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IN COOPERATION WITH COLORADO STATE UNIVERSITY
Dorothy Conroy, Executive Secretary
901 Sherman St., Denver, Colorado 80203

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Environmental Factors Affecting Growth of Carnation Stock Plants and Cuttings

by Ralph A. Altstadt[1]

Three basic phases are involved in the culture of carnations: (1) production of cuttings from stock plants, (2) rooting of cuttings in a propagation media, and (3) subsequent growth of cuttings when planted for flower production. Considerable research has been devoted to refining methods of all three phases; however, few studies relating the effects of stock plant environment to the growth of cuttings before and after removal have been performed.

At present the majority of cuttings are produced by the mother block system. Stock plants are grown from disease-free plants and increased by vegetative propagation for the sole purpose of producing cuttings. The alternate system involves the use of lateral shoots taken from flowering plants.

The mother block system allows better disease control, greater control of cultural procedures, more uniformity in size and quality of cuttings, and greater versatility in storing and marketing of cuttings than can be had with the alternate system. The ensuing studies are concerned with the mother block system.

The growth of a young crop of carnation cuttings is often variable. Undoubtedly a certain portion of this variability can be traced to fluctuating environmental conditions affecting plants in their flower production phase; however various factors involved in the stock plant environment can play a considerable role in the eventual performance of a cutting. A study of cultural methods and environmental conditions affecting stock plants, as related to subsequent performance of the derived cuttings, is necessary before quality in the cutting can be defined.

The results from three experiments will be presented in this and ensuing bulletins. In the first experiment, the effects of temperature and nutrition on stock plants were studied. The effects of age of stock plants on the subsequent performance of the cuttings was studied in Experiment 2. Finally, attempts are made to evaluate the following factors pertaining to the cutting in terms of its eventual performance when planted for crop production: 1) fresh weight, 2) dry weight, 3) percent dry matter, 4) number of expanded leaves, and 5) morphological stage of apical meristem. Possible grading of cuttings using one or more of these factors is proposed.

[1] This is part of the work done by Ralph A. Altstadt in completing the requirements for the Master of Science Degree at Colorado State University.

Effects of Temperature, CO 2, and Nutrition on Stock Plants

Four refrigerated growth chambers described earlier by Goldsberry (1) were used for this study. Sunlight received in these chambers was approximately 80 percent of outside on sunny days and 55 to 60 percent on cloudy days. Day temperatures were controlled at 65, 70, 75, and 80F and night temperature was 55F for all chambers. CO_2 was added to all chambers to maintain approximately 600 ppm.

Uniformly sized cuttings of the carnation variety Pink Mamie were planted in 10-inch pots of steamed volcanic scoria on November 12, 1962. Thirty six pots were placed in each chamber. Each of three nutrient levels was applied to 12 pots arranged in a latin square design. The nutrient levels were established at 1.5, 2.0 and 2.5 times the standard greenhouse feeding rate used at CSU and were designated low, medium, and high, respectively. Boron and iron were held constant in all nutrient treatments. The major and minor elements in the standard ratio were as follows:

Element	Source	Parts per million
nitrogen	calcium nitrate	125.0
phosphorus	phosphoric acid	100.0
potassium	potassium chloride	140.0
magnesium	magnesium sulfate	12.0
sodium	sodium nitrate	8.0
iron	iron sequestrene	3.0
boron	borax	1.5

It was found that phosphoric acid caused excessive acidity in the nutrient solution. A ratio of 1 part phosphoric acid applied in the nutrient solution, to 5 parts treble super phosphate applied as a top dressing to each pot, was substituted for straight phosphoric acid in the nutrient mixture, thus providing 100 ppm phosphorus.

Dissolved nutrients were injected in the water lines with a model PR portable Fertoject. Plants were watered every third and fourth day in winter and every second day in summer. Plants in all chambers were watered within one hour of each other on the days that watering was required.

