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Colorado Flower Growers Association, Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Six Year Evaluation Of Environment On Yield And Quality Of Greenhouse Roses[1]

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During the past decade few of the environmental factors required in growing greenhouse roses have been correlated in order to increase production and quality. Several investigators have indicated the importance of controlling the major factors including day and night temperatures, humidity, nutrients, CO_2, light and water. Maximum rose production can be achieved only when the control of these factors is correlated. A review of rose production records at Colorado State University for the past six years presents a case history which indicates the importance of a continuous program in the refinements of rose culture.

Methods And Materials

One glasshouse, 36' x 41', containing six concrete "V" bottom ground benches (35' x 3.5') has been used for rose studies during the past fifteen years. This evaluation deals with the cultural practices, production, and quality of four rose varieties: Golden Rapture, Gorgeous, Pink Delight, and Red Delight during the period September 1 through Mother's Day week (37 weeks) from 1958 through 1964.

Starting September 1, 1959, one or more cultural factors were adjusted or added each year. The 1958-1959 period was considered the base year, and all production periods thereafter are compared to it.

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Continuous Factors: The following practices were continued throughout the entire study:

1. Irrigation was scheduled according to season. From April 1 to October 1 the benches were watered every other day. The rest of the year watering was scheduled every third day.
2. An automatic fertilizer injecting system allowed the rose benches to be fed each time they were watered.
3. Continuous pruning methods have been used since the early part of 1958. This is considered to be one of the earlier cultural refinements.

	1958-59	1959-60	1960-61	1961-62	1962-63	1963-64
Temperature	Heat to 62° N 72° D Cool to 75-80° D	Same as previous period	Same as previous period	Heat to 62° N (or temp. varied more than time prior	Heat to 62° N 72° D Cool to [illegible] low spd fan 2nd fans off, top vents open	Heat to 62° N 72° D Cool to 62° low spd fan 65° high " " 90° all fans, far ends vents open
Carbon dioxide	No CO_2 added	Metering, dry ice, charcoal in tests, ing program. when vents were closed.	Metering, dry ice, when vents were closed.	Constant flow 8:00AM to 4:00PM except when vents were open more than 2°.	Irrespective to light intensity and during low fan operation, 1 hr. post sunup to 1 hr. before sundown.	Irrespective to light intensity, none during vent. periods. Same injection time as last yr.
Cycle of injection	one	27 Between Jan 27, 1960 and Mar 29, 1960	110 Between Nov 6, 1960 and May 23, 1960	198 Sept.19, 1961 to Apr 30, 1962	177 Oct 10, 1962 to Apr 29, 1963	261 Sept 3, 1963 to May 17, 1964
Ind of CO_2 added per 1000 cu ft	none	45.8	155.0	526.5	499.2	1'26.5

Table 1. Factors related to the environment of greenhouse roses at Colorado State University from 1958-1964.

Adjusted Factors: Table 1 summarizes the environmental conditions as they were developed from year to year.

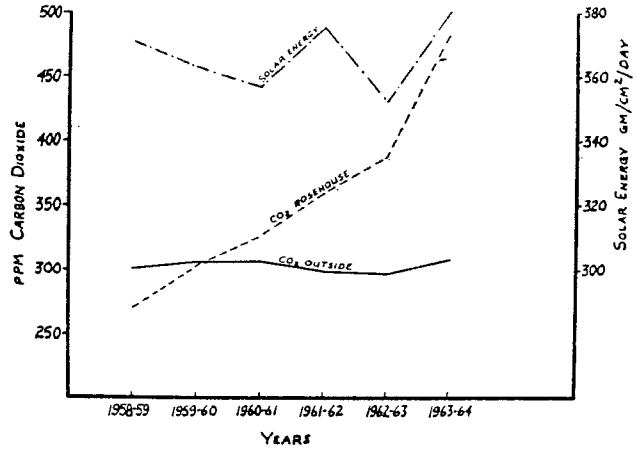

Fig. 1. Mean CO_2 concentrations and solar energy levels observed each year during the 37-week evaluation period from 1958 to 1964.

Light: The total solar energy received by the plants varied from year to year as a result of natural meterological influences, type of greenhouse covering and its degree of cleanliness. The total amount of solar energy received in Fort Collins, Colorado was similar each year. The maximum difference in mean solar energy during production years was 28 g cal/ cm^2 (fig. 1).

