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ABC'S OF POT CARNATION CULTURE

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The book "Carnation Production" (Holley and Baker, 1963) provides an excellent historical picture of the development of present day cut carnations *(Dianthus caryophyllus).* In the mid 18th century, carnations for florists' use were from seed and grown in pots. The single stem (standard) varieties held the center of interest in the 19th century and the spray types became an important crop midway through the 20th century. Both standard and spray carnations are propagated asexually. The pot carnation is not new, but the use of asexually propagated dwarf carnations for pot plant use, is. In the late 1960's a number of seed companies throughout the world were developing *D. caryophyllus* lines suitable for flower garden use, of which many were semi hardy border strains and available as seed grown bedding plants.

In the 1970s dwarf and spray *D. caryophyllus* seed lines developed by companies in Japan, Holland and Switzerland were grown and evaluated by Colorado State University for possible use as flowering pot plants. Selected plants were used as germplasm in a breeding program designed to develop a flowering pot plant for commercial use. The program to date has produced a group of dwarf carnations called the Colorado Majestic Mountain series. It is composed of cultivars named after eight of the 52 mountain peaks in Colorado that are 14,000 ft. in elevation or greater. The following cultivars have patents pending and are fingerprinted for identification:

'Creston'	— white with purple picotee edge
'Lindsey'	— light pink
'Maroon Bells'	— maroon
'Quandary'	— red and white variegated
'Redcloud'	— red sport out of Quandary
'Shavano'	— dark pink
'Sneffels'	— lavender pink
'Snowmass'	— white

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It should be noted that the pot carnations were not designed or developed to have the shape and flowering habit of a poinsettia, pot mum, exacum or Easter lily. The Colorado Majestic Mountain pot carnation has its own identity, in fact when properly grown, it will have flowers and buds in various degrees of opening and at different levels on the plant.

Growers are encouraged to try additional cultural approaches other than those described in these guidelines for this new flowering pot plant line in order to develop the best approach to providing the most marketable product. Additional research is now underway on effects of photoperiod, temperature, chemical growth regulation, STS and nutrition. The results will be reported in future bulletins.

What are pot carnations?

The Colorado Majestic Mountain carnations are dwarf cultivars of *D. caryophyllus,* bred and selected to be grown as flowering pot plants. They are asexually propagated from cuttings and, upon being rooted, potted and pinched, will develop 4 to 5 strong stems with typical blue-gray foliage having an attractive curling pattern. The plants reach a height of 7 to 9 inches above the pot at the time of flowering and have an abundance of buds that will continue to open over a period of two to three weeks in the home or office, if proper environmental conditions exist. The 1.5 to 2-inch diameter flowers of most cultivars have a clove or honey fragrance and an array of colors which can be used in a year-round market.

Plant Anatomy

The whole concept of developing a well proportioned flowering pot carnation is centered around the bud initiation of vegetative shoots created by a properly timed and positioned pinch of a rooted cutting. The carnation plant is like many other herbaceous plants in that vegetative shoots eventually become reproductive, flowering stems. A vegeta-

tive shoot (Fig. 1a) continues to develop new leaves as it elongates and has relatively short internodes. The internodes of a reproductive shoot (Fig. 1b) are elongated and flower initiation has occurred. Once flower initiation occurs, lateral buds and vegetative shoots will start differentiating.

Fig. 1: a) Developing vegetative shoot of dwarf carnation with short internodes. b) Reproductive shoots of dwarf carnation with long internodes and flower bud initiated.

An unpinched flowering stem of the dwarf carnation plant will have 12 to 13 pairs of leaves (nodes) between its terminal bud and its base. As a reproductive stem continues to develop, a terminal bud forms and lateral buds start developing on the upper four to six nodes (Fig. 2). The shoot that develops immediately below the lowest lateral bud, nodes 6 or 7, is somewhat indeterminate. Under some conditions, it may become reproductive or it may continue to grow vegetatively before a flower bud is initiated. Vegetative shoots generally form at the seventh node below the stem terminal and at all additional lower nodes.

