoleacetic acid was an excellent root-forming substance led to its practical use in the rooting of cuttings (1). Cooper (2) was the first to use lanolin with indoleacetic acid in plant propagation. He treated the apical portions of lemon cuttings with the paste which stimulated root formation. Zimmerman and Wilcoxon (17) found many widely differing chemical substances to be effective in root formation on cuttings, such as a-naphthaleneacetic acid, indolepropionic acid, phenylpropionic acid, and phenylacetic acid. Hitchcock and Zimmerman (11) listed the effects of various crystalline acids by soaking the cuttings in a dilute solution of the chemicals for a number of hours. This research stimulated the development of other new methods in treating cuttings and the discovery of many new compounds which proved active in root formation.

According to Avery et al (1) the use of a hormone powder was first described by Grace. The ease of application and the wide range of effectiveness caused this method to become popular as well as practical. Later a "quick dip" method, using a concentrated solution of the different hormones, was developed by Hitchcock and Zimmerman (12). At present the majority of the commercial preparations appear on the market in the powder form. They contain either indolebutyric acid, naphthalene acetamide, or naphthaleneacetic acid in talc, or various mixtures of these compounds and their derivatives.

Materials other than growth regulating substances have been tested for their use as aids to rooting. Vitamins, carbohydrates, amino acids, and nitrogen compounds have been investigated for their comparative influence in the rooting of cuttings without significant results.

Regardless of the treatment given cuttings with growth substances, the first essential for successful root formation was considered to be the control of the propagation house environment. Unless the new plants were given special care, the addition of any root-inducing hormone was useless. Cuttings which rooted easily under the proper environment would respond to auxin treatment. Those difficult-to-root plants were encouraged to form roots only under special conditions.

Specific methods were developed to encourage root formation. Dostal (6) found that a healthy callus tissue was formed on the basal portions of apple cuttings when they were wrapped with filter paper moistened in a dilute solution of indoleacetic acid. After wintering, these cuttings developed buds and roots. Gardner (8) etiolated the growing points of apple shoots with black paper. Later the shoots were removed and they were rooted as cuttings with success.

Air-layering, as previously mentioned, was a means of rooting stiffly-erect or difficult-to-root plants. A selected shoot was scarified, ringed, or partially cut at the point where roots were expected to develop. A moist medium was wrapped around the area, tied with a string or some binding material, and kept watered during the process of root formation. Sometimes a paper would be tied around the dressing to conserve moisture. Later a flower pot was split lengthwise and tied around the rooting medium for support as well as an aid in watering.

Workers in the United States Bureau of Plant Industry made use of a "marcottage" box of paraffin-coated paper or metal with notched or slotted ends. It permitted less frequent watering during the period of root formation. Once the air-layer was rooted, the shoot was severed from the mother plant, the marcot box removed, and the new plant placed in soil for further development. Many stems of stiff-growing plants could be rooted in this manner.

Gossard (9) wrapped pecan shoots to be marcotted with adhesive tape. Later the tape was removed and indolebutyric acid was injected with a toothpick where roots would form. A moist dressing was applied and successful rooting resulted.

Thakerta and Dutt (13) used a three percent solution of indoleacetic acid on ringed Mango (*Mangifera indica*)marcots. When they were removed from the mother plant, they were soaked again for 24 hours before planting. Successful results were obtained from two and three year old *Mangifera indica* trees.

Cooper (3) painted the girdle of *Cacao* and *Cinchona* marcots with five milligrams per milliliter of indolebutyric acid in 50 percent alcohol. Moist sphagnum moss was used to wrap the marcot. He obtained 66 percent rooting with *Cacao* and 100 percent success with *Cinchona* air-layers.

Grove (10) found that air-layering the Lychee (*Litchi chinensis*) fruit tree was improved by the use of the new plastic films. He used "vitafilm", "pliofilm", "polyethylene", and "polyvinyl" plastic films. A methods patent was applied for by Grove under the trade name of "Airwrap" and was finally granted to him four years later.

Creech (4) of the United States Department of Agriculture station at Glendale, Maryland, used "polythene" film on Rhododendron air-layers with success.

Wyman (15) described the properties of "polyethylene" film, showing its permeability to gases and its moisture-holding function. He pointed out that polyethylene was developed from high polymers of ethylene with generic names of either "polythene" or "polyethylene", and found under trade names such as "Alathon", "Howard Seal", "Pearlon", "Tralon", "Visqueen", and others. Wyman secured "Dura Clear" of 0.004 inch thickness from the Harwid Company, Cambridge, Massachusetts, to use in this series of air-layers. The important properties of this film were the high permeability to gases, such as carbon dioxide, oxygen, nitrogen, and hydrogen, and its low permeability to moisture.

The method of air-layering was described as follows. A deep two-inch upward cut was made on the twig where rooting was desired. Both cut surfaces were dusted with "Hormodin No. 3" hormone powder. A handful of moist sphagnum moss was packed around the cut, entirely covering it. Polyethylene film was wrapped carefully and tightly at the top and bottom of the layer, where Scotch electrical tape No. 33 was recommended to seal the bag, starting on the twig and spiraling over the tight portions of the film. This method would protect the dressing from the rainy weather.

Wyman reported on 130 species of woody plants on which air-layers rooted with fair success. Most of the work was done on outdoor plants late in April or July, 1951, and were examined in October of the same year. The majority were well callused and the percent rooted varied with the species.

MATERIALS AND METHODS

Some air-layers were tried on herbaceous plants with excellent success using polyethylene film as a wrapper. Six new plants were developed from eight air-layers placed on one *Hydrangea macrophylla* plant (Figure 1).

