Colorado Flower Growers Association Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Response of Carnation to Three Concentrations of CO2

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It has been established that additional CO_2, up to 550 ppm, results in higher quality and yield of carnations (1,2). Additional benefits from higher levels of CO_2 are in question.

The three greenhouses used were oriented east-west, having dimensions of 15 x 18 feet with height of 7 feet at the eave and 10 feet at the ridge. The framework was wood, and the covering of clear fiberglass.

A fan and evaporative pad cooling system was used in summer cooling and plenum tube cooling in winter. The cooling system came on at 69F in the two houses where CO_2 was added. In the control house from November 15 to March 15 cooling was at 65F, and from March 15 to November 15 cooling was at 69F. The heating system was operable at 54F at night and 60F during days for all houses. Temperature controls were housed in a shelter that allowed free air passage while minimizing stray radiation. A Foxboro 24-hour hygrothermograph was used in each house to set and adjust temperatures.

Irrigation was on demand with a standard nutrient solution. Two applications of 6-10-4 fertilizer were applied dry on April 2 and 23 at the rate of 4 pounds per 100 square feet to insure adequate nutrition.

Each house had two raised benches with dimensions of 4 x 13 feet. Eighty plants of four different varieties and two different ages were planted in each house. Two-year-old plants of White No. 88 and Safari were in place at the start of the experiment, and rooted cuttings of Elliott's White Sim and Pink Coquette were planted June 23, 1964 in steamed soil. After the plants were pinched, a mulch of leaves was applied.

A MSA Lira infrared gas analyzer was used to set the equipment for metering CO_2 to houses 1 at 1200 ppm and 2 at 600 ppm and used periodically to check these levels.

Results

Table 1 shows the yield for the three treatments and indicates that 1200 ppm CO_2 concentration did not significantly increase yield over 600 ppm. Since total flower production is in proportion to the number of lateral breaks that return from a flower stem, the optimum CO_2 level for the production of laterals for

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* This is a part of the work done by the author in completing requirements for the M.S. Degree at Colorado State University. This should be considered a progress report as the work is being continued.

Table 1. Yield of four carnation varieties grown at three CO_2 concentrations from October 2, 1964 to June 12, 1965.

	1200 ppm	600 ppm	300 ppm
Safari	1103	972	957
White No. 88	976	1110	988
Total for 2-year-old plants	2079	2082	1945
Elliott's White	1229	1346	1185
Pink Coquette	828	1033	863
Total for first-year plants	2057	2379	2048
Total all plants	4136	4461	3993
% over control	4	12	0

Table 2. Effects of three levels of CO_2 on mean grade of Elliott's White and Pink Coquette from October 2, 1964 to June 12, 1965.

Source	D of F	Mean grade	F value	Probability
1200 ppm vs 600 ppm	1	4.15 vs 4.04	1.064	N S
1200 ppm vs 300 ppm	1	4.15 vs 3.95	7.716	.02
600 ppm vs 300 ppm	1	4.04 vs 3.95	2.493	N S

the conditions of this experiment was around 600 ppm. 300 ppm reduced laterals as did 1200 ppm, when compared to 600 ppm.

The mean grade of flowers from the first-year plants, Elliott's White Sim and Pink Coquette, are shown in Table 2. Grade data collected on the two-year-old plants were not compared since lack of support of the plants resulted in downgrading many flowers due to crooked stems. Mean grade is significantly higher under 1200 ppm of CO_2 as compared to 300 ppm. There were no significant differences in mean grade between 1200 ppm and 600 ppm, or between 600 ppm and 300 ppm. This suggests a linear relationship between grade and CO_2 concentration.

The mean grade of Elliott's White Sim by months is plotted in figure 1. While there were differences in grade between 600 and 1200 ppm during January and February, mean grade was the same in these two levels from late February to June. Mean grade of

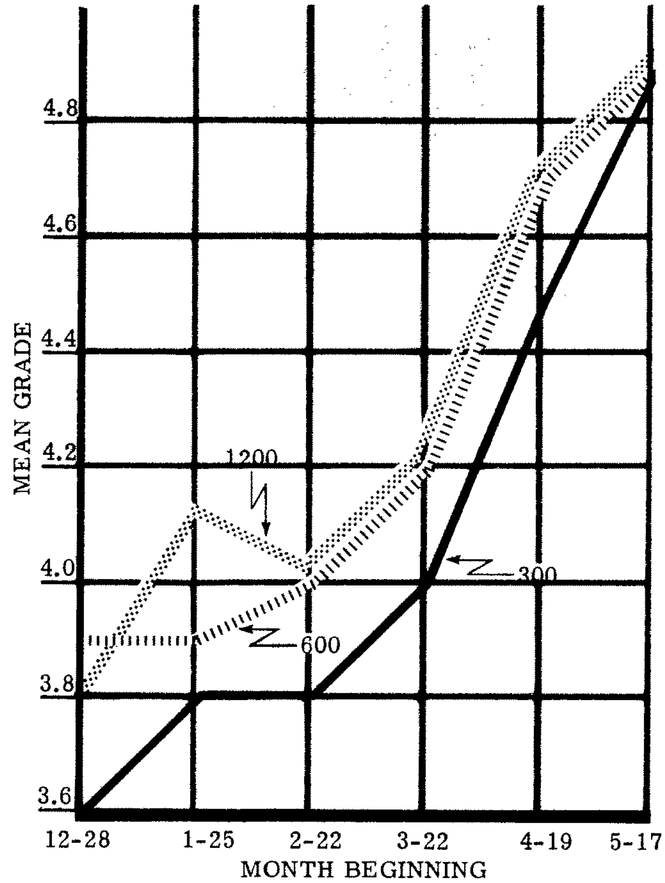

Figure 1: Monthly mean grade of Elliott's White Sim flowers produced in three concentrations of CO_2.

