Effects of Adjusting Night Temperatures on Growth of Greenhouse Roses*

James W. Boodley and John G. Seeley**

The practice of reducing night temperatures below those normally maintained as a means of improving flower growth has long been followed by commercial flower growers. This practice is based on the theory that on cloudy days the amount of carbohydrates and other food materials produced in the plants is lower than average because of reduced photosynthetic activity. Lowering the night temperatures reduces respiration resulting in a decreased utilization of the carbohydrates, proteins, etc. which should give an improvement in quality of growth.

The primary objective of this study was to determine what effect the reduction of night temperatures, to a reasonable and economic degree, would have on the rate of development and flower production of greenhouse roses.

A second objective was to determine what effect the treatment would have on the lasting quality of cut roses. The supply of carbohydrates in the flower at the time it is removed from the plant is considered to have an effect on lasting quality. If the adjustment of night temperature conserves carbohydrates there should be greater lasting life of the cut flower.

Many workers have investigated the effects of light on the growth of roses. Post (7) showed that high night temperature or low light intensity resulted in a decrease in reserve food and a reduction in color of flowers. Laurie and Kiplinger (6) found that on dull winter days a reduction in carbohydrates in roses may occur because the loss by respiration is greater than the gain by photosynthesis.

Research at Cornell (3) and Michigan State (4) showed that plants in outside rows of greenhouse bench produced more bottom breaks and more flowers than when planted in other less advantageous locations. The improved growth was attributed to better light conditions in these areas.

Most of the research on the keeping quality of horticultural crops has been with various methods of reducing respiration in storage. By reducing respiration, the utilization of carbohydrates, proteins, etc. would be lowered which in turn would prolong the life of the stored product.

*From Progress Report 218 of The Pennsylvania State University, College of Agriculture, Agricultural Experiment Station, University, Park, Pa., May 1960. Research of the 1953-54 season was supported by a Grant from Roses Inc..

**Assistant Professor and Professor of Floriculture respectively. Present address, Ithaca, New York.

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One of the easiest methods of reducing respiration is by lowering the temperature (5). An increase in temperature causes an increase in respiration; similarly a reduction in temperature has the opposite effect.

Siegelman (8) showed that respiration of cut roses stored at 59 degrees F proceeded at a rate about 3 times as great as those stored at 41 degrees F.

It is interesting to note that Alban and his co-workers (1) observed the effect of various cultural practices on the respiration rate of the harvested fruit of greenhouse tomatoes. Tomatoes were grown in three greenhouses at night temperatures of 57, 62 and 67 degrees F. Respiration rates for harvested fruit were lowest for those grown in 57, intermediate for those grown in 62 and highest for those grown in 67 degree night temperature houses.

These results suggest that roses grown under lowered night temperature would have a reduced respiration rate and subsequently the cut flowers would have a longer lasting life.

Experimental Procedure

1952-53 Season

Graft-budded, "started eye" rose plants of the varieties, Better Times, Golden Rapture, Peter's Briarcliff, and Lily White, donated by the Jackson and Perkins Co., were planted February 13, 1952, in experimental plots each consisting of 8 plants of each variety in 2 rows of 4 plants across a 4 foot bench. Seven replications of each variety were randomized throughout 3 benches in a 27 foot section of a greenhouse 32 feet in width. In this section night temperatures were adjusted according to the daily light intensity.

Seven replications of similar plots were randomized throughout 2 benches in an adjacent greenhouse section in which night temperatures were maintained at 60±2 F. degrees regardless of the preceding daily light intensity.

The roses were planted at a 12 by 12 inch spacing in a silt loam soil of medium texture and medium nutrient concentration in raised concrete benches. Standard greenhouse production methods of watering, pinching, tying, fertilizing, and spraying were followed. Flowers were cut each morning.

