PRESIDENT FILLMORE: I am sorry that we will have to terminate the discussion of this topic. Dr. Borthwick, unfortunately, will have to leave us early this evening. Questions which you may have can be directed directly to him during the remainder of the day.

Again, I want to express our thanks to you, Dr. Borthwick, for being with us and discussing your interesting work on light.

The next discussion this morning will be concerned with the propagation of chrysanthemums by Mr. Vernon Gifford of Yoder Brothers, Barberton, Ohio.

Mr. Gifford is a graduate of Ohio State University. He was a student of Dr. Chadwick's while at Columbus Yoder Brothers is a major producer of rooted chrysanthemum cuttings. In fact their annual production of this crop alone is in the neighborhood of 75 million cuttings It would seem, then, that we have one of the best sources of information about rooting chrysanthemum cuttings.

Mr. Gifford presented his paper entitled "Propagation of Chrysanthemums by Cuttings." (Applause)

PROPAGATION OF CHRYSANTHEMUMS BY CUTTINGS

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The new developments and progress made in flowering chrysanthemums in the past few years have also influenced the propagation of "mums"

It was not too many years ago that propagating mums was generally conceded to be a Spring and early Summer proposition. Plants to be used for stock were selected during the flowering season and held in a more or less dormant or inactive state during the winter. This was accomplished by replanting the selected stock in benches, flats or perhaps cold frames. Low temperatures and low moisture conditions were maintained for the winter period. Plants were held thusly until Spring when they were given conditions necessary for resuming their normal growth. This procedure is still followed in some greenhouses.

With the advent of year round flowering of mums which is becoming more and more a common practice, it was necessary that rooted cuttings be also made available any time of the year. The diligent work of several large concerns have made this possible so that now rooted chrysanthemum cuttings are available each week of the year

Propagation of mums by cuttings is by no means the only method of propagation. Seeds, grafting, and division are other methods of propagation. However, propagation by cuttings is probably the most important method. The following discussion will deal entirely on propagation by cuttings

In discussing propagation by cuttings a number of important aspects both physiological and environmental come to mind. Many of these

could be the basis of a discussion covering most any plant material. Their application, however, could be of varying degrees as applied to different plants. Two distinct phases, "Stock Plants" and "Cuttings" should be considered, and under these headings all the factors that effect them as—temperature, moisture, fertility, lighting, disease, selection of cuttings, and medias to mention a few.

STOCK PLANTS

It goes without saying that stock plants are the basic factor permitting propagation. After a new color or type has been produced by hybridizing, or a sport or mutation is discovered, it becomes necessary to build up a supply of plants as a source of cuttings. The above mentioned plants then become one phase of stock for propagating. Considered from another viewpoint, the continued selection from existing named types and colors constitutes the other phase of stock plants.

Perhaps before going further, it would be best to name the qualities to expect and demand of a stock plant. First, if selecting from established varieties, it should be a true representative of the parent plant as to color, type, size, and date of flowering Failure of a cutting to be a true representative will result in customer dissatisfaction.

Secondly, it should be free from disease. This means a program designed to produce disease free cuttings by any acceptable means must be enforced. Graft indexing, rouging, careful selection, and rigid spraying practices are part of this program.

Thirdly, stock plants should be productive. This statement might be questioned for perhaps productiveness might better be based on good cultural practices. However, if productiveness is based on the characteristic of a free breaking plant then it should be considered as a desireable quality.

With the demand for cuttings now on a weekly basis the year round, the stock program must be geared to meet this demand This means extremely careful planning months ahead to have sufficient stock plants in production to meet the demand at any given time To accomplish this, it means that the productivity of varieties must be known for any time of the year. The keeping of accurate records is a means to this end. The planning of any stock program must take into consideration all cultural and environmental factors.

SOIL—The basic soil for stock plants would be the same that would be acceptable for growing a top quality cut flower crop. A soil with plenty of organic matter and well drained would be acceptable Actually each grower should adjust soil mixtures to suit his particular needs. No doubt satisfactory plants can be grown by the gravel culture method although this may have limited use. Also good stock plants can be grown in a sand peat media by giving ample nutrients in a weak solution at frequent intervals.