Further experiments on varieties of *Hydrangea macrophylla*, *Pelargonium domesticum*, and Croton (*Codiaeum variegatum*) for the purpose of determining the proper time to remove the new plant from the parent (Figure 2). A few of the air-layers were removed soon after roots were observed under the film. The plastic was discarded and the entire ball of moss and roots was planted in good soil. The sphagnum was moist and the roots were white and tender. In all cases the new plants continued growth as though undisturbed. Other air-layers were left on the parent plants for several weeks after roots were observed growing under the film before they were removed and planted in good soil. In these cases the roots were dark brown, thin, and dry-looking. The sphagnum moss was very dry. Out of ten air-layers, only one continued growth after planting in the soil. The majority of the mature leaves turned yellow and died before good growth was resumed in this plant. The results of these preliminary trials would indicate that the time to remove the new plant from the parent should be soon after roots were observed growing under the plastic; that is, before the new roots exhausted the moisture supply from the moss and subsequently died from lack of water.

An attempt was made to root herbaceous cuttings in a similar wrap of either polyethylene or polyvinyl film using sphagnum moss for a rooting medium. Trials were made to determine the size and shape of the plastic films that would be necessary for good root formation on cuttings (Figure 3). The amount of moisture loss in grams was recorded from each sample daily. The quantity of sphagnum moss needed to root a cutting was considered.

The actual weight in grams of selected samples each day for a six-day period was kept and their averages recorded in Table I. This study showed that a successfully rooted cutting should weigh at least 50 grams gross to prevent the necessity of adding water to the package (Figure 4).

After these preliminary trials materials were selected and a method of procedure planned which seemed to fit the average herbaceous cutting. Polyethylene film of 0.004 inch thickness, under the trade name of "Visqueen", was secured from the Visking Corporation, Terre Haute, Indiana. Polyvinyl film of similar thickness, under the trade name of "Airwrap", was secured from the Agriplast Company, Sarasota, Florida. Sphagnum moss was purchased from the local garden supply. Rubber ties were selected for the first experiment to fasten the films around the moss-embedded cuttings. Later, rubber bands were used to form the package.

Each operation for wrapping a single cutting included the following materials: one square of polyethylene or polyvinyl film, size 7 inches by 7 inches or 9 inches by 9 inches in the latter film; a handful of moist sphagnum moss which had been allowed to soak in water overnight; a rubber tie of the type used in grafting work; and individual cuttings from Chrysanthemum morifolium, Begonia semperflorens, Dianthus caryophyllus, Euphorbia pulcherrima, Pelargonium domesticum, Fuchsia hybrida, Antirrhium majus, and Coleus blumei varieties, which are listed in "Plant Materials Used".

EXPERIMENT I, Plastic wrap for individual cuttings

A bench was prepared in the Nursery Crops House. One-half of the bench was reserved for bench cuttings, used for controls and placed in the bench at random in four inches of vermiculite. Excess moisture was squeezed from a handful of moist sphagnum moss and placed on the square of film. A cutting trimmed in the usual manner suited for the propagation bench was nestled nearly to the bottom of the rooting medium (Figure 5). The sides of the plastic square were lifted and a rubber tie placed around the top of the newly-formed bag (Figure 6). The wrapped cutting was placed in the propagation bench on inverted pots and beside the control cutting. An attempt was made to regulate the relative humidity within the bench. An overhead frame was constructed and a large sheet of polyethylene film was drawn over the top, housing both the benched and the bagged cuttings. The top of the film was slit in order to ventilate the bench when it was needed. A thermostatic control regulated the temperature in the Nursery Crops House to 70 degrees Fahrenheit. Two fluorescent lamps, each containing two 40-Watt daylight tubes were suspended over the bench to supplement the limited light. These cuttings were placed in the bench in groups according to the species for easy observation.

During the warm summer months a refrigerated storage room in the same building was used in order to control the temperature. The room was cleaned thoroughly. Four shelves were installed, two feet wide by ten feet long, to support the bagged plants. Two 40-Watt fluorescent units were suspended 14 inches above each shelf (Figure 7). The temperature was controlled by a cooling unit. The thermostat was regulated to give a constant temperature of 70 degrees Fahrenheit. The percent relative humidity was increased by flooding the floor of the storage with water daily to overcome the drying effect of the cooling unit fan. The cuttings were wrapped in the same manner as the plants in the bench, except for rubber bands which were used to secure the film instead of ties.

EXPERIMENT II, Plastic wrap for seedlings

Further work was planned to determine the feasibility of growing vegetables and flowers from seed for transplanting outside, using a plastic wrap and sphagnum moss. Common garden varieties of Tagetes patula, Petunia hybrida, Lycopersicon sp., and Capsicum grossum, which are listed in "Plant Materials Used", were selected. Seeds were planted in greenhouse flats of sphagnum moss, of vermiculite, and of muck soil. When the young seedlings were about three inches in height, they were packaged in squares of film and moss wrapped in a similar manner to the cuttings described in Experiment I. The moss was treated with a 10-5-5 analysis liquid fertilizer at the rate of 5 cubic centimeters for each plant. The packaged seedlings were placed in a greenhouse bench under conditions favorable to good growth for a period of three weeks. At the end of this time the plants were transplanted to the field.

EXPERIMENT III, Plastic wrap for greenhouse pots

Polyethylene squares were placed around 4- and 6-inch pots of Pelargonium zonale and Hydrangea macrophylla in an attempt to conserve the moisture loss from greenhouse potted plants (Figure 8). The film was secured with a rubber tie placed around the basal portion of the plant. The plants were placed in a window of a room which averaged a temperature of 70 degrees Fahrenheit and a relative humidity which approximated normal summer home conditions. The plants were not watered during the experiment. Daily observations of these plants were made to determine the maximum time before the plants would require additional moisture for good growth and further development.

EXPERIMENT IV, Plastic roll for cuttings

At the suggestion of a grower an attempt was made to root a group of cuttings in 3 by 4 inch spaces, using a plastic package which could be shipped in live plant boxes without additional packaging (Figure 9). Preliminary trials were made and a roll package was developed using 26 cuttings (Figure 10). Varieties of Chrysanthemum morifolium, Indianapolis Yellow and Mefo White, and mixed varieties of Dianthus caryophyllus were used in the first part of this experiment. Later rolls of 50 and 100 cuttings were prepared using such Chrysanthemum morifolium varieties as Thyra White and Thyra Bronze, Barcarole, Cassandra, Encore, and Cavalcade. Some disease developed in the closely packed leaf areas. Further tests were made in an effort to overcome this difficulty and as a result, a cone-shaped roll was developed.