Heat and ventilation were thermostatically controlled to maintain the standard night temperature (SNT) section 60±2 degrees at night, 70 on cloudy days, and 75 degrees on clear days. Following a day that had been mostly cloudy or completely overcast, the adjusted night temperature (ANT) section was maintained at a temperature of 55±2 degrees at night, 70 on cloudy days, and 75 degrees on clear days. An adjustment in temperature was made if the sky had been cloudy for at least 50 percent of the day. Following a clear day, the temperature in the ANT section was maintained at the same 60±2 degrees night temperature as in the SNT section.

Outdoor weather conditions permitted controlled 55 degree night temperatures from November 3, 1952, to April 30, 1953, a total of 176 days. Of the 176 days, 84 cloudy days warranted reducing the night temperature in the ANT section to 55 degrees. The remaining 92 days were considered to be clear and the night temperatures were not reduced.

Three periods of flower production were considered in this season: October 1, 1952, to June 1, 1953, the total yearly production; November 5, 1952 to April 28, 1953, the period of temperature control; and December 24, 1952, to April 28, 1953. From December 24 to April 28 is the period when the roses produced had been subjected to controlled temperatures from shoot initiation through to cutting of the mature flowers. This is the most important period as far as actual temperature effect is concerned.

1953-54 Season[a]

In the 1953-54 season, temperature control was not achieved until November 6, 1953. The 3 periods of production were: October 7, 1953, to May 4, 1954; November 11, 1953 to March 30, 1954; and December 23, 1953 to March 30, 1954. Of the 140 days when temperatures could be controlled at night, 70 were cloudy enough to warrant reducing the night temperature to 55 degrees in the ANT section. The remaining 70 days were clear and the night temperature was held at 60 degrees F. In an attempt to check the effect that adjusted night temperatures would have on timing of a crop, the varieties Better Times and Golden Rapture were taged daily. Dated tags were placed on shoots when they were ¾ to 1 inch long, and at the time of cutting the flower, a second date was placed on the tag. When a new shoot on the same cane had grown to a length of ¾ to 1 inch, a third date was noted. The tags were dated for a fourth time and removed when the subsequent flower was cut. Over 1200 roses were thus tagged between October 1, 1953 and April 1, 1954.

During this season 1637 roses were used to determine the effect of the preharvest temperature treatment on the lasting life of the flowers. The cut flowers were hardened for 24 hours in a 35±2 degree refrigerator and then placed in a 70±5 degree room. Records were kept of the number of days the flowers lasted.

The flowers were considered to be dead when at least 50 per cent of the blooms exhibited petal fall when the stems were struck lightly. At this time Better Times flowers had developed a slight bluing of the petals. Golden Rapture showed some drying and crinkling of the margins of the oldest petals.

1954-55 Season

For the season 1954-55 night temperatures were again adjusted as in the two previous years. During this season the three periods of production considered were: September 29, 1954 to June 7, 1955; November 24, 1954 to April 12, 1955; and January 12, 1955 to April 12, 1955.

Temperature control was maintained from November 20, 1954 until April 13, 1955 a period of 143 days. Of this total, 77 days were cloudy and allowed adjustment of night temperatures to 55 degrees, and 66 days were clear.

1955-56 Season

In this season, the experimental procedure was changed. Instead of reducing night temperatures following cloudy days, the regular 60 degree night temperature was maintained in the ANT section. Following clear days, the night temperature in this section was increased to 65±2 degrees to see if this would speed up growth and

[a]The studies for this season were financed by a Roses Incorporated Research Assistantship to the senior author.

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flower production. Night temperatures in the SNT section were maintained at 60±2 degrees.

The three periods of production considered were October 4, 1955 to February 14, 1956; November 9, 1955 to February 14, 1956; and December 28, 1955 to February 14, 1956 when the experiment was discontinued.

During this season, temperature control was maintained from November 8, 1955 until February 14, 1956, a total of 101 days. Of this period, 62 days were cloudy enough to warrant maintaining the 60 degrees night temperature in the ANT section. There were 39 clear days following which the night temperature was increased to 65 degrees in the ANT section.

