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Understanding and Producing Chrysanthemums

There are 150 to 200 known species of chrysanthemums. The name chrysanthemum is derived from Greek and means "golden flower." Chrysanthemums' family is Asteraceae. Some mums are annuals, some perennials. Most are herbaceous yet a few are semi-woody. Some species (*e.g.*, *Chrysanthemum cinerariaefolium* and *C. coccineum*) are grown commercially for the pyrethrum (an insecticide with high "knock down" properties) obtained from their dried petals, and others are grown for their marketable inflorescences.

Some "mums" respond more to temperature than photoperiod for flower induction[1] [*e.g.*, Marguerite or Paris Daisy (*C. frutescens*)], but the one grown in greenhouses (*Dendranthema* x *grandiflora*) responds more to photoperiod than temperature for flower induction. *Dendranthema* x *grandiflora* is a perennial hybrid thought to be of Chinese origin.

Chrysanthemums have three primary uses in commercial floriculture today: cut flowers, potted plants, and garden plantings. All of these uses can be fulfilled by *Dendranthema* x *grandiflora*, which is a short-day plant.[2]

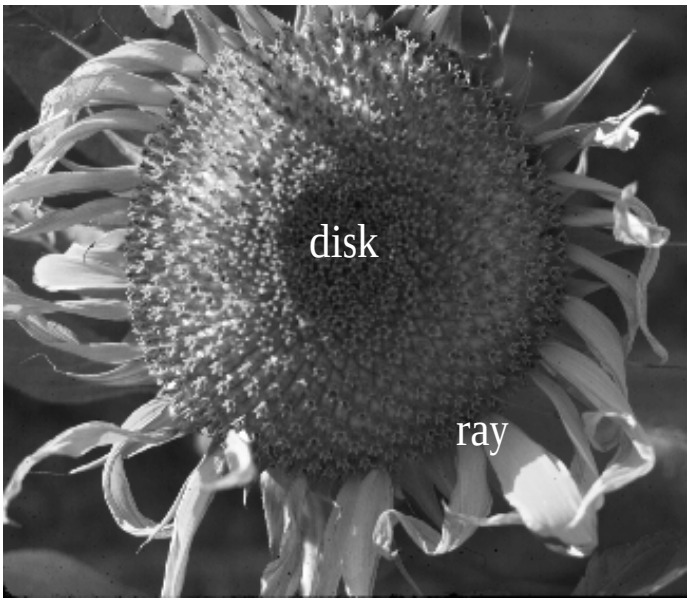

Figure 1. The sunflower (*Helianthus annuus*) exemplifies the arrangement of the ray and disk flowers of mums.

The inflorescence of a mum is actually a composite of many flowers. Its family member the sunflower (Figure 1) is a good example of the inflorescence configuration of mums. The inflorescence is composed of two flower types: (1) disk flowers are at the center. They are tubular, perfect [*i.e.*, with male (stamen) and female (pistil) parts], and fertile, but have poorly developed petals; and, (2) imperfect (*i.e.*, pistillate only) but fertile ray flowers are at its margin. They have long, well-developed petals. In a mum, a similar configuration, with ray flowers in only a row or two at the inflorescence margin, is called a "daisy type." If several outside rows of the inflorescence are composed of ray flowers, it is called an "anemone type." In a "pompon" type, the ray flowers dominate the entire inflorescence, hiding the central disk flowers, a common configuration in many of the mums grown today -- some garden types, standard cut, pot, spider, and Fuji.

Chrysanthemums were first brought under cultivation in China about the time of Christ. They were introduced into the U.S. from England just prior to 1800. For the past quarter century, until the mid-1980's, pot mums were the leading floriculture pot crop in the U.S., but the poinsettia is now king. Make no mistake about it, mums are big business. Yoder Brothers in Pendleton, S.C. (Figure 2), sells over 52 million cuttings annually. The highest demand for cuttings is in May, because of fall garden plantings, while the lowest demand is in September and October, when growers are more into poinsettia production.

Figure. 2. Rooting of chrysanthemum cuttings at Yoder Brothers, Pendleton, S.C., which roots 52 million mum cuttings annually at this location alone.