The spacing of plants for stock purposes could very well be a debatable subject. Any of several different spacings may be used with acceptable success. The closer the spacing, the more cuttings must be used to plant any given area. Spacings of 4″ x 4″, 4″ x 5″, 5″ x 5″ or wider can be used. The production from any one spacing must be known to enable the grower to plan his plantings. The time of year that the crop is being

planted and the length of time it would be in production are factors in determining the spacing.

Soil preparation is a very important factor in getting a good start. If ground beds are used, whatever organic matter and superphosphate that is to be added should be applied and this well worked with a roto-tiller or some other type of tiller. Steam sterilization is next. Details of why sterilize are well enough known that they need not be discussed here. Raking and leveling now become the next important steps. The beds should be so raked and firmed that after planting and watering, no low spots or sunken areas will appear. These low areas are sure to cause trouble, too much moisture in some places will mean a lack of aeration, high spots will be too dry, salts can accumulate in low or poorly drained areas and cause trouble, and in general the bed will be uneven in growth which will result in poor production and appearance.

Great care should be used in planting cuttings particularly in so far as depth is concerned. A mum cutting planted too deep has only a slim chance of survival. The roots are so deep that oxygen is excluded and very often the stem will rot off. After planting, the cuttings should be watered in just as soon as possible. Cuttings should never be set in a dry soil. Have the soil moist enough so that it works up well without packing. Some syringing may be necessary for several days particularly in hot, sunny weather. Once they become established so that new root growth is showing, fertilization may begin.

PINCHING—The time of pinching will vary with season of the year. In the winter when plant growth is at its lowest, three weeks or more may be needed before a pinch can be made. During other seasons when growth is more rapid, 10 to 14 days may be all that is needed. Pinching should not necessarily be based on any certain number of days after planting but rather at the time when the plant has made sufficient growth to make a soft pinch This will leave enough soft growth from which new breaks will develop rapidly. If just the tip is rolled out, there should be no danger of getting into hard wood. Pinching too low or too hard can result in retardation of new breaks which in turn will reduce production.

TEMPERATURES—There has been conducted considerable investigational work on temperatures for mums in recent years. This has been done primarily in regard to its effect on flowering Some of it is applicable to stock plants. There has been some speculation on the effect of temperatures on stock plants as to the carry-over effect on flowering. How important a factor this is remains to be seen. The most satisfactory night temperatures, when they can be maintained may be somewhere in the 50°—60° range.

The growth characteristics should be studied as a means of determining most desirable temperatures. Some varieties exhibit a very vegetative or rosetting type of growth in the cooler range of temperatures. Growing varieties that exhibit these characteristics at a higher temperature would conceivably exert an influence toward a more favorable type of growth. Production of cuttings from these varieties will generally be very low.

Now on the other side of the picture are those varieties which have a tendency to be thin and elongate excessively and possess a reduced leaf area when grown under the higher range of temperatures. Again, cuttings produced from these plants are of reduced quality and are not desirable. Corrective measures here would be to grow these varieties at a lower temperature.

The manipulation of temperatures on the downward scale should begin in the late fall or early winter as the days become shorter and light intensity reduced. Lowering the temperature should be a gradual process until the lowest temperatures desired are reached and maintained for the shortest days of spring. As the days lengthen, temperatures should be gradually raised until the point of no control is reached.

WATERING—Watering is a procedure that, it has been said, can make or break a grower. The degree of exactness in applying water can determine to a high degree the final outcome of any crop.

Watering stock plants for production of cuttings perhaps is a little more of a critical procedure than normal watering for most crops. The amount of water and frequency of application will of course depend on several factors. season of the year, age of stock plans, varieties, and type of soil. The role these factors exert on watering is generally well known and need not be discussed here

For stock plants to produce cuttings of consistent quality the year round, the watering must be carefully controlled. Plants not receiving enough water will have a tendency to be on the hard side Cuttings taken from plants on a reduced watering schedule will in themselves have a lower moisture content. These cuttings when struck for rooting will wilt more rapidly or fail to recover fast enough from a wilted condition to root properly. If rooting does occur, after a longer normal time, quality will be much reduced. Fewer roots may be formed and slower initial "take-off" after planting the rooted cuttings will be experienced.