Carnation leaves at each node are in pairs, opposite each other, and appear in a spiral pattern on the stem. Generally, a single bud or vegetative shoot develops in the axil of a leaf pair on one side of a node and in the opposite leaf positions on the nodes immediately above or below it. Some of the dwarf carnation cultivars have buds or shoots develop in both leaf axils at a single node, which contributes to a more floriferous plant.

There is no specific sequence of lateral bud development on a single reproductive stem. The terminal bud will flower first and lateral buds 5 or 3 (Fig. 2) normally flower before the others. The terminal bud of the lateral shoots (nodes 6 or 7) usually shows color before all of the upper lateral buds are fully open.

Starting Pot Carnations

Plant development starts with a rooted cutting or a pre-pinched "plug" (Fig. 3 a and b). The grower will generally have more control over plant development from a rooted cutting because the pinching position and timing can be controlled in relation to planting time and the stage of cutting development.

Rooted cuttings — A desirable rooted vegetative cutting has at least six pairs of visible leaves (Fig. 3a) and three or four pair which will unfold. Some cuttings will have initiated

Fig. 2: Dwarf carnation flowering stem anatomy. Flower buds form in opposite leave axils at top 1 to 5 nodes. Node 6 has an indeterminate shoot and node 7 a vegetative shoot.

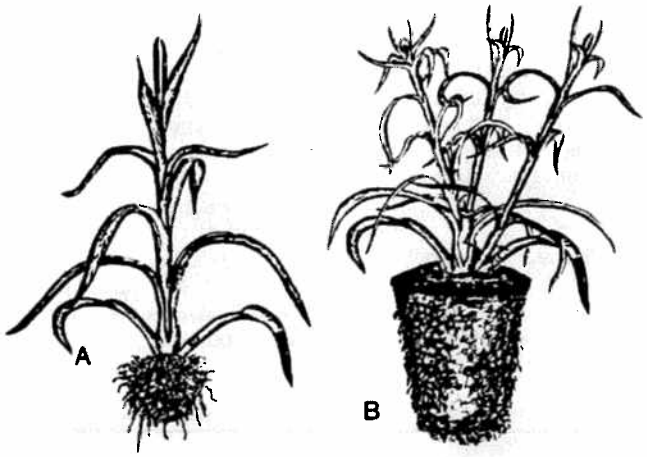

Fig. 3: A) Prime rooted cutting of dwarf carnation. b) Pinched dwarf carnation plant grown as a "plug." It was retained in the plug container too long following the pinch and flower bud initiation occurred.

flower buds prior to removal from the stock plant and others will develop a terminal bud in the rooting bench. The use of initiated cuttings does not create a problem providing at least 9 leaf pairs are visible below the terminal bud at the time of the pinch.

Pinched "plug" cutting — A "plug" cutting, if it is properly pinched and still vegetative upon planting, will provide an excellent flowering plant in the shortest bench time. A "plug" plant is rooted directly in a plug type tray or trans-

planted from the rooting bench into cells shortly after the cutting starts to root. A major concern when plug carnation cuttings are used is the development stage of the plant at potting time. Most ornamentals when confined to a small container, tend to initiate reproductive conditions earlier. The cause is not completely understood, but the change is attributed to any or all factors involving water stress, root limitations (root bound) or nutrition conditions. It is imperative that the dwarf carnation plug supplier and the purchaser keep the plants in a vegetative condition or they will have to be repinched (see section on pinching). If a pinched plug plant with reproductive shoots (Fig. 3b) is allowed to flower, it will flower prematurely, creating an undesirable product.