What are the differences among varieties grown as garden mums, as potted plants, and as cut flowers?

It would be a good idea to first look at how they are alike. All have about the same critical night length requirement for floral initiation -- it's $9^1/_2$ hrs. This means that they will change from the vegetative stage to the reproductive stage if the nights are at or exceed this point. Even though they are called "short-day plants" , it is actually the length of night that controls flower initiation. As long as they receive $9^1/_2$ hrs. of non-interrupted darkness, they will eventually initiate flowers, regardless (within reason) of the length of the days (*i.e.*, light periods) that they receive. For example, even if they receive 20-hr.days, they will still initiate flowers if the nights they receive are $\geq 9^1/_2$ hrs. If the nights aren't $\geq 9^1/_2$, they will remain vegetative. So, mums should really be called "long-night plants." Mums (garden and greenhouse types) also require non-interrupted dark periods of $\geq 10^1/_2$ hrs. for flower development.

Although flower buds will be initiated with nights of $9^1/_2$ hrs., these flower buds will not develop unless (until) the nights are $\geq 10^1/_2$ hrs. That's why horticulturists recommend giving greenhouse mums 12-hr. nights, which exceed the requirements for initiation and for development.

Exactly what mechanism within mums controls whether the plants produce vegetative or reproductive growth, and how does this mechanism work? The plants contain a blue, proteinaceous pigment called phytochrome. This pigment has two forms, each existing within the plant simultaneously and each form convertible to the other form. The quality of light the plant receives regulates which of these two forms is dominant (*i.e.*, in the higher concentration). One form absorbs red light and is commonly designated P_R. The other absorbs far red light and is designated P_{FR}. When P_R absorbs red light it changes to P_{FR}; likewise, when P_{FR} absorbs far red light, it changes to P_R. P_{FR} is not stable, and after 4 hrs. of darkness, it will begin to convert to P_R even though it has received no far red light. P_{FR} inhibits the reaction that triggers the plant to initiate flowers-- it's, therefore, called the "active form" of phytochrome. It must be the dominant form of phytochrome for flower initiation to be inhibited. The reaction that triggers the plant to change from the vegetative to the reproductive state occurs about $7^1/_2$ hrs. after the beginning of darkness. So, P_{FR} must be the dominant form of phytochrome at that time for it to prevent the plant from initiating flowers. How does all this fit together? Look at a schematic (Figure 3) of how phytochrome controls flower initiation in the short-day plant chrysanthemum. To prevent floral initiation in

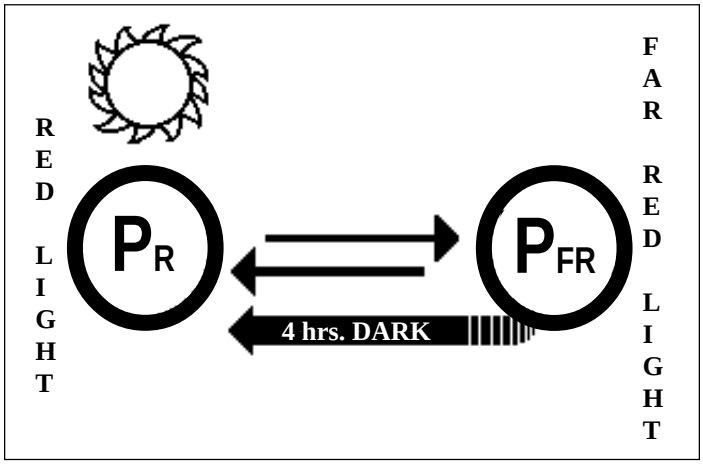

Figure 3. The effects of light quality (red and far red), sunlight, and length of the dark period on the two forms of phytochrome.

mums, P_{FR} must be present at a significant level $7^1/_2$ hrs. after darkness begins to prevent the reaction for floral initiation from taking place. The diagram indicates that sunlight has essentially the same affect on phytochrome as red light (*i.e.*, P_R is converted to P_{FR}); therefore, at the end of the day or the beginning of the dark period, phytochrome is essentially in the P_{FR} form. If phytochrome were to remain mostly as P_{FR} for $7^1/_2$ hrs., the plant would remain vegetative. P_{FR}, however, as the diagram indicates, begins to revert to P_R after 4 hrs. of darkness. Let alone, there would not be enough P_{FR} remaining at the $7^1/_2$ hr. time to prevent floral initiation. However, artificial incandescent or fluorescent lighting can be used to get P_{FR} at a high level again before $7^1/_2$ hrs. of darkness. This is because it takes very little energy to manipulate phytochrome.

