THESIS

INFLUENCE OF PRE-HARVEST LIGHT, TEMPERATURE, HUMIDITY AND SOIL MOISTURE ON CUT FLOWER LIFE OF CARNATIONS

Submitted by

Arvel H. Fairchild

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY Arvel H. Fairchild ENTITLED Influence of Pre-Harvest light, temperature, humidity and soil moisture on cut flower life of carnations. BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

[redacted] [redacted] [redacted]

Major Professor

Head of Department

Examination Satisfactory

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[redacted] [redacted]

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Chapter I

INTRODUCTION

The production of carnations forms a large part of the florist industry in Colorado. A major portion of these are shipped out of the area, much of it being in transit from 24 to 48 hours. Carnations with superior keeping quality must therefore be grown to enable the Colorado flower growers to hold their markets.

Customer complaints regarding poor keeping come in intermittently and cause much concern to the shippers. These complaints tend to group around certain unpredictable periods.

Long term 31°F. storage of cut flowers (56) has accentuated this problem, for it has been noted by wholesalers that certain lots of flowers store satisfactorily, while flowers from the same growers several weeks later do not store well.

Much research (1) has been done on the post-harvest physiology of cut flowers, but relatively little information is available on the effects of preharvest environment on cut flower life. A knowledge of the preharvest effects of light, temperature, and humidity on the keeping quality of cut carnations should help us predict the suitability of given carnation cuts for storage or distant shipping. That is, by observing the weather prior to a given day's harvest of cut flowers, a florist could decide their suitability for storage.

This study was designed to investigate the differences in carnation cut flower life as they normally occur from day to day and from week to week. An attempt is made to correlate the fluctuations of light, temperature, humidity, size of cut, and soil moisture with cut flower life.

Chapter II

REVIEW OF LITERATURE

It is generally thought that pre-harvest conditions of high light intensity along with cool temperatures are essential for long potential keeping life of carnations. Some work has been done to determine the effects of light and temperature on food accumulation in various plants, but very little has been published on how this affects the keeping of the floral or other parts of the plants. The literature will be reviewed in several sections dealing with the various aspects of cut flower keeping. Following a review of literature on stored food accumulation, other factors influencing cut flower keeping will be considered.

Stored food accumulation

Carefully controlled experiments of Matthaei (47) with the cherry laurel leaf showed that the rate of photosynthesis increased with an increase in temperature over a considerable range when atmospheric carbon dioxide was artificially increased. Under normal conditions, however, the low concentration of carbon dioxide was a limiting factor. Brown and Escombe (2) had pointed this out earlier.

Denny (11), in measuring dry weight changes in leaves of salvia during a sunny day in April, found that between 5:30 a.m. and 3:30 p.m., tip leaves increased 42 per cent in dry weight. Later Kiplinger (33) concluded from preliminary experiments that the rate of photosynthesis in leaves of flowering shoots of greenhouse roses was two to three times the rate in leaves of non-flowering shoots. Data were not presented. Kiplinger thought that leaves on non-flowering basal shoots carried on practically no photosynthesis, and the rate of synthesis was assumed to decrease with age of the leaf. Two thousand foot candles of light was considered optimum intensity for greenhouse roses.

In 1944 experiments were performed by Curtis (9, 10) in which the difference in food content of alfalfa was determined between morning and afternoon cuttings. He found that there was an average of 83 per cent higher carbohydrate content and 19 per cent higher dry matter yield from afternoon cuttings than from morning cuttings.

Howland (31), using the twin leaf method, measured the net changes in dry weight of rose leaves taken from budded shoots during the day and night at various times throughout the year. Varieties Peter's Briarcliff and Better Times were used, and translocation of carbohydrates from the test leaves was not prevented. He found that there was a grand average daily gain due to photosynthesis of 8.3 per cent for Peter's Briarcliff and 9.1 per cent for Better Times. The average, daily net gain for 24 hours was 3.9 per cent for both varieties.

The food supply in carnation cuttings, as pointed out by Odom (51), is affected by the average daily light intensity of one to several days preceding the test. The dry weight and soluble solids remained high and steady when the average light intensity was high, but were reduced by several cloudy days. During the day there was usually a build-up of the food supply, while at night this supply decreased.

In an experiment on the photosynthetic efficiency of three carnation varieties, Holley (22) found that temperature becomes increasingly important as the light intensity decreases. The amount of photosynthate produced at light intensities of 100 to 200 foot candles may be easily used up in respiration.

Knappenberger (36), in working with carnations, found significant negative correlations between total relative sugar content and light one day prior to harvest for a 30-day period beginning February 16, and for a 15-day period beginning June 7.

