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Effects of Cutting Size and Stage of Development on Subsequent Growth

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As carnation production becomes more exacting, the need for carefully graded planting stock will no doubt arise. In order to grade carnation cuttings, we must first determine the measurable factors that influence the quality of a cutting and its performance after removal from the stock plant. Previous reports (CFGA Bulletins 176 and 177) have dealt with stock plant environment and age. This report covers work designed to investigate the effects of fresh weight, dry weight, % dry matter and number of expanded leaves on the performance of cuttings when planted for crop production. A later article will take up effects of the morphological stage of the apical meristem at the time a cutting is removed from the stock plant.

While quality in a cutting may be recognized by most successful growers, it is difficult to define and to measure by objective means. The carbohydrate-nitrogen ratio and total food supply, as indicated by the size of cutting, are probably the most important measurements of rooting ability and growth potential of cuttings. Calma and Richey (1) found that cuttings of Concord grape containing a high percentage of carbohydrate produced more roots as well as earlier top growth than cuttings containing low carbohydrates. Dry weight as an indication of growth and quality has been used in many experiments with carnation. Size of a cutting, as measured by fresh weight, has been shown to affect carnation growth (2). More flowers were produced in a shorter period of time from large cuttings of 10 grams and above when compared to smaller cuttings.

First Planting

Different sized cuttings were selected from White Pikes Peak stock plants. Each cutting was removed at a position allowing 3 pairs of leaves to remain on the stock plant shoot. The cuttings were

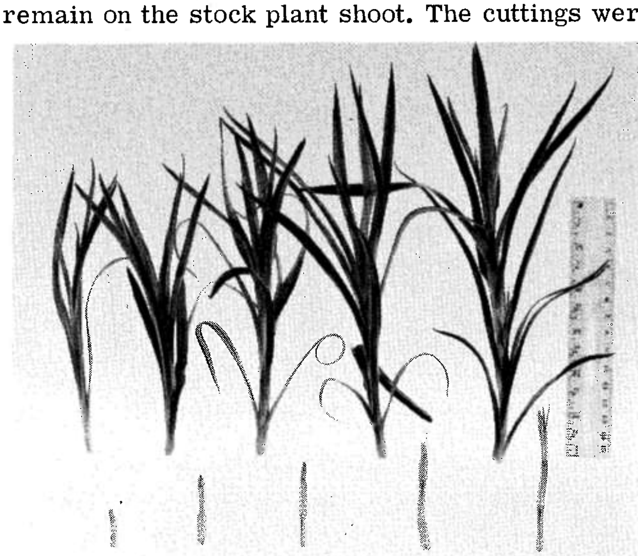

Figure 1--From left to right, cuttings taken from stock plants at 4, 5, 6, 7, and 8 pairs of expanded leaves. Note increasing length of stems and increased growth of axillary shoots as size increases (stripped cuttings below).

[1] This is a part of the work done by the author in completing the requirements for the M.Sc. Degree at Colorado State University.

Table 1. Measurements of White Pikes Peak cuttings at the time of removal from stock plants.

Treatment	Number of cuttings in average	Fresh weight per cutting	Dry weight per cutting	Percent dry matter
Leaf pair				
4	24	5.06	.78	15.42
5	24	7.34	1.09	14.89
6	24	10.29	1.58	15.38
7	24	11.52	1.74	15.09
8	24	14.58	2.28	15.62
Weight				
light	60	8.47	1.29	15.28
heavy	60	10.61	1.63	15.38

arbitrarily graded into categories of 4, 5, 6, 7, and 8 pairs of expanded leaves. Within each leaf-pair category, cuttings were further divided into light and heavy groups by weighing on a triple-beam balance. This constituted a 5 x 2 factorial study containing 10 treatments. Dry weight determinations were made on a duplicate sample of cuttings from each treatment. On September 21, 1963, 2 blocks of 5 rooted cuttings per treatment, were planted in a greenhouse bench. Plants were spaced 6 x 8 inches throughout. Leaf-pair plots were planted in numerical sequence with the 2 weight treatments arranged identically within each plot. Methods of handling young plants and measurements of first and second-crop production were given in Bulletin 176.

Figure 1 shows the cuttings in each leaf-pair category with and without leaves. Table 1 lists the measurements made on these cuttings before they were stuck in perlite for rooting.