A strategically placed light period of sufficient length to allow no more than 5 hrs. of dark on each side of it will prevent floral initiation of mums. More elaborate light/dark alternations also have proved successful.

Under naturally occurring night lengths, could greenhouse type (*e.g.*, cut and pot types) mums be successfully grow outside in South Carolina and garden types grown inside? The primary difference with respect to a variety's classification as a garden or a greenhouse type is how long it takes the variety to flower after it first receives long nights. This may vary from 7 to 15 weeks, depending on the variety. In other words, a "9-week variety" "flowers" 9 weeks after the first day it receives long nights. During this time, it changes from the vegetative to the reproductive state (*i.e.*, initiates flowers) and the flowers "develop and open."

Figure 4. The garden mum "Robin" in flower in mid-October at The South Carolina Botanical Garden at Clemson, S.C.

Garden mums are the shorter response varieties (*e.g.*, 7 or 8 weeks). During the summer, their terminals initiate flowers (the nights are $9^1/_2$ hrs.), inducing lateral growth below. This lateral growth also initiates flowers, inducing lateral growth on its shoots -- the cycle continues, resulting in plants with a mound-like appearance (Figure 4). The plants, then, contain visible flowers buds of different ages. These buds don't develop during the summer, because they must all receive the same environmental stimulation before flower development can occur. All of them (regardless of age) do, however, develop together (at the same time) in the fall -- before freezing temperatures occur. This is because all of the flower buds receive the $10^1/_2$ hr. nights required for their development at the same time. If a "10-week variety" (*i.e.*, a greenhouse type) were planted outside, it would likely freeze before flowering because it requires too many weeks to "flower," compared to a "7-week variety." Because garden types develop flowers in a shorter period of time than greenhouse types, their flowers are smaller than many greenhouse types, therefore, of a lower quality than those of greenhouse varieties which typically require 8 to 11 weeks of long nights.

At the Variety Trial Garden at Clemson University, rooted cuttings of garden mums have been planted in beds around July 4 with excellent results. Before planting, a 10-10-10 granular fertilizer was applied at 4 lbs/100 ft^2. Recommended planting dates and varieties will vary with location.

Cut mums marketed as one inflorescence per shoot [standards (≥ 4" in diameter), disbuds (<4 " in diameter), Fuji, spider, etc.] must be disbudded, leaving only the terminal flower bud. Some of the larger spray cut types are also disbudded; however, the terminal (central and largest) flower bud in the spray is always removed. This results in more uniform and larger florets in the spray. In the past decade, the demand for cut mums with a single inflorescence has decreased, but the demand for spray cut mums has increased, probably because of their extensive use in floral arrangements. In South Carolina, 10-week cut mum varieties can be grown on a year-round basis; but farther north, longer response group varieties must be grown in late fall, winter, and early spring. In addition to disbudding, which increases "flower" size and ensures rapid development, cut mum plants (*e.g.*, "standards") must be supported, most often by wire and string (Figure 5).

Figure 5. Standard cut mums. As they grow, "decks" of wire and string are added for support.

Because long stems on cut mums are required and because South Carolina is so far south, lighting during the night (dark period) is necessary year-round during the vegetative growth stage. Black cloth to ensure reproductive nights is only necessary in South Carolina from April 1 until September 25. The use of black cloth for greenhouse crop production, which is now taken for granted, was pioneered in the 1930's by Alex Laurie.

Cut mums require a longer production time if pinched; and, when pinched, a soft pinch should be used. Four shoots should be allowed to develop on plants at the perimeter of the bed (or bench) and 3 shoots allowed on the interior plants. Spacing varies with the season and whether the plants are pinched or not. If single-stemmed, spacing may be 4" x 6" in summer, 5" x 6" in winter. If pinched, spacing may be 6" x 7" in summer and 7" x 8" in winter. Some of the 10-week varieties may be grown year-round in South Carolina, others may not.

