

IN COOPERATION WITH COLORADO STATE UNIVERSITY
Richard Kingman, Executive Director
2785 N. Spear Blvd., Suite 230, Denver, Colorado 80211

Bulletin 279

August 1973

Ventilation Temperatures, CO₂ Levels, and Rose Production

JOE J. HANAN

CO₂ levels above 1500 ppm, combined with ventilation temperatures of 84° F or higher, during the heating season in Colorado, will increase rose production 16 to 20%. Love Affair, Cara Mia, and Forever Yours will respond to such treatment, but Love Affair reacts more vigorously. Higher temperatures and CO₂ levels will reduce average stem length and weight. However, the yield increase more than offsets the slight reduction in stem length. Combining average length, weight, and yield into a "Quality Index" will show higher quality for cut roses produced in 1500 ppm CO₂ levels and where first stage cooling is set to 84° F. Forever Yours will outproduce Love Affair more than 40%, with Cara Mia between the two.

In a preliminary report, Mathis (CFG A Bul. 270) showed that ventilation temperatures starting at 84° F, during the summer will cause a large number of unsalable flowers, although total yield may be increased nearly 50%. It appears that cooling temperatures of 78 to 84° F, combined with mist and elevated CO₂ levels will not affect roses adversely if time at these elevated temperatures is short. But, if such temperatures are maintained for the greater part of the day, the concomitant reduction in weight and stem length can cause excessively poor quality.

Methods

The treatments were identical to those employed by Mathis, except that the CO₂ levels were increased. Briefly, the varieties Love Affair and Forever Yours were planted in the ground in 4 individual, 16 x 18-

foot fiberglass houses May 25, 1972, 24 bushes of each variety per house. Two rows of Cara Mia across the ends of each bench served as buffers. A high pressure mist system maintained relative humidity above 70%. CO₂ was injected from sunset. Nutrients were injected into the watering line, with irrigation frequency adjusted by a combination of observation, watering records, and tensiometers. Generally, soil moisture suction was not allowed to exceed 30 as indicated by the tensiometers.

Following Mathis' preliminary work during the 1972 summer, ventilation temperatures were adjusted downward on Sept. 25, 1972, with first stage cooling starting at 76° F in all houses. On Oct. 31, 1972, the treatments were set up as outlined in Table 1. Air temperature at the thermostat was recorded continuously in each house. CO₂ levels were monitored for one or two 10-minute periods daily between 10:00 a.m. and 2:00 p.m. Roses were cut daily and the length and weight of each cut flower measured.

Results

The reported data are divided into two periods. From Oct. 31 to Jan. 3, 1973, total first stage cooling time at the low temperatures was less than one hour. Data on the basis of differences in CO₂ levels is presented for this period. From the middle of January, cooling fan time gradually increased (Figure 1). From Jan. 28 to termination on June 2, 1973, data are reported on the basis of ventilation temperature and CO₂ level. Figure 1 shows, however, that total ventilation time was still less than a fourth of the maximum daylight

hours. It is possible that the treatments could have continued into June before quality reduction began to reach unacceptable levels.

Table 1: Experimental Conditions:
 Night temperature all houses: 62° F
 Base day temperature all houses: 72° F

Treatment	Ventilation temperature (°F)		CO ₂ level (ppm)
	First Stage	Second Stage	
Lo Temp Lo CO ₂	78	82	500-800
Hi Temp Lo CO ₂	84	88	500-800
Lo Temp Hi CO ₂	78	82	1500-2000
Hi Temp Hi CO ₂	84	88	1500-2000

Oct. 31, 1972 to Jan. 14, 1973

Table 2 presents the stem length distribution and total yields as a function of variety and CO₂ level. In general, Love Affair produced fewer flowers with poor quality. There was a slight shift toward shorter stems for both varieties at the high CO₂ level. But, the increase in yield at high CO₂ concentration more than offset the slight decrease in weight and length. Roses grown at 1500 to 2000 ppm CO₂ produced 16% more flowers during this period than roses grown at 500 to 800 ppm. Although Love Affair, on the average, produced about 45% fewer flowers in all treatments, it responded slightly more to increasing CO₂ (21% increase versus 14% for Forever Yours).