The method of rolling the cuttings was as follows: a strip of plastic film 9 by 18, 36, or 72 inches long, depending upon the number of cuttings used, was placed on the table. Sphagnum moss, moistened overnight, was squeezed lightly to remove the excess water and spread evenly over one-half of the width of the film. The cuttings were trimmed in the usual manner and placed with their basal portions on the moss one inch to one and one-half inches apart, the leaf areas extending beyond the edge of the plastic (Figure 11). The other half of the plastic film was folded over the stems of the cuttings. Starting at one end of the film, the materials were rolled gently and firmly into a compact roll (Figure 12). Two rubber bands were placed around the plastic to keep the roll intact. Holding the roll with one hand, the bottom of the package was pushed upward in the center with a winding motion, working the package into a cone-shaped roll. The roll was placed on an inverted flower pot of a proper size to allow the package to stand firmly upon the propagation bench (Figure 13). The percent relative humidity of the house was kept high to prevent wilting. The temperature ranged from 55 degrees at night to 70 degrees Fahrenheit in the daytime. Occasionally a fine mist spray was applied to the leaf areas to hold the cuttings turgid. When rooted, they were placed in live plant boxes and shipped to various destinations for observations.

EXPERIMENT V, Storage

The possibility of storing this portable roll package of rooted cuttings for the purpose of arresting growth was considered. Preliminary plans were made and a storage room secured in which the temperature could be controlled accurately.

One roll of 26 rooted cuttings of Chrysanthemum morifolium, variety Mefo White, and one roll of 26 rooted cuttings of Dianthus caryophyllum, mixed varieties, were placed in unlighted storage for a period of one month in a temperature of 31 to 34 degrees Fahrenheit. At the end of this time they were removed from storage and the rooted plants were placed in three-inch pots of soil beside freshly rooted cuttings of the same varieties. All of the *Chrysanthemum morifolium* plants were soft pinched at the proper time and growth continued for a month. At this time observations were made on the growth and development of all plants.

Rooted cuttings of *Chrysanthemum morifolium*, varieties Thyra Bronze, Barcarole, Encore, Mefo White, and Cassandra, and rooted cuttings of *Dianthus caryophyllus*, varieties Jumbo Cardinal, Mohawk, Miller's Yellow, and White Sim, were placed in unlighted storage at a temperature ranging from 31 degrees to 34 degrees Fahrenheit on March 1, 1953, in an effort to control stretching over a maximum period. On April 1 they were thoroughly watered. On May 1, 1953, the entire lot was removed from storage.

RESULTS

Experiment I

This experiment with controlled environmental conditions indicated that the usual propagation house of high relative humidity with an average temperature of 70 degrees Fahrenheit was suitable for the rooting of cuttings in individual plastic packages. Table II was kept to record the time required to root the cuttings in plastic film compared to the normal bench cuttings. The period of rooting of the plastic wrapped packages in the artificially lighted storage room during the summer months was recorded in Table III. No watering of the wrapped plants was necessary during the process of rooting. The time of rooting and the quality of the roots were observed easily by looking at the bottom of the plastic bags (Figure 14). The wrapped cuttings rooted in the same period, or in some cases faster, than the bench cuttings. Disease was observed in three plants which were wrapped in plastic film, whereas sixty bench cuttings were destroyed by fungi during this period. Rooted cuttings of Chrysanthemum morifolium, varieties Indianapolis yellow and Thanksgiving Day Pink, and Dianthus caryophyllus, varieties Radio Red and Olympic Red, when potted in soil did not wilt, but continued growth as though undisturbed. Rooted single cuttings were planted in soil without any signs of interrupted growth.

Experiment II

The well-formed ball of roots in sphagnum moss on the seedlings transplants of Lycopersicon sp. and Capsicum grossum simplified the process of setting in the soil. No wilting was observed in the field plants and they grew well in the field.

Experiment III

Flowering Pelargonium zonale and Hydrangea macrophylla plants retained their turgidity for a period of twenty-one days without watering before showing symptoms of moisture deficiency when the pots were wrapped in polyethylene film. The symptoms of moisture deficiency observed were wilting, yellowing, and necrosis of the leaves in both cases.

Experiment IV

An environment of high relative humidity and temperatures ranging from 55 degrees during the night and to 70 degrees Fahrenheit in the daytime was suitable for the rooting of cuttings in roll packages of 26, 50, and 100 cuttings in each roll. The cone-shaped roll kept disease and death of the cuttings to a minimum (Figure 15). The shipped packages in live plant boxes, even in the three- and four-day shipments, when opened, were observed to be free from disease and wilt (Figure 16). When water was withheld from the plants after the cuttings were rooted, the plants hardened off, eventually wilted and died. When watered once each week, the plants remained succulent and continued growth.

Experiment V

The preliminary storage trial on rooted cuttings of Chrysanthemum morifolium, variety Mefo white, and Dianthus caryophyllus, mixed varieties, indicated that the plastic roll package was suitable for storage over a period of one month. When these plants were grown on, beside freshly rooted cuttings of the same varieties, the difference in growth and development was noticeable. The stored Chrysanthemum morifolium plants averaged four inches of growth above the newly-rooted variety. Eleven Dianthus caryophyllus storage treated plants were developing buds, whereas the fresh-rooted cuttings remained vegetative.

Chrysanthemum morifolium and Dianthus caryophyllus varieties, listed in Experiment V, after being held in unlighted storage with temperature readings between 31 degrees to 34 degrees Fahrenheit for a period of two months, were observed to be in growing condition, except five rolls which showed wilt. These rolls were watered and the plants appeared succulent within 24 hours. No stem-lengthening in any of the plants was observed while in storage. The leaves remained a deep green color. The roots appeared healthy, having formed many secondary and tertiary roots.