Temperatures: Night temperatures were maintained at 62F during the heating season. During the summer the night temperature was similar to that outside. A minimum of 72F was maintained as winter day temperature. The greenhouse was manually cooled by ventilators to a temperature of 75-80F through the first four years of evaluation. During the last two years winter cooling was accomplished by using an Acme 42'', 2-speed exhaust fan, plastic convection tubes and a mist-box system. The mist box consisted of a direct driven wire drum that skimmed the water reservoir and threw a fine mist over an evaporative pad. Air entered the plastic tubes through the evaporative pads. Fan cooling was utilized from approximately September 1 through mid-May. The fan system was turned off and top ventilation employed during the rest of the year.

Carbon dioxide: The CO_2 concentration was monitored with a Beckman infrared gas analyzer. Table 1 shows the amount, method, and times of CO_2 injection. During the last two years, the injection rate was controlled by a light sensing unit manufactured by the Ventender Company. This method of control allowed the injection rate to be correlated with the amount of solar energy received at any time during the day. Carbon dioxide was injected at the following rates for the last two years:

	1962-63		1963-64	
Light level	Light ft-c	flow rate cu ft/hr[1]	Light ft-c	flow rate cu ft/hr[1]
Low	below 2200	2.24	below 1500	3.20
Normal	2200-4400	4.44	1500-3000	5.86
High	above 4400	6.16	above 3000	8.53
Fan Speed				
Low, any light level		9.00		none
High, any light level		none		none

[1]per 1000 sq. ft. of ground area

Humidity: A high pressure mist system was utilized to add humidity. The relative humidity during the first four years varied between 30 and 50 percent. Improved controls during the last two years maintained a minimum of 70 percent.

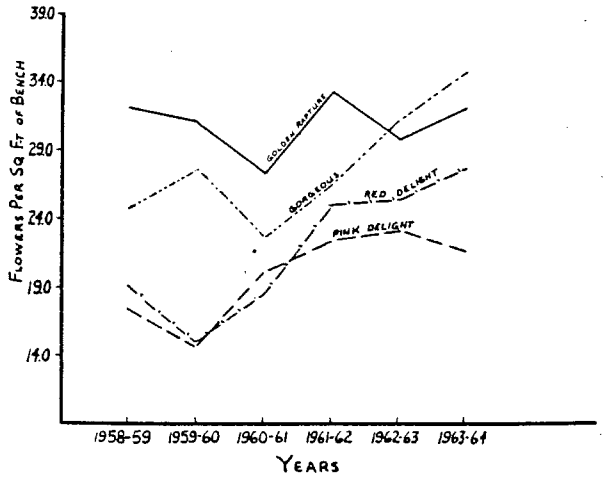

Fig. 2. Yield of four rose varieties from 1958-1964 (37 weeks/year)

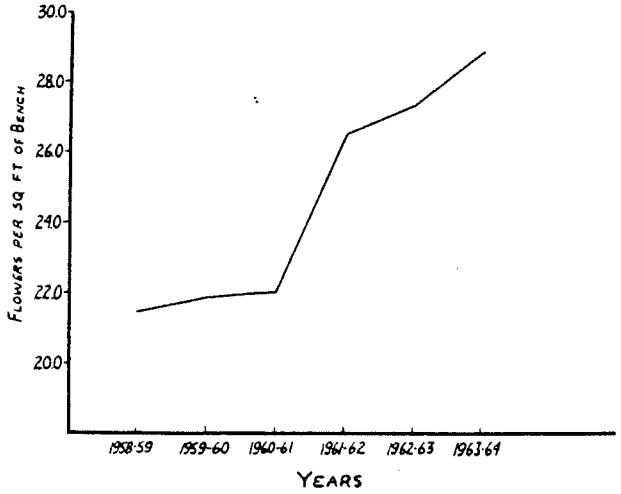

Fig. 3. The mean yield of rose varieties Gorgeous, Red Delight, Pink Delight, and Golden Rapture during a 37-week evaluation period each year from 1958 to 1964.