Considering the other extreme in moisture, stock plants grown at too high a soil moisture content do not make good cuttings. Several points can be covered in a discussion of how too much water affects plant growth.

Over watering or an excess of water will have a leaching effect and unless the loss of nutrients are soon replaced, chlorotic plans will soon result. Chlorotic plants do not produce quality cuttings. Too much water can also result in poor aeration or even a complete lack of aeration in the soil. Under these conditions, the root system is soon destroyed due to a lack of oxygen. Again plants with injured or damaged roots are incapable of normal functioning and the production of cuttings is reduced.

Too much water accompanied with quantities of fertilizers may very well produce a type of growth that is much too soft and succulent for the production of desirable cuttings. Maintaining as even a soil moisture content as is possible without extreme fluctuations should very closely approach the requirements for most desirable growth of stock plants in the production of cuttings.

The methods of applying water are many, both by manual or automatic or mechanical methods. It would be difficult here to say which method of application is best. The limitations both favorable and un-

favorable should be studied and then use the one which most satisfactorily meets the need for any particular situation.

Good watering practices should be followed at all times. In watering during periods of high light intensities, it may be permissible to water in such a manner that the foliage is moistened. This will have somewhat of a cooling effect on the plants. Also the plants dry off quickly and the dangers of disease are minimized. However, during periods of low light intensities, it may be best to avoid wetting the foliage to help in the reduction of disease.

FERTILIZATION—There is no question that the fertilization of stock plants is of a much more critical nature than is fertilizing of crops for other types of production. The fact that it is necessary to produce cuttings of the same quality each week of the year necessitates the most precise application of nutrients. Soil tests are available to enable the grower to more accurately diagnose nutrient requirements. These tests should be used only as a guide in the final analysis of how much and how often to apply nutrients. Visual observation of plant growth should also go a long way in making the final decision on any application.

If cuttings are to be taken each week or as ready, it would appear logical that the application of nutrients to replace those used by the plant should be made on the same basis. This then would keep a steady supply or reserve available at all times This sort of condition can be achieved by the use of weak liquid feeds at regular intervals. This could mean a watering between each feeding or feeding each time water is applied. The strength of the solution and frequency of application should be determined by each grower. The areas to be planted for stock should have included in the preparation the application of organic matter, superphosphate and lime or gypsum. If correct applications of these are made, then future applications would need only to contain nitrogen and/or potash in varying amounts.

The application of large amounts of nutrients at infrequent intervals could result in spurts of plant activity or growth. This type of "off and on" growth does not produce consistent quality cuttings.

After a plant has been pinched or a cutting removed, the subsequent break or breaks from the portion of the plant remaining should duplicate as nearly as possible the first removed If the soil nutrients are too low at this time, the breaks could be slow in starting and of a reduced or constricted stem diameter. This in turn means that cuttings will have to remain on the plant a longer time than actually would be needed in order to reach optimum stem diameter and leaf development. Any length of time over the very minimum necessary to produce a desirable cutting results in wasted growth and loss of production.

LIGHTING—The chrysanthemum has long been spoken of as a short-day plant, that is, one that blooms in the period of the year when days are short or when short days are provided by shading with black cloth. It has now been established that since flowering can be delayed and or provented by giving additional light in the middle of the night that mums might more correctly be called a long-night plant.

Be that as it may, it is due to this fact that additional light will prevent bud initiation which makes possible the production of vegetative shoots during the normal short days of the year.

The date when the stimulus for flower bud formation first occurs in this latitude is somewhere between the middle of August and the first of September. Knowing this, and desiring to prohibit flower bud formation on stock plants, it becomes necessary to apply additional light at this time. This could be set up for a period of two additional hours of light during August, April and May. Then as the nights become longer, it is necessary to increase the lighting schedule to three hours in September, October and March. four hours in November and February, and 4½ to 5 hours during December and January. If lighted at the right time, 4 hours additional light may be sufficient for December and January.

It has been found that lighting is not always 100% effective in preventing budding particularly on some varieties. The so-called garden varieties or very early blooming varieties many times will set bud and even flower in spite of additional light. Also at times if stock plants are permitted to become too tall, some of the lower side shoots will be shaded by higher parts of the plants. These shoots will then set buds. Another phenomena that has been noted in the fall and early winter is that when tops or first pinches are rooted and planted for stock, that they may set bud or the bud develops to a visible stage soon after planting.