SUMMARY

Herbaceous cuttings rooted well in moist sphagnum moss wrapped in squares of plastic film. This method was similar to that used in the air-layering technique. No watering was necessary during the period of rooting.

Seedling plants grew to transplanting size in plastic wrappers with the addition of a liquid fertilizer.

Planting operations of rooted cuttings and seedling transplants were simplified by the formation of a compact ball of undisturbed roots.

Polyethylene film was used successfully to conserve moisture loss in potted plants.

Plastic rolls of multiple cuttings rooted well in a medium of moist sphagnum moss. Shipments of rooted cuttings in plastic wrappers were observed to be turgid and free from disease upon arrival at their destination.

Plastic rolls of rooted cuttings remained in good condition when stored at 31 degrees to 34 degrees Fahrenheit in unlighted storage for a period of two months.

Figure 1.

Eight air-layers placed on one *Hydrangea macrophylla* plant, using polyethylene film for wrapping the sphagnum moss. The ends of each wrapper were sealed with Scotch electrical tape, number 33. Six of these air-layers, when rooted, were placed in good soil, developing into new plants.

Figure 2.

A *Pelargonium domesticum* plant with a plastic covered air-layer of sphagnum moss placed upon the lower right branch. This section was removed when roots were observed growing under the film, planted in good soil, and developed into the flowering condition during the same season.

Figure 3.

The propagation bench in the Nursery Crops House with the plastic hood for creating high humidity partially removed to show the wrapped cuttings rooting on inverted flower pots beside the bench cuttings used for controls. Two fluorescent units, each holding two 40-Watt tubes, were suspended over the bench to supplement the limited daylight.

Figure 4.

Four Dianthus caryophyllus cuttings, rooted in sphagnum moss, wrapped in polyvinyl plastic, and four Chrysanthemum morifolium cuttings, rooted in sphagnum moss wrapped in polyethylene film. When wrapped, each cutting weighed 50 grams. On the average each package lost one-half a gram weight each day during the rooting period.

Figure 5.

A table used to wrap cuttings in the Nursery Crops House showing _Euphorbia pulcherrima_ cuttings, variety A. Ecke, and _Lycopersicon sp._ transplants, variety Rutgers, resting in the uncovered humidifier in the background. A _Pelargonium zonale_ cutting, variety Olympic Red, prepared in the usual manner for propagation, being nestled into moist sphagnum moss, placed on a square of polyethylene film in preparation for wrapping, is in the foreground.

Figure 6.

A table used to wrap cuttings in the Nursery Crops House showing rooted Euphorbia pulcherrima cuttings, variety Albert Ecke, and Lycopersicon sp. transplants, variety Rutgers, resting in the uncovered humidifier in the background. A Pelargonium zonale cutting, variety Olympic Red, prepared in the usual manner for propagation, has been nestled into moist sphagnum moss, placed on a square of polyethylene film which is being lifted around the moss in preparation for tying the newly-formed bag.

Figure 7.

The storage room in the Nursery Crops House, in which plastic-wrapped cuttings rest on benches. Fluorescent lights are suspended over the cuttings for artificial illumination during the period of root formation. Each unit contained two 40-Watt tubes which were hung 14 inches above the plants. A cooling unit fan controlled the temperature from 68 to 72 degrees Fahrenheit. The floor was flooded daily to maintain high humidity.

Figure 8.

A flowering *Hydrangea macrophylla* plant with a polyethylene wrapper placed around the pot and tied with a band at the base of the plant to control the moisture loss. This plant remained in good condition over a period of three weeks without watering.

Figure 9

Three rolls of _Chrysanthemum morifolium_ cuttings rooted in moist sphagnum moss, enclosed in polyethylene and polyvinyl films. The outside rolls of 26 plants each will fit snugly in sections of grower's live plant shipping containers. The center roll of fifteen rooted cuttings would require a special box for shipping.