Results of First Experiment

The size of cuttings before planting, as measured by number of expanded leaves, significantly affected their performance after planting. The speed of growth of cuttings until pinching time increased with size of cutting (Table 2). This trend was similar for the number of axillary shoots contained by plants after pinching, except for cuttings containing 8 leaf pairs. The decrease in the latter was attributed to the removal of a large number of reproductive shoots from cuttings at pinching time. Reproductive shoots are always removed from young, producing carnations. In any leaf-pair category, heavy cuttings produced more axillary shoots in a shorter length of time than light cuttings. At the end of the first-crop flower production, cuttings containing 4 and 5 leaf pairs contained as many return, vegetative shoots as the heavier cuttings; however fresh weight per residual plant at this time was considerably less for

Table 2. Speed and quantity of vegetative growth from cuttings of different sizes.

Treatment	Number of plants in average	Number of weeks from planting to pinching	Number of axillary shoots per plant after pinching	Number of axillary shoots per plant after harvest of first flower crop	Fresh weight per residual plant (grams)
Leaf pair					
4	20	7.20a*	5.65e**	12.00	346.7
5	20	6.15b	7.05abc	11.10	383.0
6	20	5.85bc	7.10ab	12.90	439.6
7	20	4.75d	7.30a	11.50	405.1
8	20	4.60de	6.50abcd	11.10	428.0
Weight					
light	50	6.08*	6.44	11.08	379.6
heavy	50	5.14	6.88	12.34	421.3

Single and double asterisks mean significance at the 5 and 1 percent levels using analysis of variance. Means followed by the same letter are not significantly different. Means followed by different letters are significantly different.

small cuttings (4 and 5 leaf pairs). Within any leaf-pair category, heavy cuttings produced more fresh weight per residual plant.

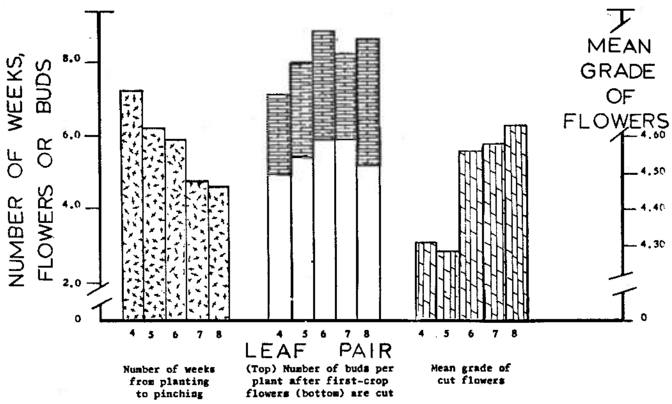

Figure 2.--Speed, quality and quantity of growth from White Pikes Peak cuttings containing different numbers of expanded leaves.

Speed, quantity and mean grade of first-crop flower production were greatly affected by cutting size (Table 3). As with the number of initial axillary shoots, production of cut flowers was directly related to size of cuttings up to 6 leaf pairs. Increasing the number to 7 resulted in no increase in production. A decrease in production was noted when the cuttings contained 8 leaf pairs. This decrease was undoubtedly due to fewer shoots per plant after pinching. The number of buds remaining after the first crop of flowers was cut was proportionately higher with small cuttings (4 and 5 leaf pairs), this being due to a portion of late, first-crop flowers being included in the bud count after the harvest period. When considering the number of flowers plus buds, it can be seen (Figure 2) that production increased with size of cutting with those groups containing 4, 5, and 6 leaf pairs and decreased at 7 and 8. Flowering was accelerated with each increase in cutting size, except with cuttings containing 7 leaf pairs. Mean grade of flowers was directly related to cutting size, this being due partially to small flowers and weak stems produced from small cuttings.

Within any leaf-pair category, heavy cuttings produced 1) more flowers and buds in a shorter period of time, 2) more total shoots at the start of the second crop, and 3) higher mean grade of cut flowers.

Second Planting--2 Pinching Methods

On November 7, 6 blocks of rooted cuttings--containing treatments and design identical to that described in the first planting--were planted in a greenhouse bench. Both September and November planting were in the same greenhouse with day and night temperatures regulated at 70 and 53F, respectively. Exceptions from the first planting in the experimental procedure were as follows: 1) Initial dry weight determinations were not made. 2) Three blocks were pinched to 5 remaining shoots, the other 3 blocks being handled as in first planting. 3) Plants were allowed to remain in production after the first crop. Total number of buds 1/4 inch or greater were counted per treatment in each block to give an estimate of second-crop production. 4) Plants were spaced 6 X 6 inches in the producing bench, giving a total of 7 plants per individual treatment.