CUTTINGS

To talk intelligently about a topic, one must first clearly define it. Since this portion of the paper concerns "cuttings," a definition is in order at this time. Just what a cutting is has been described or defined in many text books. However, the following definition, although not taken directly from a text, should be sufficient. A cutting is any portion of a plant which when severed from a plant and given certain favorable cotnditions is capable of regeneration. Now that a definition has been stated, the next thing to consider is what constitutes a good cutting or, just what are the characteristics of a good cutting.

First, assuming that it is a true selection from the parent plant, as mentioned earlier, the cutting must be one that will root with the minimum of applied effort. It must be the proper length when taken, it must have sufficient stem diameter, adequate leaf area, be free of any insect, disease or mechanical injury, and should contain an adequate amount of carbohydrates.

There is a general tendency for cuttings to elongaté to a certain degree after being placed in the propagating bench. Some varieties do this to a greater degree than others. Also at certain times of the year the tendency to elongate varies. Some cuttings elongate seemingly at the expense of rooting. Length uniformity is becoming an important factor in customer satisfaction. Therefore if the demand is for any given length rooted cutting, it must be known how much it will elongate in the bench Knowing this, the proper length for taking the cutting can then be determined This is not quite the entire story. For as mentioned above, the rate of elongation varies at different times of the year which means that the length will have to be modified to meet these changing conditions Also, if using the first pinch for a cutting, its' length will have to be reduced, as a tip cutting most generally elongates more rapidly than subsequent cuttings. Generally speaking, the length range for most mum cuttings, according to present day thinking is around 2½" to 3".

Stem diameter is another important factor in selection of cuttings. In selecting, it must be known what is an acceptable stem diameter for each variety. Knowing the natural growth tendencies of each variety will aid considerably in selecting the cutting of proper diameter. Some varieties have a natural growth habit that is somewhat on the thin or spindly side. Cuttings from stock plants of these varieties will be somewhat the same way. On the other hand, varieties with a normal growth habit that is stocky and husky may produce thin cuttings if improperly grown. The fertilization program will affect the cuttings either way—under-fertilized plants will have a reduced stem diameter, and it is also possible to over-fertilize and have cuttings with a larger stem diameter than is actually needed. Temperatures also play an important part in determining stem diameter. Any variation one way or another will effect the rooting This effect could be in time to root, number of roots initiated or length and strength of the roots. If cuttings are to be produced and rooted consistently the year round, uniformity throughout the cutting is necessary.

Many times cuttings will be of sufficient length to be taken but will lack sufficient leaf area or development to insure proper rooting. Perhaps the term immaturity would fit in here. Cuttings taken in this stage could be so soft that excessive wilting or drying out would occur if cuttings were not stuck immediately. Wilted or dried out cuttings respond slowly, if at all, to additions of moisture and will be very difficult to root. To correct this, cuttings must be left on the stock plants a little longer to gain more maturity. In doing this extra length or height is added to the stock plants which is essentially wasted growth. Pruning a stock plant after taking cuttings to reduce the height is a practice that may be resorted to in an effort to correct the height problem This cannot always be considered a desirable practice for the pruning may go down into wood that is too hard. Breaks from this portion of plant are slow and few in number. The ideal situation to arrive at is to force plant growth so that it meets all requirements to produce desirable or quality cuttings as soon as they are of the proper length and still have enough stem left on the plant for breaks for future cuttings

There should be no question that cuttings should be free of any insect, disease or mechanical injury, any one of which lowers the quality or reduces a cutting to one of little value.

The proper carbohydrate-nitrogen relationship is a physiological condition bearing on proper cultural and environmental conditions. Too little nitrogen compared to carbohydrates may cause the plant to be too much on the hard side, making rooting difficult. On the other hand, too much nitrogen may result in a weak and soft type of growth to the point where rooting would be unsatisfactory. To make sure that stock plants are well supplied with carbohydrates, give them the best of cultural practices and provide for all sunlight possible.