No correlation was obtained for a 29-day period beginning March 24. Knappenberger also obtained a highly significant negative correlation between sugar content and temperature one day preceding harvest for the June 7 period, but none for the other two periods. The sum of light and temperature for two and three days previous to cutting did not correlate with relative sugar content of cut carnations.

Light and temperature

Post and Howland (54) showed that the production of greenhouse roses was a direct function of light.

Mastalerz (41) found that reduced light intensity or an increase in growing temperature prior to harvest decreased the keeping life of chrysanthemums after being stored for varying lengths of time at 31°F. This effect is less striking during the winter months, and when the flowers were placed directly at room temperature with no storage there was no difference in keeping. He also found that the normal life at room temperature of pompon chrysanthemums was shorter during the winter months than in the months of higher light intensities. Another article (46) by Mastalerz points out that flowers grown under high light intensities and relatively low temperatures should have the longest life.

In 1955 Knappenberger (36) compared the total relative sugar content of Sim carnations each day with their mean keeping life. He obtained highly significant correlation coefficients for two different periods, but in another period the results were inconclusive because of a faulty thermostat in the keeping room. Correlations between light and temperature were highly significant.

Post (55) made the following observations:
"Calendulas have weak stems and poor keeping qualities during periods of low light intensities. It is doubtful if this condition could be corrected by keeping the soil dry and low in nitrates without seriously reducing the stem length and flower size. Calendulas are also improved by reducing the night temperature. An increased leaf area and succulency of stems may cause wilting, as evidenced by clarkia or baby's breath grown with high moisture along with unfavorable conditions for flowering (short days and low temperature)."

Schmidt (59) grew carnations at night temperatures of 48, 50, 52, and 54°F. and found no difference in the keeping life of the cut flowers. Hanan (17) used a 52°F. night temperature and 60, 65, 70, and 75°F. day temperatures without affecting the cut flower life of carnations.

Soil Moisture and nutrients

Post (55) states in his book "Indications are that fertilizer concentration and moisture supply to the growing flowers have little effect on their keeping qualities, unless they increase the leaf area or the succulency of the stem so that slight wilting causes the stem to bend easily." Mastalerz (41) concluded that soil nitrate levels had no effect on the appearance or life of carnations and chyrsanthemums. The respiration rate of carnations was not correlated with low and high soil nitrates. High soil nitrates were found by Holley (23) to raise the grade and yield of carnations, but not to affect the keeping life.

Experiments by Holley (25, 26) on potassium, sodium and calcium nutrition of carnations indicated that four or eight pounds of muriate of potash per year per 100 square feet of bench afford better yield and cut flower keeping than a one-pound application. This difference in keeping was not in evidence during the fall and winter, but became apparent from February until the termination of the experiment in April. The medium applications of potash produced the best grade of flowers. Three applications of sodium chloride at one pound per 100 square feet increased yield with better quality flowers, but did not affect cut flower keeping. No differences in yield or quality were found in plants growing with high or low calcium levels, but the higher level of calcium caused flowers to keep five per cent longer.

Caparas and Holley (5) irrigated carnations in specially aerated soil at moisture tensions of zero and 300 centimeters of water. Neither yields, grades, nor keeping life were significantly different. Earlier Holley (24) found carnation yields and grade of flowers not greatly affected by soil moisture tensions between 100 and 500 centimeters of water. He did not measure the effects of moisture on cut flower life.

The method of watering was found by Caparas (6) to influence cut flower life. In an experiment with different basic methods of irrigation, he concluded that thorough application of water at each irrigation is essential to the best keeping life of carnation flowers. Plots which had a constant water table in the bottom, and surface-watered, free-draining plots produced flowers with an average of 10 per cent less keeping life than plots which were thoroughly soaked at each irrigation then allowed to dry between waterings.

White (69) found that an increase in soluble salts reduced the yield and quality of White Sim carnations but produced no significant differences in keeping quality.

<u>Time of day</u>

Laurie (38) states that flowers should be cut in the early morning or late in the day when the stems are turgid. In contrast Neff (48) discovered that carnations cut at midday and stored at 40°F. wilted slightly, but they were many times better and more turgid than those cut in the evening. Neff theorized that lower turgidity probably dominated the internal conditions making possible the survival of the flowers. At 33°F. the differences were not so pronounced.