Results and Discussion

1952-53 Season

The data presented in table 1 show the total flower production per plot of eight plants, averages of seven replications of the varieties Better Times and Golden Rapture. Data on these two varieties only are presented since the response of the varieties Peter's Briarcliff and Lily White was similar to that of Better Times. From this table it may be seen that lowering night temperature following cloudy days resulted in a drastic reduction in production of Better Times. This amounted to 28% less flowers in the period November 5 to April 28 and approximately 33% less flowers produced in the period December 24 to April 28.

Although the variety Golden Rapture produced fewer flowers in the adjusted night temperature (ANT) section compared to the standard night temperature section (SNT) for the three periods, the differences were negligible. The total production of Golden Rapture was not as great as Better Times.

Table 1. Flower production of greenhouse roses per plot as influenced by night temperature treatments for three periods of production; averages of seven replications, eight plants per plot; 1952-53.

Treatment	*Better Times*	*Golden Rapture*
	October 1 to June 1	
SNT*	155.1	118.6
ANT	130.0	112.3
	November 5 to April 28	
SNT	100.1	68.8
ANT	71.7	62.0
	December 24 to April 28	
SNT	70.0	45.4
ANT	48.3	39.3

*SNT Standard night temperature
ANT Adjusted night temperature

1953-54 Season

During this season the response of the roses to adjusted night temperatures was similar to that during 1952-53. Better Times produced more flowers in the SNT section than the ANT section for the three periods of growth, table 2. The differences were not as great percentage wise for this season as for the first season of growth.

Golden Rapture plants again produced approximately the same number of flowers in both the SNT and ANT sections for all three periods of growth. The difference of one or two flowers indicates that reducing night temperatures had no great detrimental effect on the production of Golden Rapture.

Table 2. Flower production of greenhouse roses per plot as influenced by night temperature treatments for three periods of production; averages of seven replications, eight plants per plot; 1953-54.

Treatment	*Better Times*	*Golden Rapture*
	October 7 to May 4	
SNT*	144.0	106.6
ANT	126.4	108.4
	November 11 to March 30	
SNT	86.6	65.3
ANT	72.4	66.1
	December 23 to March 30	
SNT	59.3	44.6
ANT	48.3	42.9

*SNT Standard night temperature
ANT Adjusted night temperature

Effect on Flower Development

The effect of night temperature treatments on the time required for development of Better Times and Golden Rapture roses from flower to flower is shown in table 3. The average number of days required from flower to flower was consistently greater in the ANT section than when temperatures were 60° every night. In the ANT section the development of the Better Times flowers was delayed by four days for stems tagged in November, four days for stems tagged in December, seven days for stems tagged in January and two days for stems tagged in February. No difference in time was noted for stems tagged in March since these flowers were developing during the period when night temperature could no longer be adequately controlled.

Table 3. Number of days from flower to flower on same stem of Better Times and Golden Rapture roses as influenced by night temperature treatments, 1953-54.

Month of Tagging	Average Number of Days: Standard Night Temperature	Adjusted Night Temperature
	Better Times	
November	50.5	54.1
December	51.5	55.1
January	48.6	55.7
February	48.7	50.0
March	41.4	41.5
April	39.0	38.9
	Golden Rapture	
November	55.4	62.0
December	54.6	62.0
January	54.6	58.9
February	48.6	50.5
March	44.7	45.8
April	40.8	39.9

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Roses

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In the ANT section with Golden Rapture development was delayed by approximately six and one-half days for stems tagged in November, four days for stems tagged in December, four days for stems tagged in January, and two days and one day for stems tagged in February and March, respectively.

The difference between averages of the SNT section decreased as the period of observation approached spring. In April the night temperature could no longer be adjusted following cloudy weather because of warmer outdoor temperatures. The average number of days from flower to flower in both sections was almost equal as would be expected.