flowers produced in 300 ppm CO_2, was significantly lower until the period beginning May 17.

Measurements made on the flowers from the variety Elliott's White Sim further corroborate this relationship. Table 3 indicates that average weight and average number of leaf pairs increased with CO_2 concentrations up to 1200 ppm.

Table 3. Physical measurements of flowers and stems cut at the origin for Elliott's White Sim from May 15, 1965 to May 31, 1965.

	No. stems	Ave. weight	Ave. length	Ave. no. leaf pairs
1200 ppm	52	52.1	3' 10"	18.1
600 ppm	66	48.1	4' 0"	17.0
300 ppm	77	41.8	3' 3"	16.3

Figure 2 illustrates the effect of CO_2 concentration on the timing of crops. An extremely fast second crop followed by a period of low production occurred under 1200 ppm of CO_2. This fast second crop occurred on Elliott's White Sim and not on Pink Coquette; therefore, the response appears to be varietal. The control and 600 ppm produced more typical production curves. The response of young growth, such as laterals, to higher CO_2 is not known but appears to be very favorable at 1200 ppm. Normally this crop should return in April or May from 2-4 inch shoots. In this experiment, it returned in February, some 2 months earlier than expected. In order to return 2 months early, the shoots would have to be 4 inches longer than normal at the time first crop is cut or the growth responses of these shoots is great. The work is being repeated as this timing response may not be typical.

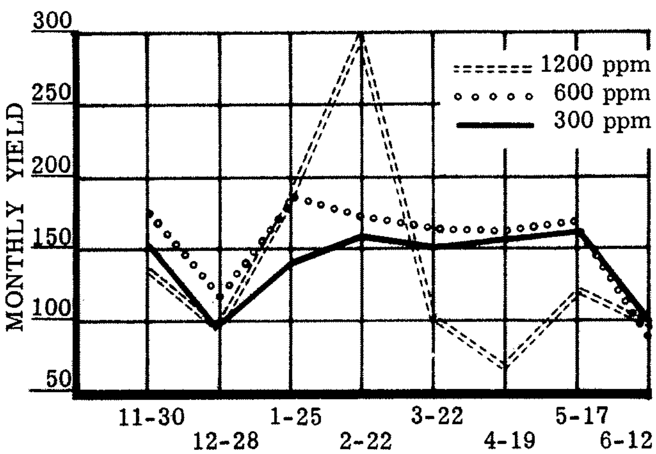

Figure 2. Total production in number of flowers for Elliot's White under the three levels of CO_2 from November 30, 1964 to June 12, 1965.

Plants of all varieties receiving 1200 ppm appeared "hardened" or checked during March and early April. This time corresponded to the low period of production (Fig. 2). Tissue samples from the three CO_2 treatments were sent to The Pennsylvania State University laboratory to eliminate hunger as a cause of this hardening. All nutrients, major and trace minerals, were adequate in these samples and not different due to CO_2 level. Other possible causes of hardening were lack of water and possible toxic gases from the natural gas burner. Close examination showed slight hardening in the 600 ppm level and more severe hardening in 1200 ppm. The problem cleared up by late April. Close observation will be made for the appearance of this problem during the current growing season.

Summary

An experiment designed to compare yield and quality of carnations under three levels of CO_2 was executed. Three small greenhouses were used; and CO_2 levels were set at 1200 ppm, 600 ppm, and atmospheric (300 ppm). Records of yield and quality from July, 1964 to June, 1965 reveal the following effects:

a. 1200 ppm increased yield 4 per cent compared to 300 ppm, while 600 ppm increased yield 12 per cent over 300 ppm.

b. Mean grade of first-year plants was significantly increased by 1200 ppm compared to 300 ppm. Differences in mean grade between 1200 ppm and 600 ppm, or 600 ppm and 300 ppm were not significant.

c. 1200 ppm CO_2 accelerated the second crop on Elliott's White Sim by 2 months when compared to 600 ppm or the control.

Literature Cited

1. Goldsberry, K. L. 1961. Effects of carbon dioxide on carnation growth. Colorado Flower Growers Association Bulletin 174.

2. Holley, W. D., K. L. Goldsberry, and C. Juengling. 1964. Effects of CO_2 concentration and temperature on carnations. Colorado Flower Growers Association Bulletin 174.