Jan. 28, 1973 to June 2, 1973

The results for this 18-week period are set out in Table 3 and Figures 2 and 3. Either a high ventilation

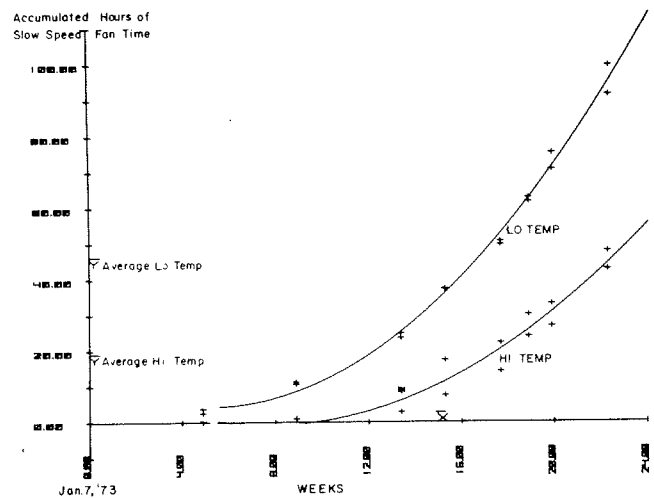


Figure 1: Accumulated hours of first stage exhaust fan time, beginning Jan. 7, 1973.

temperature, high CO₂, or combination of the two resulted in higher yields. The combination of 84° F first stage cooling and 1500 to 2000 ppm CO₂ increased total yield for this period 33% over the 78° F and 500-800 ppm treatment. The high percentages of stems 27 inches and over resulted from cutting stems to the break or below to prevent flowers from growing into the roof. This procedure did not appear to greatly affect yield or time to flower. This "non-effect" has been suggested by Goldsberry (unpublished data).

Higher temperatures caused a reduction in mean stem length and weight, which, in the case of Forever Yours, was compensated by the increase in CO₂ level (Figure 2). The decrease was relatively slight, and computation of a "Quality Index" (Figure 3) showed that the yield increase as a result of high CO₂ and longer CO₂ injection periods more than offset any decrease in stem length and weight. There was some indication toward the end of May that quality of Love

Table 2: Effect of two CO₂ levels on stem length distribution and total yield of Forever Yours and Love Affair roses for a 12-week period beginning Oct. 31, 1972.¹

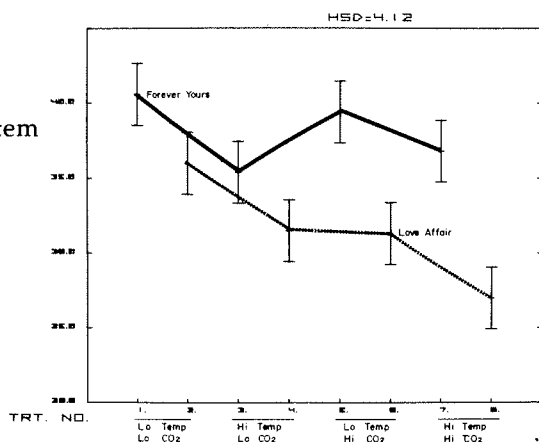
CO ₂	Variety	Percent stem length distribution								Yield (total)	Yield per plant
		9"	9-12	12-15	15-18	18-21	21-24	24-27	27"		
High ²	Forever Yours	— ³	—	3	9	21	27	23	16	792	16.5
	Love Affair	2	1	7	14	23	21	20	17	556	11.6
	Mean	1	—	5	11	22	25	22	14	1348	14.0
Low	Forever Yours	—	—	1	6	16	25	27	23	693	14.4
	Love Affair	—	2	5	11	23	17	26	17	466	9.7
	Mean	—	—	3	8	19	22	26	21	1159	12.1

¹48 plants per variety.