The same trends concerning 1) pinching time, 2) mean grade of cut flowers, and 3) speed of

Table 3. Speed, quantity and quality of first-crop flower production from cuttings of different sizes.

Treatment	Number of plants in average	Number of first-crop flowers per plant	Number of buds per residual plant	Number of flowers produced plus buds after harvest	Mean grade of cut flowers	Number of days to midpoint of crop
Leaf pair						
4	20	4.45a**	2.60	7.05	4.31ab**	31.8
5	20	5.40bc	2.60	8.00	4.28a	31.5
6	20	5.90bcd	2.95	8.85	4.56c	28.0
7	20	5.90bcd	2.30	8.20	4.58cd	29.0
8	20	5.20b	3.55	8.75	4.63cde	26.0
Weight						
light	50	5.02*	2.84	7.86	4.44	31.3
heavy	50	5.72	2.76	8.48	4.49	27.2

Single and double asterisks mean significance at the 5 and 1 percent levels using analysis of variance. Means followed by the same letter are not significantly different. Means followed by different letters are significantly different.

flower production were observed as in the first planting. Of all the measurements of performance, 1 and 3 above were the only ones that were significant effects, and were inversely related to size of cuttings. Mean grade was directly related to size of cuttings.

Plants given a late pinch developed approximately 2 more vegetative shoots per plant (Table 4) which resulted in a similar increase in the number of flowers produced in the first crop. Opposite results occurred with the number of buds counted after first-crop flowers were cut. At the time bud counts were made, a greater number of second-growth shoots were developed on plants initially pinched to 5 shoots than on plants given a late pinch. This was due to faster flower production for the former, allowing more time for development of second growth (Table 5). In general, plants pinched to 5 breaks produced 1) fewer flowers, but in a shorter period of time, 2) more buds at the beginning of the second crop, 3) more flowers plus buds, and 4) higher mean grade of flowers than plants pinched to allow growth of all possible vegetative shoots.

With either pinching treatment, trends concerning production of flowers and buds from cuttings of different sizes were not exactly comparable to those observed in the first planting (Table 5). Due to a greater number of initial shoots after pinching, cuttings containing 4 leaf pairs produced more first-crop flowers, but in a longer period of time than larger cuttings. When the number of buds is added to the number of flowers, it can be seen that a general increase occurred with cutting size, except for cuttings containing 7 leaf pairs. When the sum of light-weight cuttings for all leaf-pair categories is compared to heavy cuttings, it can be seen that heavy cuttings produced 1) more vegetative shoots after pinching resulting in more cut flowers produced in a shorter period of time, 2) more flowers plus buds at the end of harvest time, and 3) a slightly higher mean grade of cut flowers.

Table 4. Speed and quantity of vegetative growth from White Pikes Peak cuttings of different sizes when given 2 pinching treatments.

Treatment	Number of plants in mean	Fresh weight per cutting (grams)	Weeks from planting to pinching — Pinching[1] method: 5	5+	Mean	Number of axillary shoots per plant after pinching — Pinching method: 5	5+	Mean
Leaf pair								
4	42	3.95	8.0a**[2]	9.2a**	8.60	5.27	7.81	6.54
5	42	5.93	6.7ab	7.4b	7.05	5.40	7.27	6.34
6	42	7.82	6.0bc	6.4bc	6.20	5.17	7.18	6.18
7	42	9.41	5.7bcd	6.0cd	5.85	4.97	7.33	6.15
8	42	11.08	5.0cde	5.9cde	5.45	5.00	7.31	6.16
Weight								
light	105	6.52	6.5	7.4*	6.95	5.17	7.09	6.13*
heavy	105	8.94	6.0	6.5	6.25	5.15	7.69	6.42

[1] 5 = plants pinched to 5 axillary, vegetative shoots.
5+ = plants pinched to allow growth of all axillary, vegetative shoots.

[2] Single and double asterisks mean significance at 5 and 1 per cent levels using analysis of variance. Duncan's New Multiple-Range Test used to describe least significant differences between treatments. Means followed by the same letter are not significantly different at the 1 per cent level. Means followed by different letters are significantly different at the 1 per cent level.