Howland (30) found that roses cut at any time of day kept as long as did those cut early in the morning. He found that roses cut at 4:30 p.m. kept 7.3 per cent or 7.4 hours longer than did those cut at 8:00 a.m. During hot weather the afternoon cutting increased keeping time 11.4 per cent or 9.9 hours. He associated this with the concept that the keeping quality of roses and other flowers is influenced by the increase in carbohydrate content of the leaves in the afternoon. Post (55) is in agreement with Howland on this point and states that commercial trials of morning versus afternoon cutting of roses indicate longer keeping when they are cut in the afternoon. He goes on to say "Probably it makes no difference whether flowers are cut in the morning or afternoon in plants with no foliage attached to the stem (gladioli, narcissi, anemones, orchids, and many others)."

There were no significant differences in the cut flower life of carnations in an experiment by Knappenberger (34) comparing morning versus evening harvest.

Stage of cutting

Laurie (38) reported in 1928 that the proper stage of flower development should be selected for cutting. He stated that gladioli should be cut when the first floret is open, peonies when the first petals are unfolding, roses before the buds open, dahlias when fully opened and poppies the night before they open.

Carbon dioxide treatment to prolong the keeping qualities of cut roses was reported by Thornton (63) to be more effective on flowers in the bud stage than on opened flowers.

Mastalerz (41) working with carnations and chyrsanthemums found that a delay in cutting after the optimum stage of development had been reached reduced the life of cut flowers.

According to Holley (27) "The stage of opening at which a carnation flower is harvested can limit or lengthen the life of that cut flower." He goes on to say that the optimum stage for cutting carnation flowers is that stage when the outer petals are expanded but the center of the flower is still tight. A flat-sided flower should be cut when the greater portion of the flower is open; otherwise it will be older than the group of flowers with which it is cut. Hollow centered, malformed, or bullheaded flowers have inferior keeping life.

Maturity of plants

Cut flower keeping trials were run by Holley (28) on three different dates comparing flowers cut from two-year plants, one-year plants in steady production, and the first crop from single-pinched plants. The flowers cut from the second year plants kept significantly better than flowers in the other two groups. A difference of .57 days average keeping between flowers from the first crop and flowers from plants in steady production was not quite enough for statistical significance. In comparing the keeping qualities of cut flowers from pinched and unpinched plants, a highly significant difference of .79 days was found in favor of the pinched plants. It was established that flowers from unpinched plants in this test contained about half as much total sugars as did those from the pinched plants.

Pollination and fertilization

Knudson (37) states that fertilization may cause petal dehiscence, and thus it would be useless to attempt to preserve such flowers. The sweet pea was cited as an example.

Fitting (13, 14) demonstrated that the placement of pollen, living or dead, on the stigma of orchids caused premature wilting of the perianth, closing of the stigma, swelling of the column, and sometimes swelling of the ovary. Hsiang (32) affirmed Fitting's results and also qualitatively duplicated them by using naphthalene acetic acid and indole acetic acid. The wilting of the perianth resulted from an increased epidermal transpiration. There was an enhanced water uptake of the treated flowers, and cut discs from the columns absorbed more water than discs from columns of untreated flowers. This stimulation of water uptake was found to be related to aerobic processes. Both fresh and dry weight of the column were increased after pollination, while the perianth lost water and dry matter. Cut flowers responed in the same manner.

Post-harvest treatment

The life of cut flowers can be extended by a great number of practices following their removal from the plants. Rapid processing to prevent undue exposure to heat and dry air is very beneficial (29). Cut flowers, hardened by placing in warm water in an atmosphere of 40°F., absorb and retain moisture resulting in better keeping life (34,43). Chemical treatments at this time improve flower color, form, and lasting qualities (49, 68).

The value of boiling, burning, splitting, or mashing of stems after harvesting has been upheld by some writers (55), but refuted by others (37). Other mechanical practices such as cutting the stems under water (12, 39), daily removal of the lower stem portion (37), treating under water in a partial vacuum (16), or plunging deeply in water (55) have been advocated. Flowers keep just as well or better in shallow water than in deep water according to Laurie (39).

Information regarding the desirability of storing flowers has been offered by investigators. The respiratory rate is inversely proportional to the storage and keeping life (39, 61), and is dependent on the temperature (61). Also different species and varieties of cut flowers vary greatly in their storage response (52).

The special conditions of cut flower storage have been covered by many investigators (3, 18, 19, 21, 29, 40, 42, 44, 45, 48, 49, 50, 52, 63, 64, 65).

Many chemicals have been tried and found to increase the life of cut flowers. These chemicals act in a number of ways and are often combined into solutions that are more versatile in their use. Bactericides and fungicides extend the life of cut flowers by preventing the clogging and breakdown of the stem by microorganisms (1, 35, 37, 39, 52, 57, 58, 64). Enzyme poisons also prevent blocking of the stem (1, 64).