Effect on Keeping Quality of Cut Roses

Individual comparisons on how pre-harvest treatment, for example, five, four, three, two or one day of reduced night temperature prior to cutting, affected lasting quality are presented in the senior author's thesis (2). The data in table 4 show a total of 83 comparisons made when night temperatures prior to cutting were reduced to 55 degrees in the ANT section.

Table 4. Additional days greenhouse roses lasted as influenced by adjusted night temperature treatments, 1953-54.

Night Temperature Reduced to 55 Degrees Prior To Harvest in ANT Section			Night Temperature Maintained at 60 Degrees Prior To Harvest in ANT Section		
No. of Comparisons	SNT Sec.	ANT Sec.	No. of Comparisons	SNT Sec.	ANT Sec.
	days	*days*		*days*	*days*
49	No differences		40	No Differences	
16	+1	-	15	+1	-
6	+2	-	3	+2	-
1	+3	-	3	+3	-
9	-	+1	1	+4	-
1	-	+2	13	-	+1
1	-	+3	3	-	+2
			1	-	+3
83 Total			79 Total		

Expressed as percentages of the total number, the figures show that for 59 per cent of the comparisons there were no differences in the number of days the flowers lasted when grown in either section. For 27.8 per cent of the comparisons made, flowers from the SNT section lasted longer than did those from the ANT section. For 13.2 per cent of the comparisons, the flowers grown under the ANT conditions lasted longer than did those grown under the SNT conditions.

The data in table 4 also show the comparisons of lasting quality when night temperatures were not reduced in the ANT section, but maintained at 60 degrees following a clear day. A total of 79 comparisons of lasting quality were made. Expressed as percentages of the total number, the figures show that for 50.6 per cent of the comparisons there were no differences in the keeping quality of the flowers produced from either section. For 27.9 per cent of the comparisons, flowers from the SNT section kept longer than those from the ANT section. In 21.5 per cent of the comparisons made, the flowers grown under ANT conditions lasted longer than those grown under the SNT conditions.

These comparisons show that there was no consistent effect on lasting quality of the cut flowers whether the plants were grown under SNT or ANT conditions. Thus it cannot be concluded from these studies that reducing night temperatures to 55° after cloudy days will improve the keeping quality of the cut roses.

1954-55 Season:

As was noted in the two previous seasons, Better Times produced more flowers in the SNT than the ANT section, table 5. The difference for the period January 12 to April 12 although in favor of the SNT section was of a lesser magnitude than in either of the two previous seasons.

Table 5. Flower production of greenhouse roses per plot as influenced by night temperature treatments for three periods of production; averages of seven replications, eight plants per plot; 1954-55.

Treatment	*Better Times*	*Golden Rapture*
	September 29 to June 7	
SNT*	190.6	140.0
ANT	174.4	135.4
	November 24 to April 12	
SNT	81.9	51.0
ANT	64.7	46.4
	January 12 to April 12	
SNT	53.9	32.9
ANT	49.1	33.6

*SNT Standard night temperature
ANT Adjusted night temperature

The variety Golden Rapture was erratic in its response to the temperature treatment. For the overall period of September to June production was greater in the ANT section. For the period November to April production was greater in the SNT section. During the critical period of January to April there was essentially no difference in production in either the ANT or SNT section.

1955-56 Season:

During this season, temperatures in the ANT section were raised to 65 degrees following clear days, whereas in the previous three seasons the night temperature in this section was reduced to 55 degrees following cloudy days. This difference in treatments plus the termination of the study in February would conceivably cause a difference in the results expected. Examination of the data in table 6 shows a striking difference in the production of Golden Rapture. In the previous seasons, flower production of Golden Rapture was consistently below that of Better Times regardless of temperature treatments or production period. During 1955-56 Golden Rapture had production equal to or greater than Better Times in either temperature treatment for the three periods noted. This was unusual, since in previous seasons, Golden Rapture consistently produced fewer flowers than Better Times.