The shoot tips of cuttings in all treatments were removed to five remaining nodes as soon as lateral shoots were visible. Each week, from January 17, 1963, to November 5, 1963, cuttings were harvested from the stock plants. All cuttings were taken from stock plant shoots containing 8 pairs of expanded leaves. The cutting contained 5 pairs of expanded leaves with 3 pairs of leaves being left on the shoot from which it was taken. The total weight and number of cuttings from each treatment were recorded weekly until the experiment was terminated. Dry weights were calculated on the treatments, at various times. Before fresh and dry weights were determined, cuttings were allowed to absorb water from their basal ends to remove variation between treatments due to wilting.

Temperature greatly affected performance of stock plants while nutrition effects were varied and inconsistent. Table 1 summarizes these effects on growth of stock plants and the size and quality of cuttings produced. For total fresh weight produced, significant decreases were observed for each increase in temperature. While the number of cuttings produced was similar in the three cooler temperatures, there was a significant drop at 80F. The size of cuttings decreased with increasing temperature.

Table 1. Effects of temperature and nutrition on production of Pink Mamie stock plants.

Treatment	Total number cuttings	Fresh weight per cutting grams	Mean % dry matter	Dry weight per cutting
Temperature F				
65	1,316[1]	9.6[2]	13.8	1.3
70	1,323	8.6	14.4	1.2
75	1,325	7.5	15.3	1.1
80	1,192	6.9	15.8	1.1
Nutrient level				
1.5X standard	1,250	8.3	14.8	1.2
1.5X standard	1,250	8.3	14.8	1.2
2X standard	1,296	8.0	14.8	1.2
2.5 standard	1,321	8.11	14.9	1.2
	NS[3]	NS	NS	NS

[1]Total production for 41 weeks from January 17, 1963, through November 5.

[2]Mean values for fresh and dry weights were derived from 10 monthly samples from January through October.

[3]NS means differences due to nutrient level were not significant.

Initial growth on stock plants was faster at higher temperatures (Table 2). This trend was duplicated when samples were taken from July to August. Cool-grown plants required more time to develop standard-sized cuttings than those grown at high temperatures. The percentage of shoots developing from blind wood (where a cutting was removed) was 67% for both sampling dates on plants grown at 65F. This percentage was 100 for the 3 warmer temperatures in the January to March period, and decreased differentially to the July-August period (Table 2).

Table 2. Shoot development from Pink Mamie stock plants grown at 4 temperatures.

Sampling period	Temperature F 65	70	75	80
	Days of development of cuttings (5 prs. leaves) from blind wood			
Jan. through March	51	50	50	48
July through August	39	35	34	34
	Percentage of blind wood developing shoots			
Jan. through March	67	100	100	100
July through August	67	89	83	78

Nutrition

There were no consistent differences in production of cuttings or in size or dry matter content of cuttings due to nutrient level. The "low" level (1.5 X standard for cut flower production) is apparently adequate under the conditions of this experiment.

Typical stock plants and cuttings grown at the 4 temperatures are shown in Figures 1 and 2. In general, fresh and dry weight per cutting increased as temperature decreased. Similarly the diameter of stems and the number of visible axillary shoots increased as temperature decreased. Cool-grown cuttings (65 and 70F) had a greater amount of leaf curling than those grown at 75 and 80F.

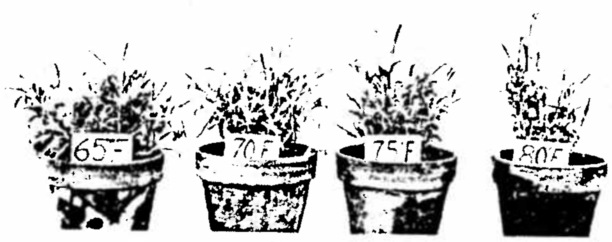

Figure 1--Samples of Pink Mamie stock plants grown at 4 temperatures. Note compressed growth and increased branching of plant on left. Picture taken on October 14, 1963.