Other types of compounds that may benefit cut flower life are respiratory inhibitors (1, 15, 39, 64, 67), sugars (35, 36, 39, 64), inorganic salts and micro-elements (1, 37, 39, 67), pigment fixing salts (67), and certain mixtures of compounds (1, 35, 36, 37, 39, 64, 67). Also, controlling the Ph (1, 53), gibberellic acid (1), boric acid (1, 39), urea (1), and the use of Geon 31X as a plastic coating (60) are helpful.

Growth compounds (1), glucocides (1), and many other chemical compounds (21, 37) have proven to be ineffective.

Basic research as to the chemical changes associated with senescence and blueing of Better Times roses wase conducted by Weinstein (66, 67).

Chapter III

METHODS AND PROCEDURE

Although much of the trouble caused by poor keeping quality can be attributed to an over supply of flowers during poor market periods, it is nevertheless strongly suspected that flowers do not keep the same from one day to the next. If such variations actually exist, they could possibly be a result of the constantly changing environment under which the flowers are grown. During the period from August through October, a careful study of the temperatures inside and outside the greenhouse shows that the daily spread between the maximums is sometimes as much as 24^{o}F. Extreme fluctuations, which are of greater magnitude inside the greenhouse, often occur during the months of September and October, and to a lesser degree at other times. Flowers may also be affected by an extremely hot day following several cool days.

In an effort to survey this problem, the potential keeping life of cut carnations was measured along with the light, temperature, and humidity before harvest.

Determination of average cut flower life

Young plants of the carnation variety William Sim were transplanted from a nursery bed into one greenhouse bench on May 5, 1953. One month after planting, a program was started whereby the apical tips were removed from the young carnation plants. By removing the tips of approximately 1/5 of the branches each week for five weeks, a steady crop of flowers for fall and winter tests was started.

The culture of these plants was similar to that used by commercial growers of carnations at the time the investigation was done.

In measuring the cut flower life of carnations from September 2, 1953 to May 31, 1954, the flowers were cut each morning and placed in warm water in a 36°F. cooler until the afternoon of the next day. They were then moved to a keeping room where they were divided equally into three groups. They were placed in clean milk bottles with fresh tap water which was not changed throughout the keeping period. The bottles were washed after each use. The keeping life was the number of days required for a flower to lose its turgor and begin closing less one day. Time in the keeping room only was counted.

The room used for this measurement was in a basement with a temperature of 65 to 70°F. and a relative humidity of 60 to 65 per cent. Two large nutrient tanks which were being used for gravel culture crops in an adjacent greenhouse were probably responsible for the unusually even temperature and humidity in the room. Temperature and humidity were recorded by a Foxboro hygrothermograph.

Since the experiment was to be continued the second year, the plants were pruned down gradually starting May 6, 1954, so that they would again be in steady production the following season.

Daily keeping measurements were again made on the flowers from October 8, 1954, through March 18, 1955. It was suspected that the potential life of the flowers would be more nearly realized if a bactericide were used in the water, so sufficient calcium hypochlorite to give 100 ppm chlorine in solution was added.

During this second series of keeping trials, the flowers were cut in the morning as before, and placed in chlorine solution in a 36°F. cooler until the next morning. They were then divided into three parts, placed in milk bottles of fresh chlorinated solution, and stored in the keeping room for observation. The solution was not changed throughout the keeping period.

The number of flowers used in keeping trials varied according to the number that were cut. At first all of the flowers were kept, but later 15 was considered a reliable sample. Occasionally there were only three flowers which afforded only a rough estimate of the average keeping.

Light measurement

A continuous record was kept of the incident light by a Foxboro dynalog recorder with a Weston photo-electric light target located on the roof of a building adjoining the greenhouse. The light for each day was totaled by planimetering the recording charts and converting the readings back to the original units. Planimeter readings are in square inches, so a curve was drawn plotting light against square inches. The mean light was then obtained from the curve at the point of the measured planimeter reading.

Humidity and temperature measurement

A Foxboro hygrothermograph was used to measure the humidity and temperature in the greenhouse near flower height on the south side of the bench. The same scale was used for both temperature and humidity--reading directly in degrees F. for temperature, and per cent for relative humidity. The means for temperature and humidity were obtained in the same manner as was the mean light. Outdoor temperatures were obtained from the U. S. Weather Bureau.

Simple, partial, and multiple correlations

The data were examined and preliminary studies were made by means of graphs and simple correlations between the daily keeping life of the cut carnations and light, temperature, and humidity.