The actual taking process should involve no more than being able to snap off cutting with the fingers with a nice clean break. Cuttings that fail to snap off at the proper length are not ready to take and in turn will not root satisfactorily or make good rooted cuttings. Cuttings taken from stock plants that are somewhat on the dry side will have a reduced internal moisture content and will be difficult to root. Any mal-practice

in growing that results in cuttings not snapping off easily will result in cuttings of reduced quality.

Is there a best time to take cuttings in so far as time of day is concerned? No doubt there could be arguments for and against taking either in the morning or afternoon. Temperature, wilting, and food storage would all have to be considered in arguing for one time or the other. Results observed so far in taking cuttings in the morning or afternoon show no positive indication one way or another. However more comprehensive and exhaustive tests might throw more light on the subject.

MEDIA—Of all the various medias used at one time or another for propagation, sand or sand and peat appear to have stood the test of time and are still the most widely used. A few years ago vermiculite appeared for a while that it might be a big asset in propagating While many still use it today, it has enough faults that it is not as popular as before.

There is, however, a new product today that shows promise of becoming a very satisfactory media for propagation. This material is called "perlite." It is a white granular material of several different sizes or grades It is being used in the East and Denver areas for carnation propagation, and to some extent for chrysanthemum propagation. It has been used alone and in combination with peat. For mums, a mixture of peat and perlite seem to work best. Used alone, it requires the equivalent of a mist system to keep the cuttings turgid and moist. Being of a granular structure and very light, water drains through it very readily. Cuttings stuck in it dry out very rapidly unless an almost constant supply of moisture is applied. As soon as cuttings show roots, watering can be reduced for the granule seem to retain a supply of water which is available to the root hairs. Considerable amounts of perlite are retained by the roots when pulled for shipping. Preliminary tests indicate that cuttings rooted in perlite are of just a little different quality, not quite so soft, and ship better than cuttings rooted in sand and peat.

Mixtures of peat and perlite appear to be more satisfactory for mums than perlite used alone. The peat provides for more moisture retention in the media in the beginning and cuttings do not dry off quite as rapidly. One thing that is important is the mixture; it must be uniform The peat must be completely broken up and thoroughly mixed with the perlite. Perlite is extremely dusty and some kind of respirator is necessary when handling it. Also it seems that some sort of a large mixer would be necessary for mixing the peat and perlite For whatever media is used, if a mixture, it must be uniform and should be sterilized. To date, steam sterilization is probably the most widely used. The mixture most suited for one propagation may not meet the requirements of another propagator Using 1/3 peat and 2/3 sand as a starting mixture, it can then be modified one way or another to meet the propagators needs.

STICKING—Before sticking the media must be thoroughly moistened. Sticking into a dry or non-uniformly moist media can mean trouble from the start. If the base of the cuttings is inserted into a dry media, moisture will be lost immediately from the cuttings into the media. This will result in more time and energy being spent trying to get the cutting turgid, all of which will mean longer time in the propagating bench.

The old process of sticking cuttings by firming the media, cutting through it with a sharp edged tool, sticking the cuttings and then tamping the media firmly about them has been replaced by another method. Now markers or dibble boards are used with the pegs set for whatever spacing is desired. The marker is plunged into the surface and then withdrawn leaving a series of holes in which to place the cuttings.

It may be necessary at certain times of the year to remove some of the lower foliage of certain varieties before sticking. This is necessary to reduce spread of any disease that might get started in the propagating bench. Actually in so far as rooting is concerned, the more foliage that can be left on the cutting, the better up to a certain point. That would be when it interfers with sticking or would be conducive to spread of disease.

The use of some root promoting substance in propagating is almost a universal practice. Several different materials are available and may be used either in powder or liquid form. Their value has been proven and more uniform results are obtained when they are used.

WATERING—After the cuttings are placed in the holes, they should be watered in by any convenient method It should be kept in mind that the watering-in process should be thorough enough so that the media is well settled around the cuttings. Failure to water them in thoroughly may result in the base of the cuttings drying out and rooting will be retarded or completely inhibited. After the cuttings are well watered-in, subsequent applications of moisture need only to be some means of dampening or misting to keep the humidity up and the cuttings turgid.