Plants: Due to the age of some varieties, benches were replanted to the same variety as follows:

Golden Rapture	Planted April 19, 1958
Gorgeous	Replanted May 29, 1961
Red Delight	Replanted July 13, 1959
Pink Delight	Replanted June 17, 1959

Results

Yield: The variety Golden Rapture produced the most flowers per square foot but showed no distinct trend (fig. 2). Gorgeous showed a definite trend from the time it was replanted and yielded the most flowers per square foot during the last two years. Pink Delight started out well in 1960-61 but leveled off the following year. Red Delight production was similar though less than Gorgeous. The average yield per square foot for the 37-week period over the last five years was: Golden Rapture, 30.8; Pink Delight, 20.4; Red Delight, 22.3; and Gorgeous, 28.5. The yearly mean production for the four varieties during the evaluation period is plotted in figure 3. The increase in mean yield during the last three years graphically approximates the increased CO_2 concentrations (fig. 1).

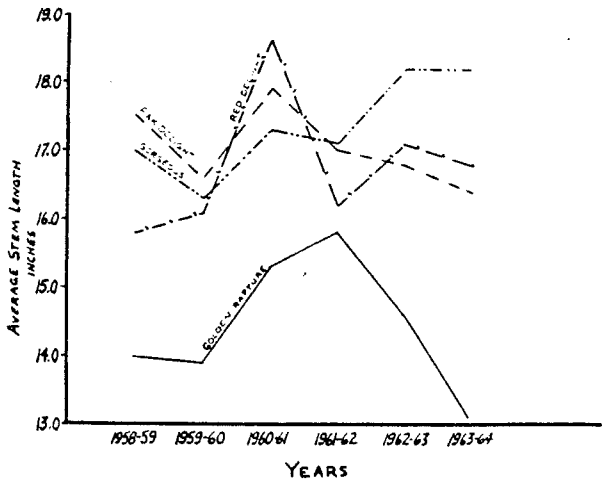

Fig. 4. The yearly average stem length of four rose varieties grown at Colorado State University (1958 to 1964).

Stem length: The variety Gorgeous showed an over-all increase in stem length from year to year after it was replanted in 1960. The stems of Golden Rapture were relatively weak and decreased in length during the last two years (fig. 4.) The stem length of Red and Pink Delight varieties was variable though somewhat shorter than Gorgeous. The mean stem length in inches for the last five years was: Golden Rapture, 14.5; Pink Delight, 16.9; Red Delight, 17.0; and Gorgeous, 17.4.

Carbon dioxide concentrations: Figure 1 shows the relationships of CO_2 levels inside the rosehouse and in the outside atmosphere to the solar energy received during the production periods throughout the six-year evaluation. The injection rate for the 1963-64 period maintained approximately 800 ppm carbon dioxide when ventilation was off during daylight hours. Ventilation requirements decreased the mean concentrations to 483ppm for the period of evaluation.

Ventilation: The use of fans and tubes during the last two years allowed the house to be automatically cooled from approximately September 1 to mid May or later. Temperatures could not be held within the desired cooling range when the daily outside temperatures approached 80°F and solar energy totaled approximately 500 g cal/cm^2 per day. The mist boxes generally precooled the air entering the tubes 15°, thus allowing the house to be cooled automatically for a greater period of time. Top ventilation and mist gave the best results for summer cooling since the fan, tube, and mist box combination could not maintain adequate temperatures during this period of high light and high temperature.

Temperatures: Higher day temperatures maintained the last two years did not affect yield adversely. The automatic controls were effective in maintaining temperatures in a desired range, with minimum temperatures variation nine months out of the year.

Discussion

The correlation of environmental factors for growing greenhouse roses is important to yield and quality. Improved methods of controlling temperature, humidity, and CO_2 are of primary importance. These factors can be controlled and maintained automatically during the fall, winter, and spring.

It is evident that rose varieties respond to cultural changes in different ways and may involve interactions. The decrease in stem length of Golden Rapture, Pink Delight, and Red Delight may be attributed to an interaction between high CO_2, high temperature, and/or age of plants. The response of the Gorgeous and Red Delight varieties to the environmental regimes was more desirable than that of Golden Rapture. Thus, the environment favorable to one variety may be unfavorable to another.

The response of rose varieties, old and new, to more accurately controlled and better balanced environments should lead to more profitable greenhouse rose culture.