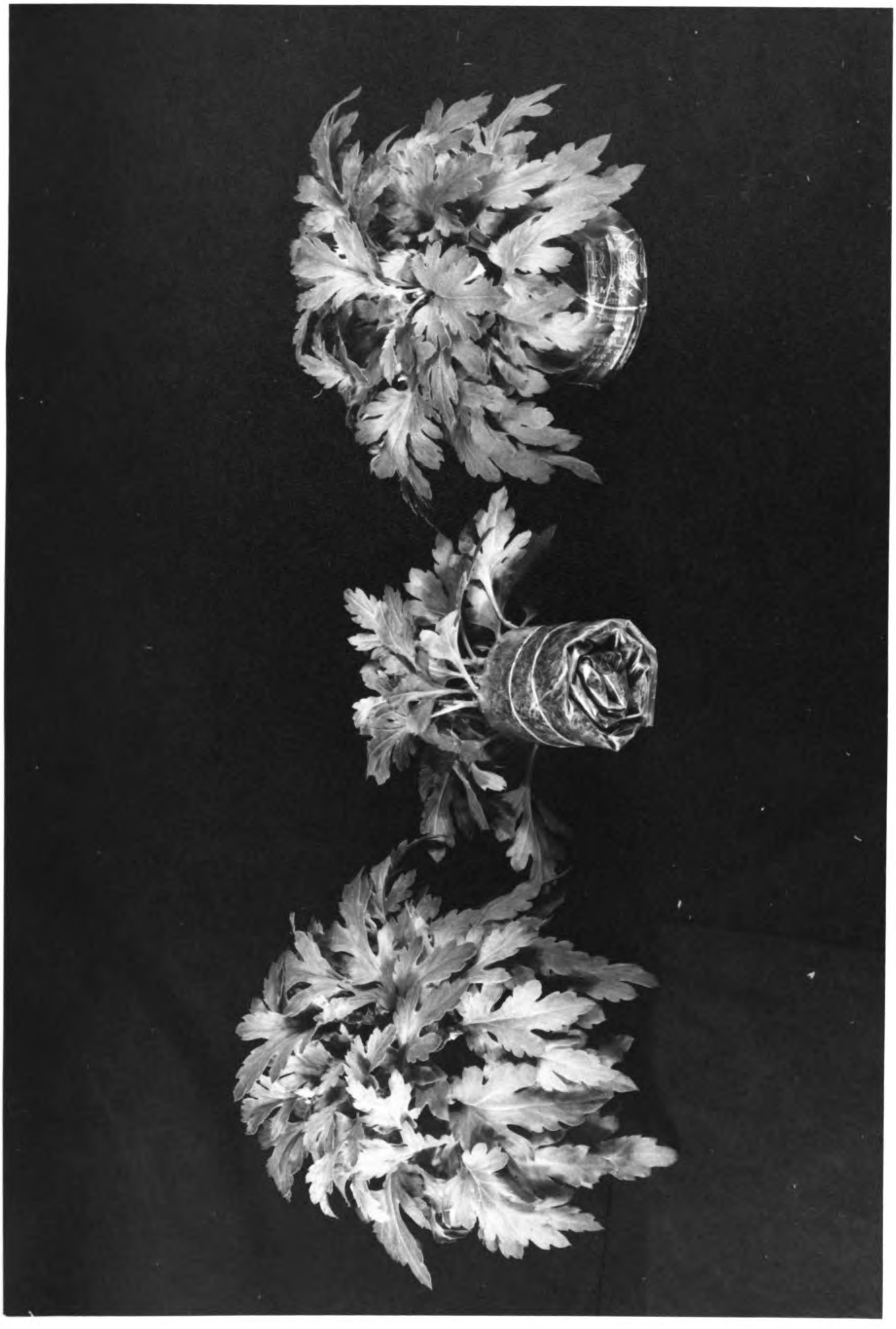

Figure 10.

Plastic rolls of *Chrysanthemum morifolium*, *St. Paulia sp.*, *Dianthus caryophyllus*, and *Pelargonium zonale* rooted cuttings ready for shipping. The type of materials used in this method of propagation are placed on the table. They include a strip of plastic film, moist sphagnum moss, and a cutting placed in the proper position for the roll method.

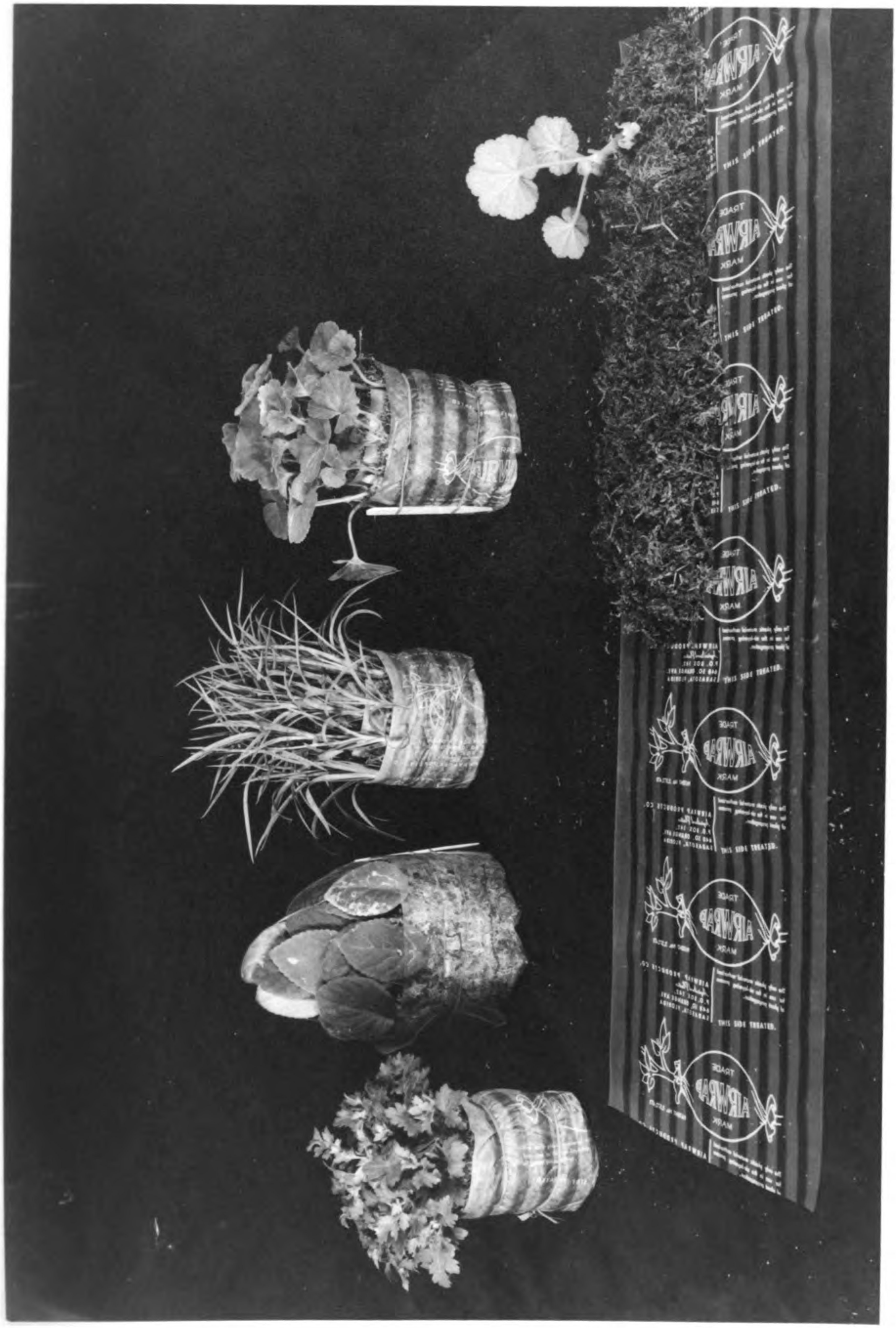
TRADE
AIRWRAP
MARK
THIS SIDE TREATED.