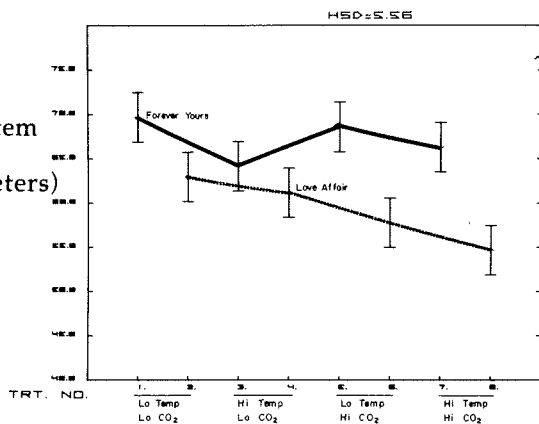
²"High CO₂," ranging from 1500 to 2500 ppm; "Low CO₂," ranging from 500 to 800 ppm with exhaust fans off, from sunrise to sunset.

³Less than 1%.

Upper
Mean stem weight (grams)



Middle
Mean stem length (centimeters)



Lower
Mean weekly yield per treatment

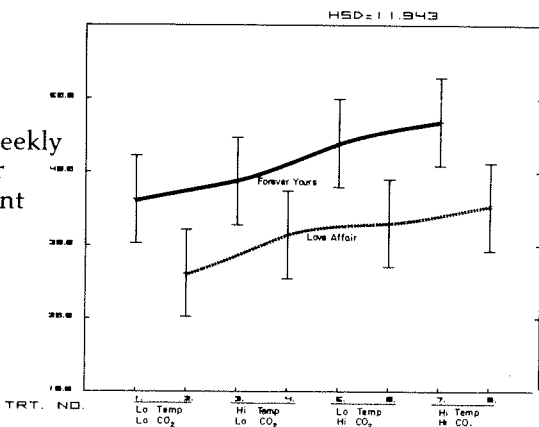


Figure 2: Summary of effects of CO₂ levels and ventilation temperatures on Forever Yours and Love Affair roses produced between Jan. 28, 1973, and June 2, 1973. "Lo CO₂" levels 500-800 ppm; "Hi CO₂" levels 1500-2000 ppm; "Lo Temp" first stage ventilation at 78° F; "Hi Temp" first stage ventilation at 84° F. Vertical bars through each point are limits for a 95% confidence interval. That is, where the bars of two points being compared do not overlap, there is a 95% probability that the differences are real.

Affair was beginning to suffer. The 9-inch, or less, stem lengths were 14% of the total flowers cut as contrasted to 4% for Forever Yours in the same treatment (Table 3). Similarly, as in the first 12-week period, Love Affair showed a greater response to treatment (37% yield difference between treatment extremes versus 30% for Forever Yours). However, Love Affair produced 25% fewer cut roses on the average.

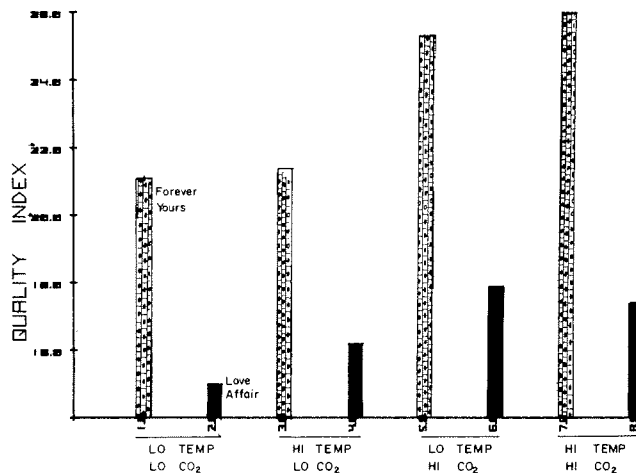


Figure 3: Mean Quality Index of Forever Yours and Love Affair roses subjected to different CO₂ levels and ventilation temperatures.