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Table 6. Flower production of greenhouse roses per plot as influenced by night temperature treatments for three periods of production; averages of seven replications, eight plants per plot; 1955-56.

Treatment	*Better Times*	*Golden Rapture*
	October 4 to February 14	
SNT*	112.1	112.2
ANT	98.4	104.4
	November 9 to February 14	
SNT	67.3	67.9
ANT	54.7	57.3
	December 28 to February 14	
SNT	31.7	32.0
ANT	24.7	26.4

*SNT Standard night temperature
ANT Adjusted night temperature

There are three possible reasons for this lack of difference in production. The first is that the experiment was ended approximately two months earlier in 1955-56 than in the three preceding seasons. This meant not as many flowers were cut as in the previous years. Production following February might have been much less on the average for Golden Rapture and so would have reduced the average production figures reported.

A second possibility is that Better Times had started a natural decline in productivity and Golden Rapture had not, but the figures in table 7 show that both Better Times and Golden Rapture had an increase in productivity for the 1955-56 season.

Table 7. Average production per plot per week of two varieties of greenhouse roses; two night temperature treatments combined for four season's growth; 1952-56.

Season	Variety	
	Better Times	Golden Rapture
1952-53	4.07	3.29
1953-54	4.50	3.58
1954-55	5.07	3.68
1955-56	5.54	5.25

The third possibility is that for reasons unknown, Golden Rapture produced more flowers during this season than in the preceding years. No other explanation can be offered for this occurrence.

Increasing night temperatures following clear days was not the reason since production in the section where temperatures were maintained at 60 degrees at night was greater than in the ANT section.

Summary

The rose varieties Better Times, Golden Rapture, Peter's Briarcliff, and Lily White were grown under standard and adjusted night temperature conditions for four seasons. During the first three seasons, night temperatures were reduced to 55 degrees Fahrenheit following cloudy days. In the fourth season night temperatures were increased to 65 degrees following clear days. A control section of the greenhouse was maintained at 60 degrees night temperature regardless of the previous daily light conditions.

In the three seasons during the period when night temperatures could be reduced to 55 degrees in the ANT section, approximately half of the days were considered cloudy enough to warrant a reduction to 55 degrees and the remainder were clear enough to maintain 60 degrees at night.

Reducing the night temperature to 55 degrees after cloudy days reduced the flower production and the rate of plant growth of Better Times, Peter's Briarcliff and Lily White but had negligible effects on Golden Rapture. The treatment resulted in no increase in keeping life of the flowers of any of the varieties tested.

Increasing the night temperature to 65 degrees after clear days did not improve the flower production over the standard night temperatures, but the results of this season cannot be considered as conclusive because the production period was short, running only from October 4 to February 14.

Since production in the SNT section was so much greater in the first season than production in the ANT section it might be concluded that subsequent improved production in the SNT section was an accumulative effect carried over from the preceding year's growth. This might have occurred had the plants been allowed to continue growth uninterrupted except for normal harvesting practices; however, the roses were cut-back to a height of 18 inches in June of each year.

Although the reduction of night temperatures to 55 degrees was not beneficial it must be remembered that six cloudy days was the longest consecutive period of cloudy weather that prevailed during the winter of 1953-54 at University Park, Pennsylvania. Since the growth process is not a simple start and stop function dependent on light only, the effects of one day's environment may be carried over for several days, and one adjustment in night temperature may not be enough to cause any differences to occur. Nevertheless, there is the possibility that during a prolonged period of cloudy weather for two or three or more weeks it may be beneficial to maintain night temperatures cooler than they are normally held.

Until further studies are made, and on the basis of these experiments, it appears desirable that standard night temperatures be maintained during fall, winter and spring regardless of the previous daily light intensity.

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