A "pasteurized" growing medium[1] with perlite and at least 1/4 peat by volume is ideal. The pH should be 6 to 6.5. Liquid fertilization with a 1-1-1 ratio is recommended. The plants should receive about 200 ppm N every 10 days until floral initiation -- then less fertilizer. They should not be fertilized during the final two weeks.

It is recommended that cut mums be grown in a 60-65°F (15.6-19.4° C) minimum greenhouse during the vegetative and floral initiation stages. During floral development, lower minimum temperatures, between 55 and 60° F (12.8 and 15.6° C), are recommended. It takes a month for complete floral initiation to occur.

Plants must receive short nights (via night lighting) to ensure adequate stem length [about 36" (91 cm) maximum]. This varies from about a month in summer to five weeks in winter for pinched crops. Specific instructions are included in the packaging with cuttings. Single-stem plants require a week or two less lighting than pinched plants.

Stems may be cut when buds are a little less than half open (for distant shipping) to fully open (for local markets). Leave about 4" (10 cm) of stem below the cut to avoid leaving woody tissue on the cut stem. Woody tissue does not absorb water well. Cut flowers should be immediately placed in a 96° F (36° C) sugar/biocide solution and placed in a lighted (100 ft-c min.), 70° F (21° C) room for opening.

Mums are among the longest lasting cut flowers commercially produced. In fact, they may be stored dry (no water!) in airtight containers at 31° F (-0.6° C) for several weeks before selling. When removed from these containers, they must be recut and then handled in the same way as freshly cut stems.

Many disease and insect problems may be encountered in greenhouse mum production. Recommendations for their control are constantly changing. Please follow the latest edition of the South Carolina Agricultural Chemicals Handbook when applying pesticides. It is published annually by the Clemson University Cooperative Extension Service. The cost of the 1994 issue is $25. Make check payable to Clemson University and send to: Bulletin Room, Room 82 Poole Agricultural Center, Clemson University, Clemson, SC 29634-0311.

The primary year-round insect pests are aphids, white flies, and perhaps mealy bugs, all of which are easily controlled. Spider mites and thrips are more likely to be problems in the warmer seasons, but they too may be controlled. To combat mites, remember to switch from one miticide to another. Mites have the ability to produce populations resistant to miticides.

Many disease problems can be precluded by using a "pasteurized" growing medium, disease-free cuttings, maintaining recommended temperatures, providing vigorous air circulation, and prudent watering.

Rhizoctonia stem rot and Pythium stem and root rot can usually be prevented by using a "pasteurized" growing medium. Recommended fungicide drenches during production also help.

Septoria leaf spot, which produces irregular, black areas on the foliage, is spread by careless watering.

Botrytis (gray mold) can become a problem during periods of low temperatures and high humidity. It is the same fungus that may grow on strawberries in a refrigerator, where low temperatures and high humidity also occur. It first appears as a water soaked area on the "petals" which later turn brown. Growing the plants at the recommended temperatures and reducing the humidity via increased ventilation will help prevent its development. Recommended fungicide applications should also be made.

Ascochyta (ray blight) results in deformed flowers. It develops only in the presence of water, usually first infecting the outer, ray "petals," then spreading inwardly. It can, however, infect the foliage before it infects the inflorescence. Its development is promoted by high temperatures

Figure 6. Ideal pot mum-- 12" wide, 12" high (above pot rim), and with ≥12 flowers.

and high humidity. Careful watering, temperature control, and prudent fungicide applications help prevent its development.

RECOMMENDATION: With any greenhouse crop, NEVER water so late in the day that water on the plant's foliage, flowers, etc. doesn't have time to evaporate completely before nightfall.

Pot mums are the number two potted plant produced in the U.S. Unlike poinsettias or Easter lilies, pot mums are not associated with any particular holiday; therefore, they are produced on a year-round basis. They are typically grown in a 6" "azalea pot" or pan. The "ideal" pot mum has been defined as one that is 12" in height (from the pot rim), 12" wide, and has ≥12 flowers (Figure 6); however, today, non-disbudded spray types that do not produce this effect (*e.g.*, daisies, anemones, etc.) are also marketed (Figure 7).