By studying the graphs and simple correlations, it was decided that partial correlations with keeping should be run, using the sum of four days' light, temperature, and humidity previous to the time the flowers were cut. Partial correlations were then run for three different periods using the method outlined by Hayes and Immer (20). The periods were December 1, 1953, to January 19, 1954; April 12 to May 13, 1954; and January 3 to March 18, 1955.

By using the values obtained for partial correlations the multiple correlations were then determined by the formula

$$R^2A{\cdot}BCD = (rAB \times \beta AB.CD) + (rAc \times \beta AC.BD) + (rAD \times \beta AD.BC).$$

Then $R = \sqrt{R^2A.BCD}$.

In addition, simple correlations were run comparing weekly means of keeping with light and temperature.

Chapter IV

PRESENTATION OF DATA

Flowers were cut from William Sim carnations each morning from Sept. 2, 1953, to May 31, 1954, and from Oct. 8, 1954, to March 18, 1955. The cut flower life was measured by placing them in a cool basement room after being conditioned in a refrigerated cooler. Records were kept of temperature and humidity in the greenhouse, and also of watering dates. Outdoor light and mean maximum temperatures were also recorded.

Figures 1 and 2 show the mean cut flower life for the periods mentioned above. Three-day moving means were used to smooth the curves slightly.

Measured cut flower life for 1953 and 1954 (Fig. 1)

During the period from September of 1953 through May of 1954, the keeping was rather erratic, but averaged above seven days. Keeping fluctuated from above six days to about nine days except in late May when it jumped to over 10 days.

Periods of good keeping included the first two weeks in October, late November and early December, the first half of