Handling Rooted Cuttings and Plugs

Ideally, rooted carnation cuttings and plugs should be planted immediately upon arrival, or they must be stored in a cool shaded place until planted. If planting is delayed for more than 8 hours, both types of cuttings should be refrigerated at 34°F to 40°F. Storage for 5 or 6 days will not cause problems. Refrigerated, plants should be checked daily for moisture conditions. Remove them at least four hours before planting is scheduled and store in a shaded area so they will be acclimated to the planting temperatures.

Plants Per Pot

The CMM carnations were developed to be grown in 4-inch azalea pots. The goal was to have a pinched plant that was symmetrically proportional and aesthetically pleasing, upon flowering. Since the plants are self branching, and have an abundance of buds, a single plant in a 4-inch azalea pot provides a full 9 to 10 inch tall (bottom of pot to top of plant) product. 'Shavano', 'Sneffels' and 'Snowmass'' tend to be a little tall for a 4-inch pot, but look well when placed 3 per 6-inch azalea pot. All eight cultivars can provide a very desirable 6-inch pot plant when the cuttings are sized and spaced equidistant around the outer edge of the pot.

Some cultivars, such as 'Lindsey' and 'Crestone' will provide a relatively good plant in a 5-inch azalea pot, for special sales, in some geographical areas.

Pinching Procedures

The "pinch" location on the stem controls the "plant load" just as it does on a pot poinsettia or chrysanthemum. Based on the discussion in the section "plant anatomy", one can easily determine that the top six nodes (leaf pairs) must be removed in order to obtain a well formed pot plant. Approximately 7 to 10 days after planting, a vigorous rooted cutting will have developed 7 pairs of visible leaves and very small vegetative breaks at the lower 3 to 4 nodes. Thus, the pinch should leave 3 to 4 leaf pairs on the plant which will provide 4 to 5 good shoots. Proper growing conditions of some cultivars cause quiescent buds to develop, yielding 1 or 2 additional shoots.

If the cutting has not developed enough leaf pairs and the "pinch" is made too high on the stem, 1 or 2 premature buds will develop. A number of vegetative shoots should be below the buds, if "strong" cuttings were supplied.

Second pinch — When premature buds form, they must be carefully removed — which might be considered a second pinch.

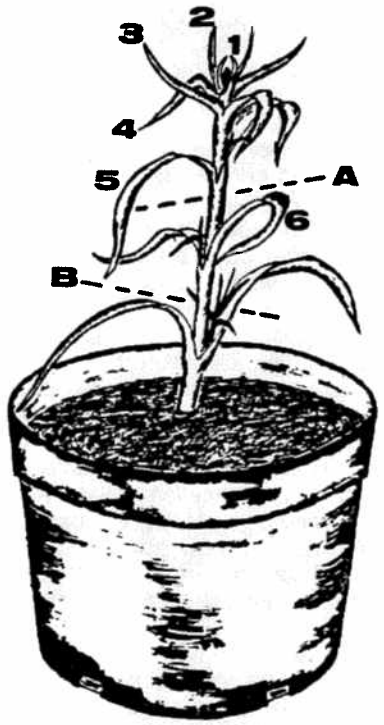

Fig. 4: Pinching level of an initiated, established, dwarf carnation plant. Since the plant has initiated a bud, a pinch at position "A" would probably result in a plant with 3 to 4 good vegetative shoots. A position "B" pinch would provide 2 to 3 shoots.

Plug cuttings (Fig. 3b) that develop reproductive shoots prematurely will have to be re-pinched at the 6th leaf pair below the terminal bud. Care should be taken to make sure at least one leaf pair is left on each pinched stem so a new vegetative shoot forms. If two or more leaf pairs are left, the resulting plant may be over loaded with new shoots, especially in a 4-inch pot.

Repinching a prime prepinched plug plant is not advantageous because it defeats the purpose of reducing the bench time for a crop. Second pinches should only be accomplished when exhibition plants in 6 or 8-inch pots are desired.

Next to watering, the pinch is the most important aspect of producing a desirable pot carnation and experience is going to be the best teacher!