Summary

As cutting size increased from 4 through 8 pairs of expanded leaves, less time was required for development of young plants and quality of the first crop of flowers increased. In the first planting higher production of cut flowers occurred in a shorter period of time as size of cutting increased from 4 through 6 leaf pairs and decreased slightly at 7 and 8. In the second planting, first-crop production was higher with cuttings containing 4 leaf pairs but longer time was required for flowering. Considering the sum of first-crop flowers and

Table 5. Speed, quantity, and quality of first-crop flower production from White Pikes Peak cuttings of different sizes when given 2 different pinching treatments.

Measurements	Pinching[1] method	Treatment — Leaf pair: 4	5	6	7	8	Weight: L	H	Mean
Initial fresh weight per cutting (g)		3.95	5.93	7.82	9.41	11.08	6.52	8.94	3.93
Number of plants in mean		42	42	42	42	42	105	105	210
Number of flowers per plant	5	3.84	4.03	4.07	3.81	3.91	3.98	3.88	3.93
	5+	4.91	4.34	4.41	4.27	4.40	4.30	4.61	4.46
Average		4.38	4.19	4.24	4.04	4.16	4.14	4.25	
Number of buds per residual plant	5	2.25	2.38	2.22	2.52	2.75	2.21	2.64	2.43
	5+	1.65	2.15	2.20	2.10	2.72	2.28	2.12	2.20
Average		1.95	2.27	2.21	2.31	2.29	2.25	2.38	
Number of flowers plus buds	5	6.06	6.41	6.16	6.19	6.33	6.08	6.58	6.36
	5+	6.56	6.49	6.78	6.47	6.98	6.63	6.68	6.66
Average		6.31	6.45	6.47	6.33	6.66	6.36	6.63	
Mean grade of flowers	5	4.21	4.16	4.21	4.25	4.18	4.17	4.24	4.21
	5+	4.08	4.24	4.23	4.28	4.39	4.23	4.25	4.24
Average		4.15	4.20	4.22	4.27	4.29	4.20	4.25	
Days to midpoint of crop	5	38.7	35.5	38.0	38.8	34.9	38.3	35.7	37.0*
	5+	45.0	42.2	37.3	38.5	26.0	40.1	39.5	39.8
Average	**	41.9 a	38.9 ab	37.7 abcd	38.7 abc	35.5 bcde	39.2	37.6	

[1] 5 = plants pinched to 5 axillary vegetative shoots.
5+ = plants pinched to allow growth of all axillary, vegetative shoots.
Single and double asterisks mean significance at 5 and 1 per cent levels using analysis of variance. Means followed by the same letter are not significantly different at the 1 per cent level. Means followed by different letters are significantly different.

buds after harvest of both plantings, increases were observed as cutting size increased to 6 leaf pairs, decreased at 7 and reached a high at 8. Within any leaf-pair category, heavy cuttings outperformed light cuttings. The largest difference in total cut flowers was 39.3%, observed between light cuttings containing 4 leaf pairs and heavy cuttings containing 5 leaf pairs (original fresh weights of 4.67 and 8.63 grams). Plants pinched to allow growth of all possible vegetative shoots slightly outperformed those pinched to 5 shoots.

Considering data from all experiments, reported here and elsewhere, maximum all-around performance of cuttings was achieved with cuttings containing at least 6 pairs of expanded leaves and weighing at least 10 grams.

Effects of Flower Bud Initiation on the Growth

The growth stage of the apical meristem in a cutting is considered to affect its subsequent performance. Furuta and Kiplinger (3) showed that initiated chrysanthemum cuttings developed crown buds on much shorter stems than did vegetative cuttings. After a terminal bud is removed, apical dominance is lost. Van Overbeek (6) observed that auxin content increased in the stem after the terminal bud had been removed. He postulated that auxin blocks the passage of nutrients to the lateral buds which have a poor connection with the main cylinder. When the amount of auxin is reduced a better connection is established. Nutrients can then pass into the axillary buds thus allowing their development. Another postulated mechanism is that auxin is considered to cause synthesis of a growth inhibitor which, upon movement into lateral buds, prevents their growth (5). It is probable that, when flower initiation occurs, growth of axillary meristems is accelerated in the same manner as when the apical bud is mechanically removed. It is implied that an initiated apical meristem does not produce sufficient quantities of auxin to inhibit growth of axillary meristems. At any rate, the formation of a flower bud in a cutting causes the same reaction as the removal of the stem tip.