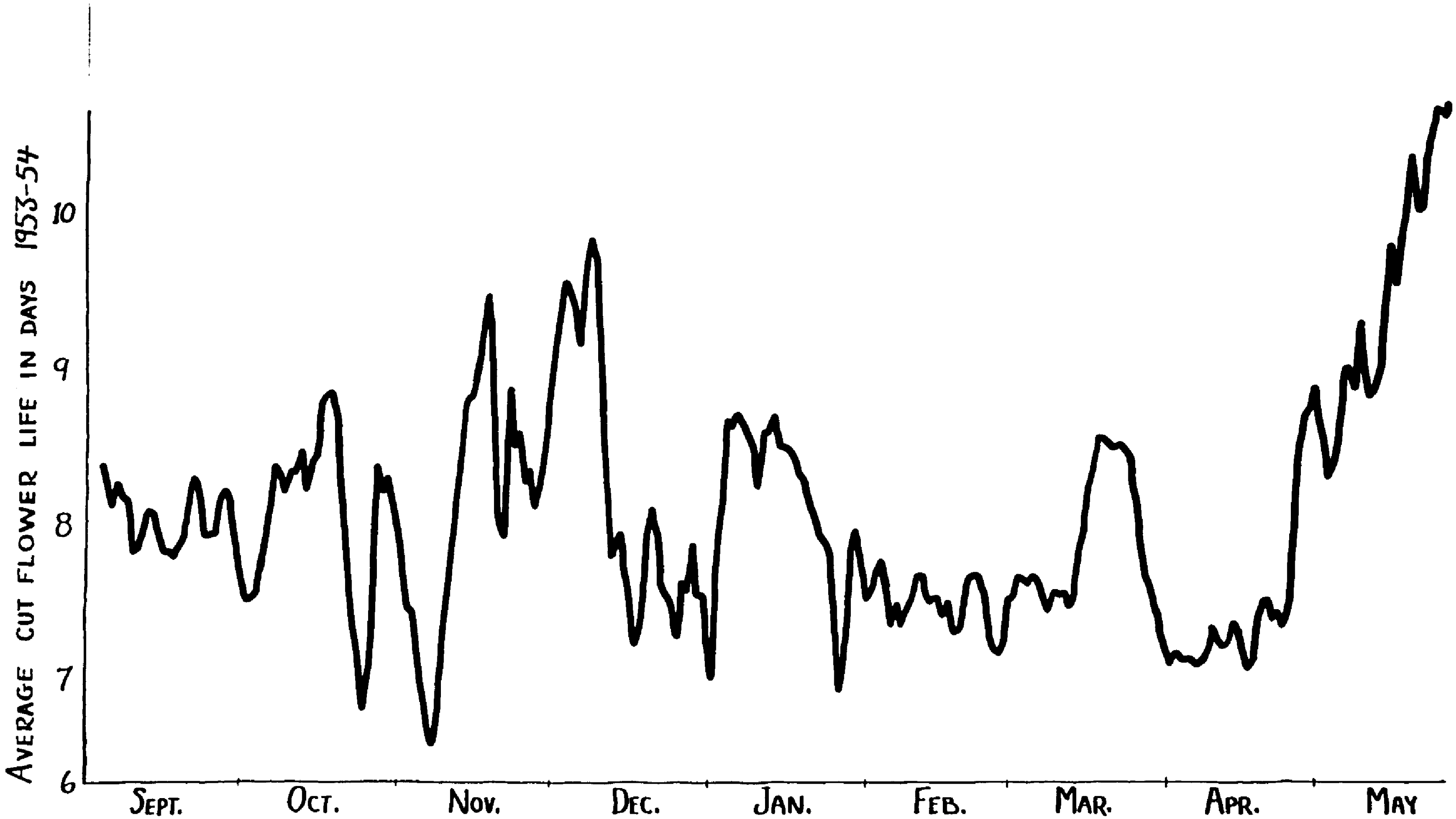

Fig. 1. The mean daily cut flower life of William Sim carnations at Fort Collins, Colorado for parts of 1953 and 1954.

January, mid March, and late April and May.

The periods of poor keeping were late October and early November, the last three weeks in December, February and early March, and the first half of April.

Measured cut flower life for 1954 and 1955 (Fig. 2)

During this period cut flower life fluctuated between seven and eight days through October and November. In early December it increased sharply to over nine days, and remained from just under nine days to over 10 days until the termination of the experiment in March.

The best keeping period was from early January through the third week in February. The poorest keeping occurred in October and November.

Comparisons and Correlations

Many graphs were made comparing cut flower life with light, temperature, and humidity for the day before harvest; and with a summation of these factors for two, three, and four days prior to cutting. Comparisons were also made between weekly mean keeping life and weekly means for greenhouse temperature, light, humidity and outdoor temperatures. The results of these graphs were inconclusive--the data seeming to follow one pattern at one time, a reverse pattern at other times, or no pattern at all.