Some means of protecting the cuttings from the sun is necessary after sticking. This means covering the cuttings or shading the glass or both. Newspaper and cheese cloth have been used as coverings. Shading compound or camouflage cloth may be used to cover the glass. All of these methods work to a degree but in so doing are excluding the maximum light available to the cuttings in full sun. The mist keeps a constant or near constant film of moisture on the cuttings. This prevents any burning or sun scalding and at the same time keeps them turgid so that the full photosynthetic capacity can be realized.

The results published to date on mist propagation of mums indicate that there are some drawbacks to this procedure Mum cuttings under mist have a tendency to stretch or elongate to the point that fertilization in the propagating bench is necessary to prevent chlorosis. If the cuttings are to be used by the propagator, this practice may be entirely satisfactory. If the cuttings are to be shipped, this practice might not be advisable as the fertilized cuttings would elongate excessively during shipment.

HUMIDITY—Without sufficient or proper humidity in the propagating area, the rooting of cuttings could be quite a problem. High humidity will of course mean less watering and to a degree lower temperatures. High humidity will keep the cuttings in a turgid condition and will hasten rooting. When the cuttings are turgid, the internal plant processes are able to function more efficiently and in turn hasten rooting.

There are several different methods of maintaining humidity and this may be accomplished by applying the moisture to the cuttings them-

selves, or by applying moisture to the walks or atmosphere. Skinner lines, Binks system, air conditioning, mist systems are all means of applying moisture to increase the humidity.

DISEASE—It must be kept in mind that in providing ideal conditions for rooting cuttings, ideal conditions are also provided for disease. In combating this nuisance, prevention is probably the best path to follow. Cleanliness in the propagating area is of prime importance. This means that everything must be kept clean from the ground up. A rigid program of disease control in the stock area must be practiced to avoid bringing any into the propagating area To insure against the start or spread of disease, the cuttings may be sprayed after they are partially or fully rooted with any good fungicide Spraying too soon or before rooting has progressed to a certain point will slow down the rooting. There may be times when disease hits the cuttings before they are sufficiently rooted for spraying. It is still possible to spray them provided they are dampened before the spray becomes entirely dry This may not give complete control of the disease but it will slow it down. Hand cleaning or rouging is necessary at times.

TEMPERATURE—In propagating all year, the temperatures employed will cover a wide range During the summer when there is little chance of control, the temperatures may run rather high in the high 80's or 90's. During other seasons of the year when it is possible to control temperatures, a lower range is probably more satisfactory In attempting to maintain any kind of a schedule, the temperatures must be controlled within a range for any given period Thus during periods of the year when there may be frequent rises in temperatures above the average, additional heat would have to be available to bring up temperatures at these times to meet this peak. This would tend to keep scheduling as stable as possible.

For winter time propagation much lower temperatures can be maintained. This in order due to short days and reduced amount of sunlight. The important temperature phase in winter propagation is bottom heat. Here bottom heat can be more or less adjusted to meet the propagators needs. Low temperatures, below 60°F in the media, means that the cuttings will be in the bench a longer time before rooting. Any rise in temperature up to somewhere around 70°F. will mean less time in the bench due to more rapid rooting. If a figure could be stated that would most closely come to being the most satisfactory temperature, it would probably be around 65°F. media temperature with approximately a 10°F. lower air temperature.

One thing that must be said about bottom heat is that it must be uniform. Merely having heat pipes under the bench is not sufficient unless the sides are enclosed so that the heat is uniformly dispersed under the media. Where the sides are not enclosed, the media will be the warmest just over the heat lines and rooting will be more rapid here than elsewhere in the bench.

This discussion on "chrysanthemum propagation" should by no means be considered as a closed subject. Only the more important points have been covered and some of these only briefly. In making any concluding statements, it should be kept in mind that the above discussion

has been prepared mostly on the basis of experience and review of literature and not on the basis of any planned experimental investigation.

(Mr. Gifford concluded his discussion by showing a series of kodachrome pictures illustrating the procedure of rooting chrysanthemum cuttings at Yoder Brothers.)

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PRESIDENT FILLMORE: We thank you, Mr. Gifford, for this excellent discussion based on the extensive chrysanthemum cutting operation at Yoder Brothers. The late start this morning necessitates our concluding this session at this time. Mr. Gifford will be present at the Plant Propagation Question Box Session tonight and questions relating to his talk can be taken up at that time.

The session recessed at 12:30 o'clock.