Flowering Trials

Once a month, starting April 16 and ending October 1, 1963, cuttings were taken from each stock plant treatment, weighed, and stuck in perlite for rooting. Dry weight determinations were made on duplicate samples in each case. After sufficient roots were formed, cuttings were planted at 6 X 8 inches in a flowering trial containing 2 randomized blocks of 5 plants per treatment. A total of 6 flowering trials were used with a control from untreated stock plants included in the last 4 trials. By growing each flowering trial in different benches and at different times of the year, more accurate, all-around performance of the stock-plant treatments could be measured.

Figure 2--Samples of cuttings taken from plants in the order as shown in the above photograph. Note the increased axillary growth and increased width of stem, and decreased internode length of the two cuttings on the left (65 and 70^{o}F).

After 3 weeks of growth, the plants were pinched to allow growth of all possible vegetative, lateral shoots. Production, grade, and other measurements taken during or at the end of the first crop of flowers are shown in Table 3. The fresh weight of the plants remaining after the first crop is used to indicate second crop production potential. Other counts and measurements were made but are not included in the data presented here.

Table 3 is divided in 3 parts to show effects of temperature, nutrient level, and variation in flowering trial. Cuttings from low temperature stock plants (65 and 70F) contained more lateral shoots at planting time and developed these shoots faster than those from high temperature stock plants (75 and 80F). The differences in yield, and fresh weight of residual plant were not statistically significant; however consistently higher values occurred for cuttings produced at 65 and 70F. Differences in mean grade of cut flowers were small, but significant, in favor of the high temperature stock.

None of the nutrient effects in Table 3 are significantly different. There were significant differences in every measurement between flowering trials. This is to be expected since plantings from April to October produce first crops in gradually changing environments. Biggest differences were in time required to produce the first crop (not shown here), mean grade of flowers, and in fresh weight of residual plants.

Table 3. Yield and mean grade of flowers and weight of plants after the first crop from cuttings produced at 4 temperatures and 3 nutrient levels.

Source of variance	No. plants in average	Fresh weight[1] of cuttings	Shoots after pinch	Yield per plant	Mean grade of flowers	Fresh weight per plant[2] (grams)
Temperature of stock plant						
65	180	8.7	6.1	5.3	4.20	342
70	180	8.2	6.2	5.4	4.20	338
75	180	6.7	5.8	5.2	4.28	325
80	180	6.2	5.8	5.0	4.28	312
Nutrient level						
1.5X standard	240	7.5	5.9	5.2	4.21	320
2 X standard	240	7.4	5.8	5.1	4.25	333
2.5X standard	240	7.4	6.0	5.3	4.24	334
Flowering trial planting date						
4/16/63	120		5.1	4.4	4.15	218
5/17/63	120		4.7	4.5	3.44	329
7/3/63	120		6.3	5.8	4.19	409
8/1/63	120		6.6	5.1	4.61	359
9/5/63	120		6.4	5.7	4.48	340
10/1/63	120		6.8	5.9	4.48	318

[1]Weight in grams when removed from stock plants
[2]Weight of plant to soil line after first crop of flowers removed.

Summary

Nutrition of stock plants within the levels tested in these experiments produced little or no effects on yield or performance of cuttings. 1.5 times the rate used for cut flower production was adequate for carnation stock plants.

Each decrease in temperature produced an increase in fresh and dry weight per cutting with the opposite trend for percent dry matter. Yield of cuttings was approximately equal for 65, 70 and 75F, but a decrease was observed at 80. As plants aged and solar energy increased, the size of cuttings decreased at all temperatures.

Cuttings taken from stock plants grown at 65 and 70F produced more first-crop flowers in a shorter time and more second-crop potential than those grown at 75 and 80F. Mean grade of flowers was slightly higher for the cuttings produced at higher temperatures.

Literature Cited

1. Goldsberry, K. L. 1963. The effects of carbon dioxide on carnation growth. Proc. Am. Soc. Hort. Sci. 83:753-760.

Your editor,

COLORADO FLOWER GROWERS ASSOCIATION, INC.
OFFICE OF EDITOR
W. D. HOLLEY
Colorado State University
Fort Collins, Colorado 80521

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