Figure 11.

Plastic rolls of Chrysanthemum morifolium and Dianthus caryophyllus cuttings ready for rooting. When the cuttings are placed on the moist sphagnum moss one and one-half inches apart, the bare half of the strip of film is folded over the basal portions of the cuttings. The package is formed by rolling the materials from one end with the hands.

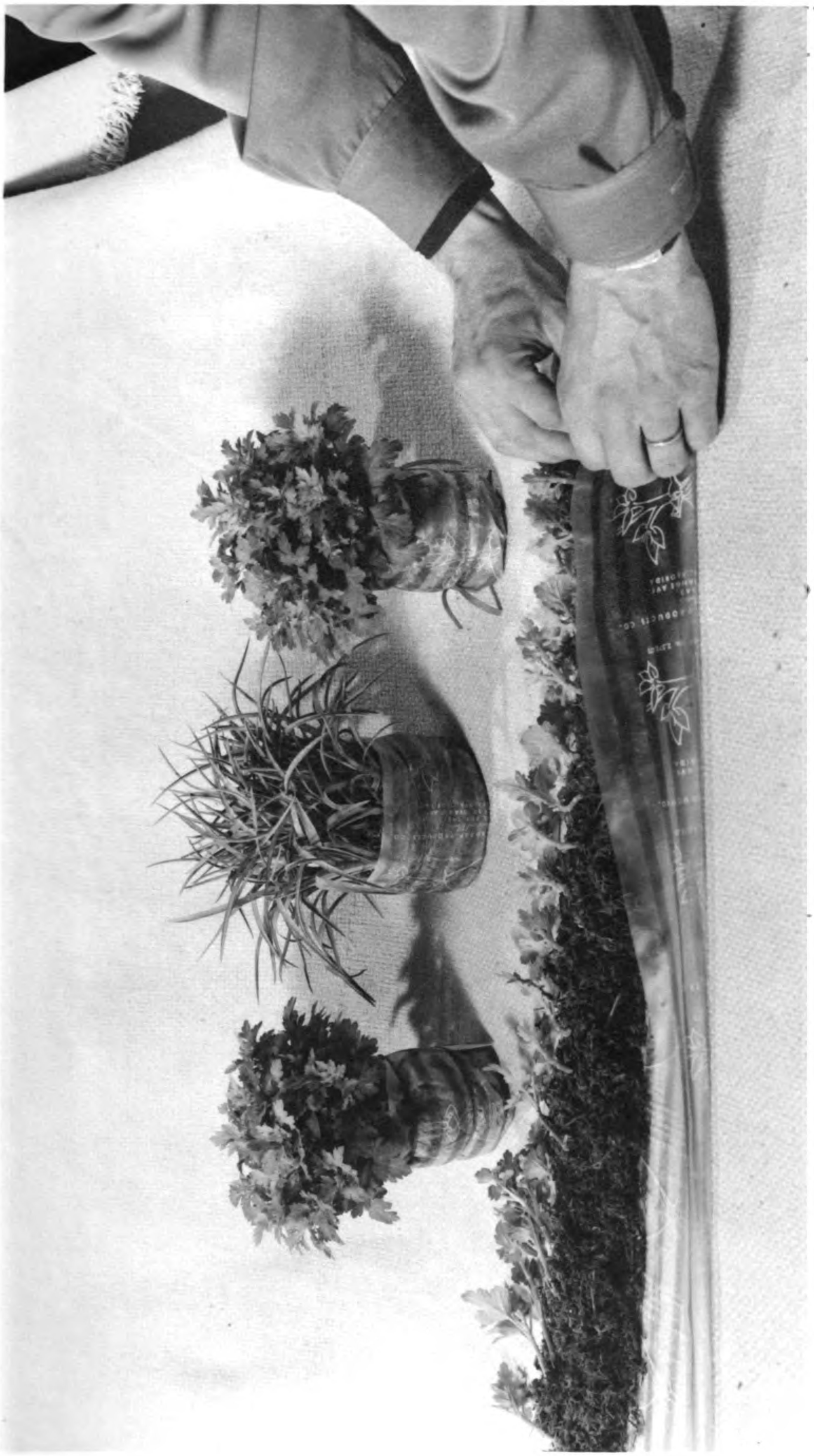

Figure 12.

A roll of Pelargonium domesticum cuttings, placed in moist sphagnum moss enclosed in polyvinyl film, ready for rooting. The package has been formed into a cone-shaped roll for better spacing of the cuttings.


The only plastic
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Figure 13.

A cone-shaped roll of Dianthus caryophyllus cuttings rooted in moist sphagnum moss wrapped in polyvinyl film. Rubber bands secure the roll which is placed on an inverted flower pot for rigid support in the propagation bench.

Figure 14.

A rooted *Chrysanthemum morifolium* cutting with the polyvinyl wrapper removed showing the roots growing in the moist sphagnum ball.

Figure 15.

A cone-shaped roll of 50 *Chrysanthemum morifolium* cuttings free of disease and rooting 100 percent in moist sphagnum moss, wrapped in polyethylene film.

Figure 16.

Rolls of _Coleus blumei_ and _Chrysanthemum morifolium_ rooted cuttings, which were sealed in live plant boxes for periods of time equal to long distance shipments; when removed, appeared to be turgid and free from disease.