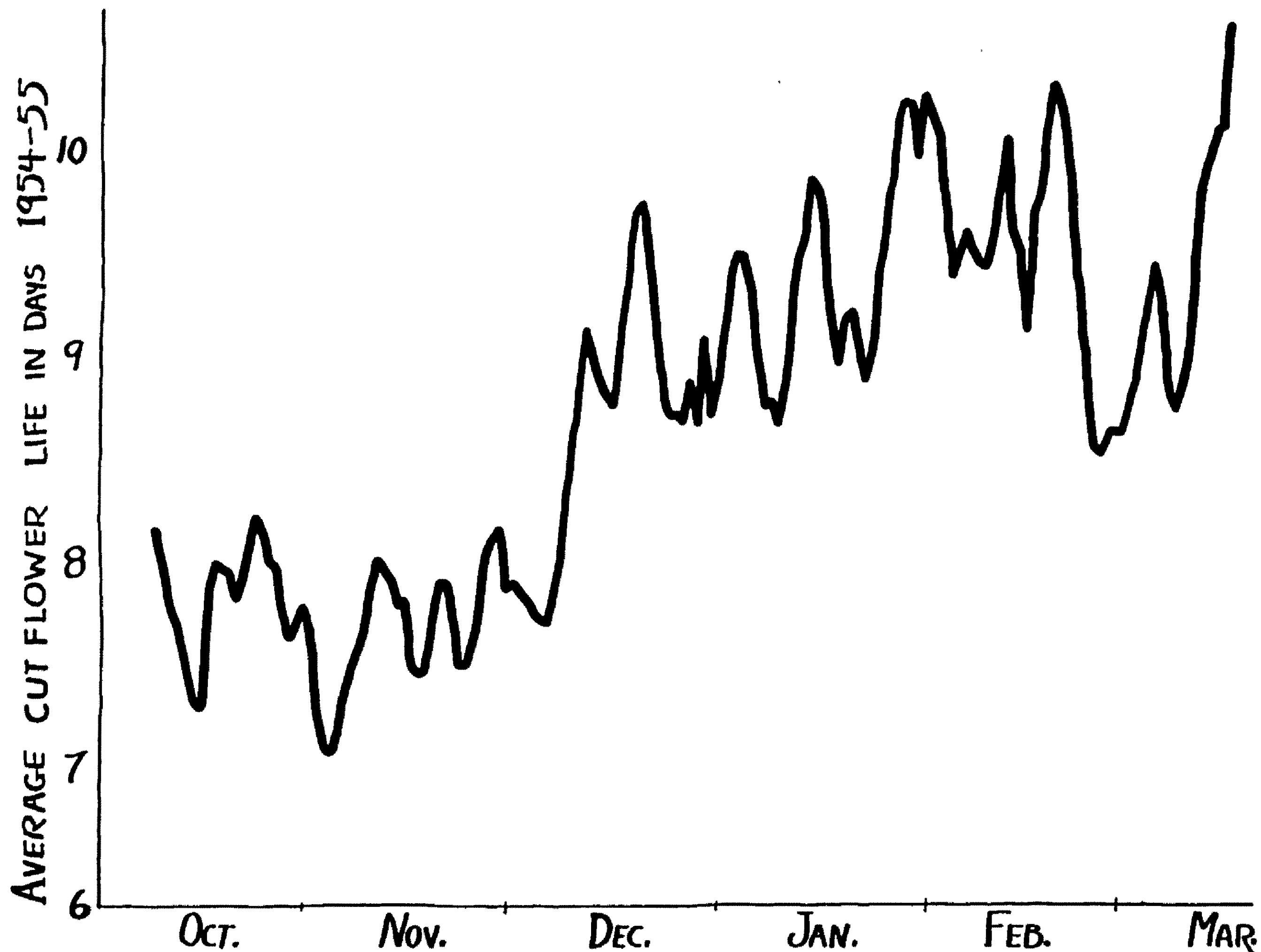

Fig. 2. The mean daily cut flower life of William Sim carnations at Fort Collins, Colorado for parts of 1954 and 1955.

Simple correlations were run on keeping with a summation of one, three, and four days previous light, temperature, and humidity, and of two days previous light. Simple correlations were also attempted using weekly means of these factors. In addition, partial and multiple correlations were run on mean daily keeping with a summation of four days previous light, temperature, and humidity. The results of these correlations are summarized in tables 1 through 5.

Light with temperature and humidity .— All simple and partial correlations between light and temperature were positive and highly significant except for one partial correlation in April and May. In most cases there was a highly significant negative correlation between light and humidity in both the simple and partial correlations.

Temperature and humidity.— There was a highly significant negative correlation between temperature and humidity for the December and January, 1953-54, period, when these factors were measured the day before harvest. When these factors were accumulative for four days prior to harvest there was an insignificant positive correlation. Correlations for two other periods when a four-day summation was used, however, were negative and highly significant. No significant correlation was found when using a three-day summation of these factors.

Cut flower life with light, temperature and humidity.— Simple correlations for the December and January, 1953-54, period between keeping and light, temperature, or humidity were not significant when these environmental factors were for one, two, three, and four days prior to harvest of the flowers. No correlation was attempted using a two-day summation of temperature and humidity. Partial correlations using a four-day summation of these factors for this same period were not significant.

Simple correlations of cut flower life for the April and May, 1954, period and using a four-day summation of light, temperature, and humidity were significant. Keeping with light was positive and significant. Keeping with temperature was positive and highly significant. Keeping with humidity was negative and highly significant.

Negative and highly significant correlations were obtained during the November and December, 1954, period between keeping and a four-day summation of light and temperature.

Negative, but insignificant, correlations were obtained during the January to March, 1955, period between keeping and a four-day summation of light and temperature. Keeping with a four day summation of humidity for this period was positive and significant.

No partial correlations between keeping and a four-day summation of light, temperature, and humidity were significant.

Multiple correlations of keeping with a combination of light, temperature, and humidity were significant for the December and January, 1953-54, and the January to March, 1955, periods but not for the April and May, 1954, period.

Simple correlations of keeping with light and temperature, using weekly means, were not significant.

As an over-all picture, the keeping varied inversely with the mean maxium outdoor temperature except during part of October and November of 1953, March of 1954, and May of 1954.

In another type of comparison light for each month was grouped into five intensities and compared with the cut flower life. These grouped light intensities were not comparable from one month to the next and could not be compared with each other. The cut flower life was variable within the groupings, but set no standard pattern. Two months, December of 1953 and January of 1955, followed a similar curve in which the next to the highest light afforded the best keeping. Lesser and higher light intensities reduced the keeping. The cut flower keeping values of thirteen other months, however, produced curves of questionable significance.

Size of cut.--The cut flower life of small, medium, and large harvests was measured for the September 2, 1953, to April 30, 1954, and the October 8, 1954, to March 18, 1955, periods. Differences in keeping were very small except between the medium and large cuts for the latter period. The medium cuts (10 to 15 flowers) kept .62 days or 7.5 per cent longer than the large cuts (16 or more flowers). A "t" test showed this difference in keeping to be highly significant. Results are summarized in Table 6.