Environmental Conditions

Medium — The CMM series was developed using a 1 soil, 3 sphagnum peat, 3 No. 8 perlite (V:V:V) mix. The peat-lite products produce an excellent plant, but overwatering can be a problem. A straight bark medium is not conducive to good plant growth. A number of commercially available growing media are presently being evaluated for pot carnation production.

Planting depth — Deeply planted carnation cuttings are delayed or do not grow. Plant them only deep enough to cover the root ball/plug and firm in. Care must be taken not to break off the root ball when firming. If cuttings are not planted deep enough a wobbly plant may develop. Experience will be the teacher in this area too.

Spacing — Plants can be started pot-to-pot, but the final recommended spacing should be as soon as the foliage reaches the container edge (2 to 3 weeks following pinch).

4-inch — 3.5 pots per square foot and not more than 4.0 per square foot.
6-inch — 1 pot per square foot maximum.

Plug grown plants, especially the 6-inch types, may have to be spaced immediately upon planting. Pot carnations tend to stretch when grown too close together. Space yields quality plants.

Temperatures — The carnation is a cool temperature crop. The pot carnation has been developed in 52 to 54°F night and 60 to 62° day "heat to" temperatures. Greenhouse cooling starts at 65° in the winter and 70° in the summer. Temperatures during the winter might be increased 1 or 2° without hindering growth. A combination of high light and above 60° night and 75° day temperatures in the greenhouse results in poor plant quality. Thus the production of the pot carnation in warm temperature locations during the summer is almost impossible unless proper cooling is achieved.

Fertilizing — The CMM series of pot carnations have been developed using a year-round continuous (with every watering) feed program normally used for cut carnations. The final feed at the end of the hose with automatic fertilizer injection per liter approximates:

N, 200 ppm	Ca, 82 ppm	Zn, .3 ppm
P_2O_5, 52 ppm	Mg, 18 ppm	Fe330, .11 ppm
K_2O, 220 ppm	B, .6 ppm	

A small amount of boron (B) must be included in the nutrition program for carnations. Excellent plant growth can be expected if the medium pH ranges from 5.5 to 6.5 and soluble salts readings are about 200 mhosx10^{-5}.

Carbon Dioxide — The dwarf carnation has been developed in an environment with 600 to 1000 ppm CO_2 during daylight hours and periods of no ventilation.

Light — Carnations are high-light requiring plants. They should be grown in full sun in the "brightest" greenhouse. They have been developed under FRP, but have responded well in glass houses at evaluation sites. Some shading may have to be used to help control temperatures in the summer, but it should be removed during winter months.

Photoperiod Treatments — It may be possible to increase the number of vegetative breaks by providing short days in the summer, but preliminary studies show that flowering is delayed.

Watering — The type of growing medium used for the pot carnation and plant growth will determine the watering frequency, as it should for any pot crop. As a general rule, water when the soil is starting to feel dry to the touch and definitely before the plant wilts. The 4-inch pot has been successfully grown on watering mats in the summer. All plants can be watered overhead until the buds start showing color. Once buds start to open, the flowers will be susceptible to *Botrytis*, in some greenhouse conditions, if water gets into the flower. The moisture content maintained in the medium will determine, to a degree, the plant height at flowering and timing for scheduling purposes. **Watch watering! If the plants wilt when they approach flowering, some stems may break off. Remember, the watering person controls the crop!**

Scheduling

The CMM carnation series will normally flower, depending on the cultivar, 12 to 14 weeks following a late fall or early winter pinch. Pinches made during other periods of the year usually reduce the flowering time by 1 to 2 weeks.

A single pinched "plug" plant should be supplied to the grower within 10 to 20 days following a pinch. A quality finished plant can be expected within 9 to 10 weeks in the winter and 8 to 9 weeks during other growing seasons.

Like most pot crops, the bench time for the dwarf carnation will depend on air temperatures, amount of solar radiant energy and the watering person. Each grower will have to establish the best program for timing and scheduling based on in-house results.