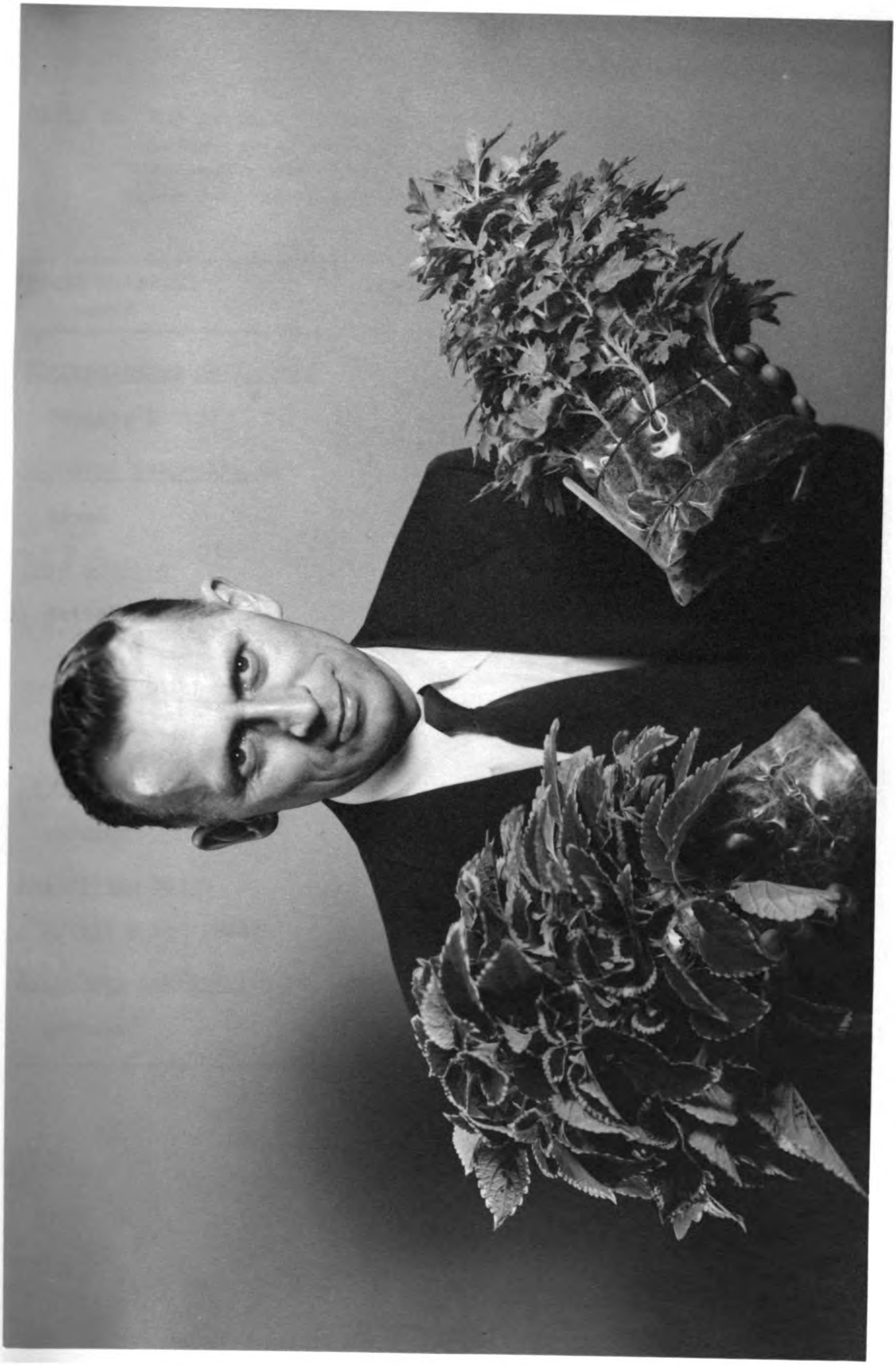

TABLE I. The average weight in grams of plastic wrapped cuttings of different sized packages taken four times over a six-day period to determine the quantity of moist sphagnum moss needed to root the cutting without adding water during the rooting period.

Plant Material Used	May 12	15	16	18
Chrysanthemum morifolium				
Francis K	52.1	51.2	50.4	49.9
Dianthus caryophyllus				
Mixed	51.0	50.6	50.3	50.2
Rosa odorata				
Better Times	72.4	71.3	70.8	70.3
	218.5	216.5	213.0	213.0
Euphorbia pulcherrima				
Albert Ecke	200.0	200.0	--	199.7
Rhododendron sp. (Azalea)				
unknown	74.6	74.0	73.6	73.1
Antirrhium majus				
Hybrid # 13 (MSC)	64.8	64.0	63.3	63.2
Hydrangea macrophylla				
unknown	100.0	100.0	99.1	98.3

TABLE II. The rooting response of certain cuttings, placed in moist sphagnum moss, wrapped in plastic film, compared with the period of rooting required for the cuttings used for controls that were placed directly in the bench of vermiculite in the Nursery Crops House.

Plant Materials Used	Number of cuttings	Number of days after planting 10	15	20	30
(Cuttings wrapped in plastic packages)					
Chrysanthemum morifolium					
Indianapolis Yellow	25	15	10	0	25
Thanksgiving Day Pink	10	8	2	0	10
Francis K	20	3	15	1	19
Begonia semperflorens					
Common	10	0	9	1	10
Antirrhium majus					
Spartan Rose	60	10	38	10	58
Total cuttings	125	36	74	12	122
(Cuttings placed in bench for controls)					
Chrysanthemum morifolium					
Indianapolis Yellow	25	14	--	--	14
Thanksgiving Day Pink	10	0	9	--	15
Francis K	20	0	15	--	15
Begonia semperflorens					
Common	10	0	10	--	10
Antirrhium majus					
Spartan Rose	60	--	--	--	0
Total cuttings	125	14	34	--	48

TABLE III. The number of days required to root certain varieties of softwood cuttings wrapped in plastic films and placed on the shelves of an artificially lighted storage room in the Nursery Crops House during the summer months of 1952.