$$Q.I. = \text{Mean stem Weight} \times \text{Yield}$$

Oct. 28, 1972 to June 2, 1973

Figures 4 and 5 compare treatments for both reporting periods. Figure 5 shows that roses subjected to 1500-2000 ppm CO₂ increased the number of cut flowers produced on the average of 138 per week, whereas those plants subjected to 500-800 ppm increased total production at the rate of 118 flowers per week (96 plants). That is, one may expect, on the average, a 17% increase in total flowers produced each week when roses are subjected to 1500-2000 ppm CO₂. Figure 5 is a smoothed curve of total weekly production for Forever Yours in the treatment extremes. A number of points may be emphasized: 1) During the experimental period there were 5 peaks of production for the "hi temp-hi CO₂" treatment as compared to 4 for the "lo temp-lo CO₂" treatment. 2) The peak production and number of flowers during off-crop production steadily increased throughout the experimental period (30 weeks) in the "hi temp-hi CO₂" as compared to the "lo temp-lo CO₂" treatment. 3) The time to return from peak production to the next peak for Forever Yours at "hi temp-hi CO₂" was usually one week quicker than Forever Yours in the "lo temp-lo CO₂" treatment. Similar plots of Love

Table 3: Effect of CO₂ level and ventilation temperature setting on stem length distribution and total yield of Forever Yours and Love Affair roses for 19-week period beginning January 28, 1973.¹

Treatment	Variety	Percent stem length distribution								Yield (total)	Yield per plant
		9"	9-12	12-15	15-18	18-21	21-24	24-27	27		
Lo Temp	Forever Yours	— ²	2	3	4	7	11	16	55	641	26.0
Lo CO ₂	Love Affair	5	6	5	4	10	11	14	45	471	19.6
	Mean	3	4	4	4	8	11	15	51	1112	23.2
Hi Temp	Forever Yours	3	4	6	6	9	9	11	51	698	29.1
Lo CO ₂	Love Affair	6	8	6	5	6	11	14	44	567	23.6
	Mean	4	6	6	5	8	10	12	48	1265	26.4
Lo Temp	Forever Yours	2	4	5	5	9	7	12	57	792	33.0
Hi CO ₂	Love Affair	8	9	7	6	10	9	11	40	591	24.6
	Mean	4	6	5	5	9	8	12	50	1383	28.8
Hi Temp	Forever Yours	4	4	6	4	6	9	12	54	835	34.8
Hi CO ₂	Love Affair	14	14	9	5	6	7	11	33	645	26.9
	Mean	8	8	7	4	6	8	12	45	1480	28.8

¹"Lo Temp," ventilation started at 78°F; "Hi Temp," ventilation started at 84°F; "Lo CO₂," concentration ranging from 500 to 800 ppm with no ventilation; "Hi CO₂," concentration ranging from 1500 to 2500 ppm with no ventilation.

²Indicates less than 1%.

Affair did not show the regular progression of production peaks, although yield gradually increased toward the end of the experimental period.

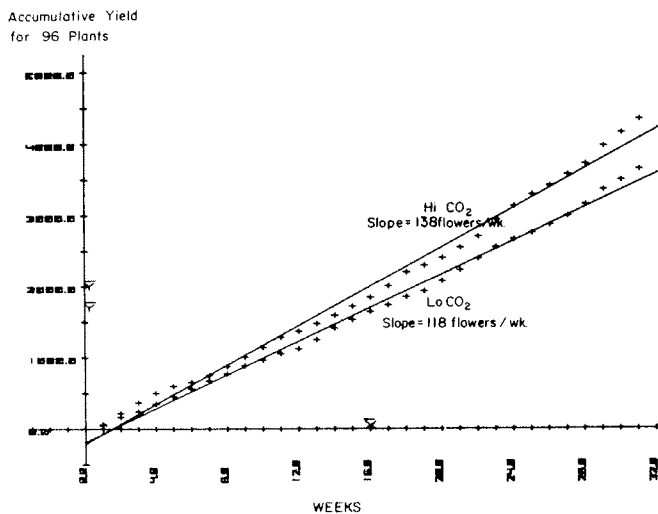


Figure 4: Weekly accumulated yield of Forever Yours and Love Affair roses subjected to CO₂ levels of 500-800 ppm and 1500-2000 ppm. The number for each slope shows the rate at which flowers were being produced each week (96 plants per treatment).