Dis-budding

CMM carnations have been designed and developed without a "disbudding" requirement so minimum labor would be involved in the final product. The terminal bud of each stem could be removed when it is pea sized, but about 1 week of bench time and a few seconds of labor will have to be added to the cost of production.

The master pot carnation grower will monitor the crop daily. Premature budded shoots will have to be removed and extra vigorous breaks periodically repinched in order to shape and develop a pleasing finished product.

Growth Retardants

The dwarf carnation responds relatively well to some of the growth retardants. Retardants will be recommended as soon as possible for toning plants and making CMM cultivars such as 'Snowmass', 'Shavano' and 'Sneffels' more aesthetically pleasing in 4-inch pots.

Pot Carnation Pests

Diseases — Carnations in general are susceptible to a number of stem diseases. Even though no problems have been observed during the development of the CMM dwarf carnation series, a Benlate 50% WP drench (1 lb. per 100 gal. water) can be applied shortly after potting.

In some greenhouse environments, *Botrytis* may attack open flowers, especially 'Crestone', if free water is present.

Insects — Like their cut counterparts, the dwarf carnation can provide a "field day" for red spider mites and aphids. Thrips are almost impossible to control once they enter the opening buds. A preventative program for thrips is advisable and keep a close watch for the other insects.

Marketing CMM Carnations

It is recommended that pot carnations be marketed when the first terminal bud is open and at least two buds are showing good color. An open flower will remain in prime condition for about one week in the greenhouse. However, some flower colors will start to fade after 3 to 4 days in full summer sun.

Prime plants can be held in 34 to 40°F refrigerator temperatures for 1 to 2 weeks but watch watering. They dry

Fig. 5: Prime dwarf carnation plant in 4-inch azalea pot disbudded and almost ready to market 10 to 12 weeks after the pinch.

out. Do not get water on flowers before shipping. The buds and flowers are somewhat brittle and may break if care isn't taken during handling. Sleeving is recommended at all sales levels.

Post Harvest Considerations

Light requirements — The continued development of flower buds is related directly to the amount of light the plant receives after it leaves the greenhouse. All fully developed buds will open in artificial office light or normal home conditions, providing 10 to 14 days of enjoyment. As flowers complete their flowering cycle, start aging and wilting, they should be carefully cut off with scissors just above the next bud or flower. Attempts to break off a shriveled flower will generally result in breaking off adjacent buds or flowers.

Immature buds require natural light of relatively high intensities to assure their continued development. A south, west or east window exposure will provide the greatest amount of light in the northern hemisphere and extend the useful life of the pot carnation. If buds do not continue to develop and open, light intensity is probably the limiting factor. The home greenhouse, office atrium or southern window exposure will provide adequate light for continued plant development.

Watering — The pot carnation will use more water than one anticipates. They should be watered when the soil starts getting dry to the touch. The 4-inch pots usually require daily watering.

Temperature — Studies have shown that the CMM carnations perform well in home temperatures ranging between 60 and 72°F. The cooler air temperatures and highest light intensities will increase the effective life of the product.

Fertilization — If the plants were properly fertilized during the greenhouse stage, adequate nutrients are present for a two or three-week period in the office or home. Where near-ideal light conditions are available for continued plant development, a weekly fertilization program with a complete fertilizer is appropriate.

Scent — The clove or honey scent related to some of the CMM carnations is apparently associated with the temperature of the flower petals. While in the greenhouse the scent is very evident. When plants are located in the home or office without solar radiation, the fragrance disappears almost completely.

Perpetual longevity — Aside from the useful aspect of the pot carnation as a flowering pot plant in the home or office, it can be used in flower gardens of the cooler climatic geographical areas. Spring planting is recommended. The soil ball should be gently broken open around the edge, planted in a well drained soil and watered daily for at least 5 days, then water as needed. The plants appear to do well where summer night temperatures remain below 60°F and winter conditions approach 0°F.