It had been suspected by the writer that the amount of axillary shoot growth of cuttings was related to flower initiation. To study this theory, cuttings were taken at 4 through 10 pairs of expanded leaves, leaving 3 pairs of leaves on the stock-plant shoots from which they were taken. Cuttings were then stripped of all leaves, the nodes from the base of the cutting to the apical meristem were counted, and the meristem was examined under the binocular microscope to determine its height and stage of development. It was found that, as the height of the apical meristem increased from 185 to 476 microns, there occurred a gradual transition from completely vegetative meristems to those that had formed a majority of primordial floral organs. Furthermore, this transition occurred as cuttings increased in size from 6 to 10 pairs of expanded leaves and an associate increase in fresh weight from 8.66 to 13.80 grams (Table 6). As cutting size increased from 6 to 10 leaf-pairs, the number of nodes subtending the apex increased from 11.9 to 15.0.

During the time the above study was made, the average number of leaf pairs subtending the flowers on Pink Sim producing plants was counted to

Table 6.--Comparisons between the developmental stage of the apical meristem and size of cuttings. (5 sampling dates from October to November, variety Pink Sim used).

Leaf pairs	Fresh weight (grams)	Total length (inches)	Number of nodes from base of cutting to apex	Height of apex (microns)	Growth[1/] stage to apex	Length of stripped cutting (inches)
4	5.43	7.13	10.3	148.9	1.00	1.02
5	6.50	7.32	11.1	144.9	1.00	1.72
6	8.66	10.07	11.9	185.0	1.27	2.24
7	10.02	9.87	13.1	194.7	1.45	3.53
8	11.71	10.52	13.5	214.6	2.30	3.58
9	11.23	11.30	14.3	428.0	2.75	--
10	13.80	12.00	15.0	476.0	3.20	--

1/ Mean stage of development determined by the following system:

Points allotted	Stage	
1	1	vegetative
2	2	elongation and floral initiation
3	3	early floral development, calyx visible
4	4	advanced floral development, calyx and corrolla visible

determine the maximum number of leaf nodes contained by mature flower stems. Of 150 flower stems arising from different positions on the plant, the average number of leaf nodes subtending the flower was 15.6, with the range from 13 to 18, depending upon the position of the plant from which the flower stem grew. It was noted, in accordance with Hanzel et al. (4), that the higher the position of the flower stem on the plant the fewer the number of leaf nodes subtending the flower. Measurements of this type were not made on stock plants, thus direct findings concerning positional effects on the number of nodes subtending the flower could not be made. However a reasonable estimate can be made from the counts on flowering plants. With these points in mind, it can be seen from Table 6 that, when the number of leaf nodes left on stock plants is added to the number of nodes subtending the apex on cuttings of different sizes, the range is from 13.3 for cuttings containing 4 pairs of expanded leaves to 18.0 for cuttings containing 10 leaf pairs. It can also be seen that the apical meristems of cuttings in the latter two groups were changing from the vegetative to the reproductive stage. Relative axillary shoot growth of cuttings of different sizes is shown in Figure 1. It can be seen in this photograph, and was observed throughout the study, that cuttings containing 4 and 5 leaf pairs have very little stem development and only a small amount of axillary shoot development; whereas a considerable increase in development of stems and axillary growth occurred with larger cuttings. When apical meristems of cuttings were changing from the vegetative to the reproductive stage, an associate, rapid increase in axillary shoot growth occurred.

The fresh and dry weights and % dry matter of cuttings ranging from 3 to 9 leaf pairs in size are shown in Table 7. Percent dry matter was initially high at 3 leaf pairs, decreased to 5, and increased gradually thereafter. These tables are placed together for ease in making comparisons between all macroscopic measurements of the cuttings and the developmental stage of their apical meristems.

Cuttings containing 4 and 5 leaf pairs were vegetative, those containing 6 leaf pairs were in the transitional stage, and from 7 through 10 leaf pairs, rapid development of floral organs occurred. Figure 3 illustrates the effects of growth stage of meristem on time required to pinching and first-crop production.