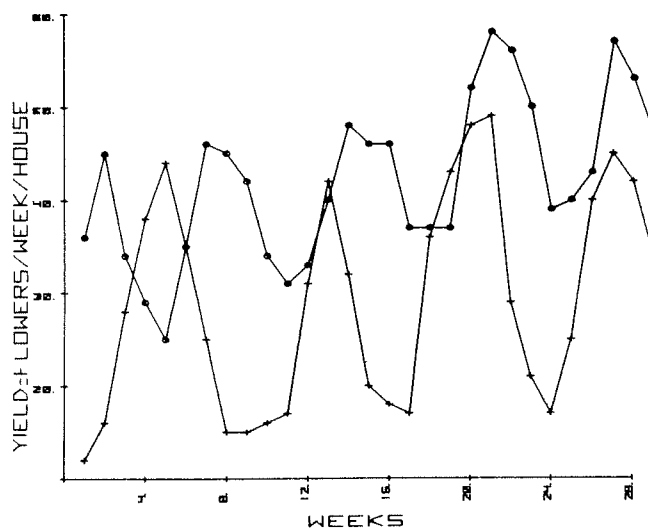


Figure 5: Smoothed weekly production of Forever Yours roses subjected to 1500-2000 ppm CO₂ and first stage ventilation at 84° F (circles); and the same variety subjected to 500-800 ppm and first stage ventilation at 78° F (crosses). Experiment beginning Oct. 31, 1972, and terminated June 2, 1973.

Summary

Increasing the temperature at which cooling begins allows roses to be subjected to high CO₂ levels for a longer period. If we assume that the 1972-73 heating season is representative for Colorado, then a first stage cooling setting of 84° F is acceptable. We estimate that total weekly, first stage cooling time should be less than 6 hours. When it begins to exceed this amount, there is increasing probability that temperatures may remain high enough and exhaust fans run long enough, to significantly reduce CO₂ levels and reduce quality. The cooling temperatures should then be adjusted downward to below 78° F for the first stage. One may characterize the best rose environment as one in which people are uncomfortable. High temperatures and high CO₂ levels should be accompanied by high relative humidity levels.