Plant materials used	Number of pkgs.	Days after wrapping 10	11	12	13	14	15	20	Total rooted	%
<u>Euphorbia pulcherrima</u>										
Albert Ecke	40	0	0	0	0	6	2	10	37	92.5
<u>Pelargonium zonale</u>										
Radio Red	27	6	7	2	0	0	8	0	24	89.0
Madonna	6	2	0	0	4	0	0	0	6	100.0
<u>Begonia semperflorens</u>										
Common	26	0	8	0	2	10	4	1	25	96.0
<u>Fuchsia hybrida</u>										
unknown (red)	5	0	0	0	2	1	2	0	5	100.0
<u>Dianthus caryophyllus</u>										
Mixed	30	0	0	0	0	0	0	19	25	83.0
<u>Chrysanthemum morifolium</u>										
Mefo White	24	4	4	2	10	0	0	4	24	100.0
<u>Coleus blumei</u>										
unknown	52	41	2	4	2	0	0	0	49	94.0
Total	210	53	21	8	20	17	16	34	195	94.0

PLANT MATERIALS USED

Common name	Scientific name	Variety
Azalea, Florists	*Rhododendron sp.*	
African Violet	*Saintpaulia sp.*	Mentor Boy Double Duchess Pink Lady
Begonia, Perpetual	*Begonia semperflorens*	Pink Adeline
Begonia, Tuberous	*Begonia tuber-hybrida*	
Carnation, Florist	*Dianthus caryophyllus*	Miller's Yellow Jumbo Cardinal Mohawk White Sim Juno Mixed
Chrysanthemum, Florist	*Chrysanthemum morifolium* (*C. Hortorum*)	Mefo White Thyra White Thyra Bronze Encore Indianapolis Yellow Indianapolis White Thanksgiving Day Pink Francis K Barcarole Cassandra Cavalcade
Coleus, Common	*Coleus blumei*	unknown
Fuchsia	*Fuchsia hybrida* (*F. speciosa*)	Black Prince
Geranium	*Pelargonium zonale*	Better Times Madonna Salmon Supreme Radio Red Olympic Red
	P. graveolens	Rose Leaf
	P. odoratissimum	Nutmeg
	P. peltatum	Ivy Leaf
	P. domesticum	Lady Washington

Common name	Scientific name	Variety
Hydrangea, Big Leaf	*Hydrangea macrophylla* (*H. hortensis*, *H. opuloides*)	unknown
Ivy, Groundsel, German	*Senecio mikanoides*	unknown
Ivy, English	*Hedera helix*	unknown
Ivy, Grape	*Vitis rhombifolia*	unknown
Ivy, Boston; Japanese	*Parthenocissus tricuspidata*	unknown
Lantana, Common	*Lantana camara*	unknown
Marigold	*Tagetes patula*	Harmony
Petunia, Common	*Petunia hybrida*	Celestial Rose
Poinsettia	*Euphorbia pulcherrima*	Albert Ecke
Pepper	*Capsicum grossum*	California Wonder
Philodendron	*Philodendron cordatum*	unknown
Rose, Florist	*Rosa odorata*	Better Times
Snapdragon	*Antirrhium majus*	Spartan Rose Helen Tobin Rockwood Pink-Supreme
Snake plant	*Sansevieria zeylanica*	unknown
Tomato	*Lycopersicon sp.*	Rutgers Ground cherry Early Chatham
Wandering Jew	*Tradescantia sp.*	unknown

LITERATURE CITED

1. Avery, Jr., G. S., Elizabeth B. Johnson, Ruth M. Addoms, and Betty F. Thompson. 1947. Hormones and Horticulture. McGraw-Hill Book Company, Inc. pp. 14-17.

2. Cooper, W. C. 1935. Hormones in relation to root formation on stem cuttings. Plant Physiol. 10: 789-794.

3. ------------. 1944. The vegetative propagation of Derris and Lonchocarpus with the aid of growth substances. Botan. Gaz. 106: 1-12.

4. Creech, J. L. 1950. Air-layering a Rhododendron hybrid. National Horticultural Magazine, July, 1950.

5. Darwin, C., and F. Darwin. 1880. The power of movement in plants. London. 592 pp. Reprinted 1888. New York.

6. Dostal, R. 1942. The importance of growth-producing substances for slip-rooting of the gooseberry and of the apple (Cox's Reinette). Sbornik Ceskoslov. Akad. Temerdekske. 17: 2-7.

7. Duhamel du Monceau. 1758. La physique des arbres. Paris. 1758.

8. Gardner, F. E. 1937. Etiolation as a method of rooting apple variety stem cuttings. Proc. Amer. Soc. Hort. Sci. 34: 323-329.

9. Gossard, A. C. 1942. Root and shoot production by young pecan trees treated with indolebutyric acid at the time of transplanting. Proc. Amer. Soc. Hort. Sci. 41: 161-166.

10. Grove, W. R. 1947. Propagation of the Lychee. Proc. of the Florida Hort. Soc. 1947.

11. Hitchcock, A. E. and P. W. Zimmerman. 1936. Effect of growth substances on the rooting response of cuttings. Contrib. Boyce Thompson Inst. 8: 63-79.

12. Hitchcock, A. E. and P. W. Zimmerman. 1939. Comparative activity of root-inducing substances and methods for treating cuttings. Contrib. Boyce Thompson Inst. 10: 461-480.

13. Thakurta, A. G., and B. K. Dutt. 1941. Vegetative propagation of mango from gootes (marcotte) and cuttings by treatment with high concentration auxin. Current Sci. (India) 10: 297.

14. Went, F. W., and K. V. Thimann. 1937. Phytohormones. The MacMillan Company. New York. pp. 185-186.

15. Wyman, D. 1952. Air layering with polythene film. Journal of the Royal Horticultural Society. London. April, 1952. pp. 135-140.

16. Zimmerman, P. W., W. Crocker, and A. E. Hitchcock. 1933. Initiation and stimulation of roots from exposure of plants to carbon monoxide gas. Contrib. Boyce Thompson Inst. 5: 1-17.

17. Zimmerman, P. W. and F. Wilcoxon. 1935. Several chemical growth substances which cause initiation of roots and other responses in plants. Contrib. Boyce Thompson Inst., 7: 209-229.