Figure 7. Many pot mum producers grow them on a year-round basis.

For the "ideal" pot mum, certain standard varieties are used, as are "disbuds" (*i.e.*, an intermediate type between standards and spray types), decoratives [their "flowers" are flat in appearance -- shaggy (dahlia-like)], and spray types that have the ability to develop a relatively large inflorescence if disbudded. To produce this "ideal" pot mum, the cultivar must have the ability to flower well on relatively short stems, branch easily (after pinching), form a well balanced plant (display), and produce "flowers" of the size and shape desired. Also, it must be suitable for production during the selected season. When planting in pots, rooted cuttings are planted (generally 4 per pot in summer, 5 in winter) along the soil surface perimeter at a 45° angle, leaning outwardly (over the pot rim edge). This allows the cuttings to receive more light. Some say the reason that cuttings planted this way produce more lateral shoots after pinching is because apical dominance is not as easily reestablished as when they are planted upright. There is a cultivar effect too; cultivars vary in their ability to produce lateral shoots after pinching. Once the number of shoots/cutting is established following pinching, the lateral growth on these shoots must be removed (spray types are an exception). The cost involved of removing this secondary lateral growth is the biggest cost of production of pot mums.

A "pasteurized" 6.5 pH growing medium of equal volumes of peat, perlite, and soil is excellent, but any well-drained medium with enough peat can produce a high quality pot mum.

Superphosphate (20%) at 4 lbs/yd^3 added to the growing medium before potting, followed by liquid 25-0-25 (6 oz/100 gal. water) every 3 days, works well. When the buds show color, reduce liquid fertilization.

Unlike cut mums, pot mums are grown at the same night temperature, about 62° F (13.5° C), during their vegetative and reproductive stages. The pot spacing on the bench is $1^1/_4$ ft^2, regardless of season.

There are three basic cultural schedules under which pot mums are grown. The schedule is dictated by whether the cultivar is it naturally short, medium, or tall. The schedules are referred to as the short, the medium, and the tall schedule. All cultivars, regardless of the schedule, receive short nights just after potting "to get them going." The difference among the schedules is the relationship (timing) between the pinching date and the date long nights are begun.

The medium schedule is designed to maintain the "natural height" of the cultivar. The cuttings are given short nights after planting then are pinched on the same date long nights are begun.

The short schedule is designed for a cultivar that is naturally short and is designed to increase the height of the cultivar. As before, the cuttings receive light at night (short nights) after potting; they are then pinched and continue to receive short nights after pinching. This ensures continued vegetative growth after pinching (more stem length). Finally, they are given long nights until "flowering."

The tall schedule is designed to reduce the height of cultivars which naturally are too tall. Initially, the

cuttings are given short nights. They are then given long nights (before pinching) and pinched after long nights are begun. This really reduces stem length; hence, they are shorter than they would normally be.

The exact schedule to be followed for a particular cultivar in a given season is supplied to the grower with the cuttings. It should be followed "to the letter."

These schedules work because it is the date long nights are imposed, not the date of pinching, that controls when the plants "flower." The relationship between pinching date and the date long nights are begun regulates the amount of vegetative growth produced (*i.e.*, plant height). It doesn't matter when the cuttings are pinched -- a 9-week cultivar will "flower" 9 weeks after long nights are begun, even if not pinched. This concept is very difficult for some people to accept. They find it hard to believe that pinching has no influence on when the plants "flower."

Plant height may also be controlled by chemical growth regulator application(s). This should not be necessary if the cultivar and season are matched and the cultural schedule recommended is followed.

The disease and insect problems of pot mums are the same as those of cut mums.

Two common "physiological" problems associated with pot mum production are:

1. "Only one or two breaks per cutting after pinching": The cuttings are not getting enough water, fertilizer, or day light intensity -- or some combination thereof.

2. "Uneven bud set" is caused by temperatures below the recommended low (<62° F) .

Pot mums are marketed at nearly full flower maturity. To prevent bruising, they are sleeved for shipping. They are very long lasting.

Remember, pot mums and other floricultural potted crops require lots of water because of their relatively large leaf area and small growing medium volume.

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