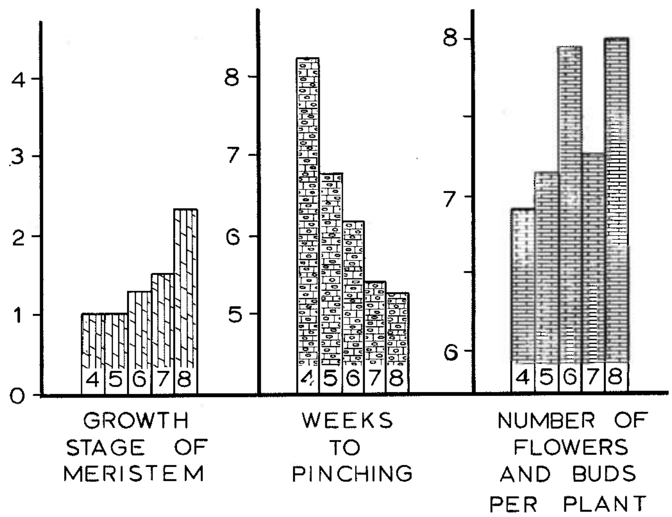

Fig. 3. Growth stage of meristem, weeks to pinching and number of flowers and buds produced per plant in first crop. Number of expanded leaf pairs are shown at base of bar graphs.

Summation--Effects of Cutting Size on Subsequent Growth

Table 8 was compiled as a summation of all experiments done with stock plant plant environment, juvenility, and size of cuttings. Colorado Flower Growers Bulletins 176 and 177 contain additional information on these experiments. The size and quality (dry weight per cutting) of cuttings had considerable effect on their performance after planting. The date when cuttings were planted was also important to the performance of the crop, no matter what size cutting was initially planted; however, when considering any single planting date, the effect of initial cutting size was still apparent. Cuttings from young stock plants con-

Table 7.--Fresh weight, percent dry matter, and dry weight of cuttings of 2 Sim varieties containing different numbers of expanded leaves. July sample - Pink Sim; September sample - White Pikes Peak.

Measurement	Sampling date			Number of expanded leaves				
		3	4	5	6	7	8	9
Fresh weight per cutting	July 16, 1963	3.33	3.60	5.88	7.66	8.78	10.73	13.95
	September 12, 1963		5.06	7.34	10.29	11.52	14.58	
Percent dry matter	July 16, 1963	17.2	16.7	16.6	16.9	17.0	17.1	17.3
	September 12, 1963		15.4	14.9	15.4	15.1	15.6	
Dry weight per cutting	July 16, 1963	.38	.60	.98	1.39	1.50	1.83	2.41
	September 12, 1963		.78	1.09	1.58	1.74	2.28	

sistently outproduced those from old stock plants, even when the two groups were of equal sizes. When all performance measurements are considered, it is concluded that cuttings weighing 10 to 15 grams and having 6 to 8 pairs of expanded leaves performed significantly better than smaller cuttings.

Proposed Grading System for Cuttings

The following recommendations are advocated for the maximum performance of carnation cuttings:

1. Grow stock plants at 65 to 70F, increase atmospheric CO_2 to 1000 ppm when possible, and supply a complete nutrient solution at 1.5 times the rate used for flowering plants.

2. Take cuttings that weigh no less than 10 grams each and contain 6 pairs of expanded leaves (3 pairs left on the stock plant).

3. At certain times of the year (summer and winter), when cuttings containing 6 leaf pairs do not weigh 10 grams, take cuttings with 7 and 8 pairs of leaves.

Fresh weight and number of expanded leaf pairs are indicated as the best criteria on which to base a grading system for carnation cuttings.

Literature Cited

1. Calma, V. and H. Richey. 1931. Growth of Concord grape cuttings in relation to vigor, chemical composition and relative position on the cane. Proc. Am. Soc. Hort. Sci. 28:131-137.
2. Holley, W. D. 1954. Propagate carnations with large cuttings. Colo. Flower Growers Assoc. Bull. 51.
3. Furuta, T. and D. C. Kiplinger. 1955. Chronological age of cuttings, a factor influencing the spray formation of pompon chrysanthemums. Proc. Am. Soc. Hort. Sci. 66:383-385.
4. Hanzel, R. J., K. S. Nelson, and D. C. Kiplinger. 1955. Floral initiation and development in the carnation, var. Northland. Proc. Am. Soc. Hort. Sci. 65:455-462.
5. Meyer, B. S., D. B. Anderson, and R. H. Bohning. 1960. Introduction to plant physiology. D. Van Nostrand Co., Inc., N.Y.
6. Van Overbeek, J. 1938. Auxin distribution in seedlings and its bearing on the problem of bud inhibition. Botan. Gaz. 100:133-166.