Acknowledgements

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Effects of CO2 on Poinsettia

BY K. L. GOLDSBERRY

CO_2 fertilization affects plant species and varieties within species in different ways. The effects of three CO_2 concentrations on poinsettia were observed at Colorado State University during the 1964 poinsettia season.

Poinsettia plants variety Barbara Ecke Supreme were propagated under mist in 2-1/4 inch pots by Park Floral Company, Englewood, Colorado, on September 16, 1964. The cuttings were "watered in" with an 8 oz/50 gal Dexon-Terraclor solution and no supplementary light was given. After rooting they were fed 20-19-19 every 5 days at the rate of 2-1/2 oz/2 gal of water. On October 22, 3 rooted plants were panned per 6-inch clay pot, and 20 pots placed in each of three growing compartments. The compartments, described by the author (1), were controlled at 60-62F night, and 70-75F day temperatures. Plants were watered on demand with the standard nutrient solution used at Colorado State University (2).

Three CO_2 levels were established as follows: Treatment 1, low level had no CO_2 added. Treatments 2 and 3, the medium and high levels averaged 492 and 831 ppm respectively. The CO_2 was added during daylight hours from liquid CO_2.

Results

Bract coloring: Most plants grown in the high CO_2 treatment showed slight coloration of the bracts by November 6. The medium and check treatments had no color change at this time. On November 11 (20 days after planting) every plant in the high CO_2 treatment was showing good color, while progressively less color was present in the medium and low levels. Bract development was delayed in part of the check treatment due to light seepage from another experiment. Only the plants that did not appear affected were considered in the results. Figure 1 shows the bract development of the three treatments on December 8, 47 days after panning.

Foliage development: The condition of the foliage in all treatments was similar the first 20 days of growth. After this time foliage in the high CO_2 level gradually developed a lighter green color between the veins. Plants in the medium and check treatments appeared normal. Nine days later, November 27, the foliage of the high treatment showed critical chlorosis, while plants receiving medium CO_2 showed interveinal yellowing. The foliage color in the check treatment continued good. At this time 1/2 tsp/pot of a complete, low analysis fertilizer was fed to plants in the two higher CO_2 levels. Further development of chlorosis was stopped, but the foliage of plants in the high CO_2 level caused them to be unsalable. The leaves at the top of Figure 1 indicate typical appearance on December 8.

Flower development: Flower buds developed first in the high CO_2 level and were all visible by November 11. No buds were showing at this time in the other treatments. Table 1 shows the number of full nectar cups and the dates they were observed. Most of the plants in the high CO_2 level were past maturity on December 16, the bracts having reached the salable stage December 1.

Date	Mean CO_2 concentration in ppm		
	317	492	831
November 27	0	0	5
December 3	0	3	11
December 8	0	12	35
December 12	2	41	93
December 16	13	124	243
December 21	49	204	---

Table 1. Dates and numbers of full nectar cups on poinsettia, Barbara Ecke Supreme, grown in three CO_2 concentrations.

Bract size: The average diameter of bracts was variable before maturity (Figure 1). As the plants matured, bract sizes in the two higher CO_2 levels were nearly equal, while those in the check treatment were slightly smaller (Table 2).

	Mean CO_2 concentration in ppm		
	317	492	831
Ave. plant height at maturity in inches	---	14.6	12.5
Ave. bract diameter at maturity in inches	12.0	13.5	13.5

Table 2. Effects of CO_2 on poinsettia height and bract diameter.

Conclusions

Increasing the CO_2 concentration of the greenhouse atmosphere during daylight hours from 317 ppm to an average of 831 ppm:

1. Accelerated poinsettia growth and maturity by almost two weeks;
2. Increased nutrient requirements to a degree that damaged the salability of the crop, when fed normal rates;
3. Increased bract diameter slightly; and
4. Decreased plant height slightly at maturity.

Literature Cited

1. Goldsberry, D. L. 1961. Effects of CO_2 on carnations. Colorado Flower Growers Association Bulletin 138.
2. Holley, W. D. 1958. Feeding greenhouse plants. Colorado Flower Growers Association Bulletin 97.

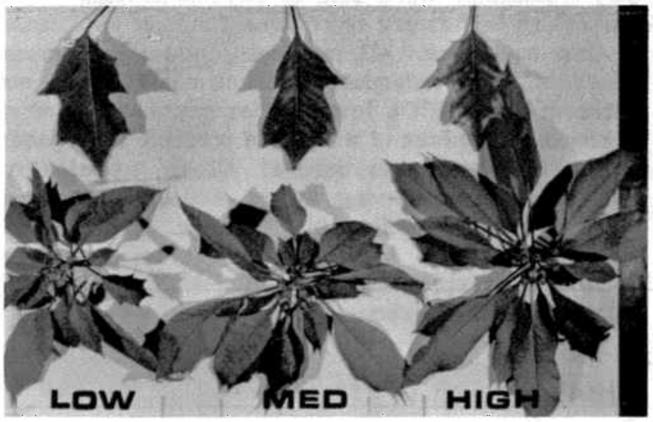

Fig. 1. Leaf, flower and bract development of poinsettia grown in 3 CO_2 concentrations on December 8, 47 days after panning.

your editor
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