Index of Colorado Flower Growers Association Bulletins 230 to 279

- Air inflated roof 276
- Air pollution 243,252,262,264
- Argentina, floriculture 231
- Benlate 260,271,272,273,274,275
- Boiler selection 247
- Boron, excess in rose 235
- Branching-cytokinins 259
- Brazil, floriculture 237
- Breeding, carnations 242,243,261,278
- Burners, open flame 247,262
- Calcium-boron nutrition 259
- Calcium carbonate testing 240
- Carnation
 - Breeding 242,278
 - Bud cutting 232
 - Ca-B nutrition 259
 - Clonal comparisons 242
 - Cyclic lighting on 265
 - Disbudding studies 272
 - Ethylene effects on growth 277
 - Floral initiation 255
 - Fusarium stem rot 252,271,272,273,274,275
 - Fusarium wilt resistance 232
 - Gibberellins in 232
 - Growth and development 239,249,261,277,278
 - Inert substrates 240,256
 - Light and temperature 232
 - Lighting 257,265
 - Littleleaf necrosis 259
 - Miniatures 269,278
 - Micronutrition 258
 - Mutation frequency 268
 - Mutation, induced 241
 - Nematode control on 260
 - Nitrogen sources 253
 - Nutrition 248,249,250,251,259,261
 - Phialophora wilt 260
 - Planting density 277,278
 - Salinity effects 251,253,254
 - Seed production on 243,261
 - Single crop production 251
 - Spacing 277
 - Stomates, glass and FRP 233
 - Summer quality 276
 - Temperature effects 240,254,255,267
 - Timing 234
 - Tissue, nutrient content 261
 - Watering frequency 234,250
 - Water loss
 - under glass 233
 - under fiberglass 236
- Chile, floriculture 231
- Chrysanthemum
 - bud cut 232
 - fast crop 246
- CO₂ production from natural gas 262
- Colombia, floriculture 230
- Computer use in floriculture 244
- Condensation in greenhouses 244
- Cut flower life
 - carnation 239,255,263
 - ethylene effects on 263,267,276
 - gypsophila 277
 - rose, growth regulators on 266
- Dexon on Easter lily 247
- Easter lily 247
- Ecuador, floriculture 230
- Ethylene 262,263,264,267,276,278
- Ethylene measurements, Denver 264
- Ethylene on carnation growth 277
- Ethylene-temperature on cut flower life 263,276
- Europe, cut flower production 242,246
- Flammability of FRP 242
- Flue gas injury 262
- Foliage plants 246
- Fungicides, systemic 260,271,272,273,274,275
- Fusarium stem rot 271,272,273,274,275
 - biological control 252
- Fusarium wilt
 - control 260
 - resistance 232
- Gas heater check list 247,262
- Geranium, field tests 270
- Greenhouse
 - cooling 238,255,276
 - coverings
 - glass 233,235
 - fiberglass 233,235,236,242,244
 - temperature observations 255
- Gypsophila 277
- Imports 231,250,271
- Inert substrates 234,240,256

- Irrigation 232,234,250
 - water, calcium carbonate 240
 - systems 232,245
- Israel, floriculture 241
 - carnation growing in 241
- Kingman 234
- Leaf roller, roses 239
- Light energy 235,239
- Marketing 231
- Mediterranean horticulture 242,261
- Mertect 260,271,272,273,274
- Methyl bromide fumigation 269
- Micronutrition, carnation 258
- Miniature carnations 269,278
- Mutation frequency 268
- Mutation, induced 241
- Natural gas source of CO₂ 262,269
- Nematodes
 - carnation 260
 - roses 239
- Nitrogen, sources, carnations 253
- Nutrition, carnation 248,249,250,251,258,261
- Nutrient content, carnation leaves 261
- Paraquat 231
- Peru, floriculture 237
- Phialophora wilt control 260
- Photoperiodism
 - carnation 232,257,265
- Photosynthesis and stress 260
- Plant by-products 269
- Plastics, cellular 236
- Plastic structures 236
 - inflated roof 276
- Pollination of carnation 243
- Poinsettia 246
- Production records, computer 244
- Radiation in greenhouses 239
- Relative humidity 238
- Roses 246, 279
 - Boron excess 235
- Cut flower life 266
- Inert substrates 256
- Omnivorous leaf roller 239
- Powdery mildew 252
- Pruning and development 273
- Temperatures 270, 279
- Tight bud opening 234
- Salinity, carnation 251,253,254
- Seasonal growth rates 278
- Seed production, carnation 243,261
- Snapdragon 246
- Soil warming 269
- Sound, effects on plants 267
- South African floriculture 246
- South American floriculture 230,231,237
- Stomates, carnation 233
- Systemic fungicides 260,271,272,273,274,275
- Temperature 238,240,254,255
 - carnation 267,276
 - rose 270
- Timing production 234,257
- Tissue analysis 258,261,267
- Tomatoes, quick crop 236
- Watering frequency 234,250
- Watering systems 232,245
- Water loss under glass 233
 - under fiberglass 236
- Water stress
 - carnation 233,254
 - on photosynthesis 260
- Width of carnation beds 277
- X-ray induced mutation 241

Your Editor,



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

FIRST CLASS