TABLE 8.--EVALUATION OF THE EFFECTS OF CUTTING SIZE AT DIFFERENT PLANTING DATES ON THE QUALITY AND QUANTITY OF THE FIRST CROP OF FLOWERS. DATA TAKEN FROM EXPERIMENTS I, II, AND III. SECOND-CROP POTENTIAL PRODUCTION ESTIMATED BY FRESH WEIGHT OF RESIDUAL PLANTS PER SQUARE FOOT.

Comparative sample		Number of cuttings in average	Number of expanded leaves per cutting	Fresh weight per cutting grams	Per cent dry matter	Dry weight per cutting (grams)	Planting date	Number of weeks from planting to final harvest	Number of flowers per square foot per week 2/	Mean grade of flowers	Fresh weight of residual plants per square foot
Mean values for	1	120	5	9.21	13.60	1.21	4/16/63	19	.78	4.15	741
flowering trials	2	120	5	8.82	14.50	1.28	5/16/63	21	.73	3.44	1,119
(Variety Pink Mamie,	3	120	5	7.14	16.90	1.21	7/16/63	28	.70	4.19	1,391
Average temperature 72.5 F	4	120	5	6.65	16.90	1.12	8/16/63	30	.58	4.61	1,217
Average nutrient level	5	120	5	5.71	15.15	.87	9/ 5/63	32	.61	4.48	1,153
2x standard	6	120	5	6.30	14.15	.89	10/ 1/63	31	.65	4.48	1,081
Average carbon dioxide 525 ppm)	check 1/	40	5	6.38	16.70	1.06		30	.57	4.32	1,050
Juvenility study	young	60	6	9.22	16.30	1.51	8/17/63	32	.63	4.38	1,557
(age of stock plants)	old	60	6	6.73	18.30	1.23			.53	4.23	1,156
(Varieties Red Gayety and White Pikes Peak,	young	28	5	7.20	15.00	1.08	11/12/63	30	.57	4.55	1,036
Standard growing conditions)	old	28	6	7.12	15.50	1.10			.44	4.48	1,064
		20	4	5.06	15.42	.78	9/12/63	32	.47	4.31	1,176
Size of cutting study	first planting	20	5	7.34	14.89	1.09			.57	4.28	1,302
(Variety White Pikes		20	6	10.29	15.38	1.58			.63	4.56	1,493
Peak,		20	7	11.52	15.09	1.74			.63	4.58	1,377
Standard growing conditions)		20	8	14.58	15.62	2.28			.55	4.63	1,455
	pinching study	42	4	3.95			11/7/63	32	.58	4.15	
		42	5	5.93					.56	4.20	
		42	6	7.82					.57	4.22	
		42	7	9.41					.54	4.27	
		42	8	11.08					.55	4.29	

1/ Mean values for the last 4 flowering trials - stock received no additional CO_2
2/ Weekly values figured for the period of time from planting to the end of the first crop

Thoughts and Facts

CO_2 Injection Rates

CFGA bulletin 119 contained graphs of varying CO_2 levels in the greenhouse when no CO_2 was injected. CO_2 concentrations in a greenhouse will also vary from day to day during injection periods. Variations in solar energy and outside temperature help to determine CO_2 uptake rates by plants and the cooling requirements within a greenhouse.

If the injection rate is set to maintain approximately 900 ppm on a medium to bright day not requiring ventilation, the average CO_2 level maintained for the complete injection season will be at least 300 ppm lower. A seasonal CO_2 average is established because there are days when no CO_2 is added, short or long ventilation periods, and days or weeks of varying light intensity.

Growers need to base their injection rates on the seasonal average (400, 500, or 600 ppm) desired in order to obtain maximum benefits from CO_2 fertilization.

Controlling Greenhouse Temperatures

On bright days greenhouse temperatures cannot be accurately controlled or measured with unprotected instruments (CFGA Bulletin 165). An aspirating system is needed to obtain accurate air temperatures in the greenhouse on sunny days. Temperatures measured under hoods, in the shade or in semiprotected areas will be 3-6 degrees warmer than the actual air temperature.

Instruments placed in these semiprotected areas and set to cool at a desired temperature will actually cause air temperatures several degrees lower. Temperature recommendations from CSU have been established by the aspirated box method.--K.L.G.

Your editor,

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FIRST CLASS