Effect of soil moisture on cut flower life.--A comparison was made between the life of flowers cut on the morning of watering when the soil was driest, and on the day after watering when the soil was moist. The differences were so small that they were not analyzed statistically (Table 7).

Table 1.--Total correlations between keeping, light, temperature, and humidity with light, temperature, and humidity measured the day previous to harvest. a/

	Light	Temperature	Humidity
Keeping			
Dec. 1-Jan. 19, 1953-54	+0.106	-0.123	-0.120
Light			
Dec. 1-Jan. 19, 1953-54		+0.399**	-0.364**
Temperature			
Dec. 1-Jan. 19, 1953-54	+0.399**		-0.513**

a/ Since n for the different correlations varies, the correlation coefficients are not comparable between periods.

* Significance to 5 per cent level.
** Significance to 1 per cent level.

Table 2.--Total correlations between keeping, light, temperature, and humidity with light, temperature, and humidity accumulative for three days prior to harvest. b/

	Light	Temperature	Humidity
Keeping			
Oct. 12-Nov. 30, 1953	+0.427**	+0.399**	-0.380**
Dec. 1-Jan. 19, 1953-54	+0.185		
Light			
Oct. 12-Nov. 30, 1953		+0.763**	-0.022
Temperature			
Oct. 12-Nov. 30, 1953	+0.763**		-0.217

b/ Since n for the different correlations varies, the correlation coefficients are not comparable between periods.

* Significance to 5 per cent level.
** Significance to 1 per cent level.

Table 3.--Total correlations between keeping, light, temperature, and humidity with light, temperature, and humidity accumulative for four days previous to harvest. c/

	Light	Temperature	Humidity
Keeping			
Dec. 1-Jan. 19, 1953-54	+0.213	-0.249	-0.240
Apr. 12-May 31, 1954	+0.353*	+0.55**	-0.51**
Nov. 1-Dec. 30, 1954	-0.519**	-0.463**	
Jan.3-Mar. 18, 1955	-0.087	-0.005	+0.232*
Light			
Dec. 1-Jan. 19, 1953-54		+0.394**	-0.301*
Apr. 12-May 31, 1954		+0.75**	-0.79**
Jan. 3-Mar. 18, 1955		+0.859**	-0.846**
Temperature			
Dec. 1-Jan. 19, 1953-54	+0.394**		+0.168
Apr. 12-May 31, 1954	+0.75**		-0.79**
Jan. 3-Mar. 18, 1955	+0.859**		-0.711**

c/ Since n for the different correlations varies, the correlation coefficients are not comparable with each other. The asterisks, however, indicate their significance.

* Significant to 5 per cent level.
** Significant to 1 per cent level.

Table 4.--Partial correlations between keeping, light, temperature, and humidity; with light, temperature, and humidity accumulative for four days prior to harvest. d/

	Light	Temperature	Humidity
Keeping			
Dec. 1-Jan. 19, 1953-54	+0.297	-0.333	-0.076
Apr. 12-May 31, 1954	-0.21	+0.33	-0.23
Jan. 3-Mar. 18, 1955	+0.069	+0.126	+0.293
Light			
Dec. 1-Jan. 19, 1953-54		+0.525**	-0.363
Apr. 12-May 31, 1954		+0.38	-0.51**
Jan. 3-Mar. 18, 1955		+0.672**	-0.643**
Temperature			
Dec. 1-Jan. 19, 1953-54	+0.525**		+0.282
Apr. 12-May 31, 1954	+0.38		-0.37
Jan. 3-Mar. 18, 1955	+0.672**		+0.017

d/ Since n for the different correlations varies, the correlation coefficients are not comparable with each other. The asterisks, however, indicate their significance.

* Significant to 5 per cent level.
** Significant to 1 per cent level.

Table 5.--Multiple correlations of keeping with a combination of light, temperature, and humidity.

Date	RA.BCD	Percentage of time keeping correlates with these factors
Dec. 1-Jan. 19, 1953-54	+0.426*	18
Apr. 12-May 31, 1954	+0.373	14
Jan. 3-Mar. 18, 1955	+0.331*	11

Table 6.--Comparison of cut flower life of small, medium, and large cuts.

Date	Number of flowers harvested	Total Flowers	Total Flower Days	Mean cut Flower Life
Sept. 2 1953 to April 30 1954	3 to 9	344	2731	7.94
	10 to 15	1191	9475	7.96
	16 and up	1999	15931	7.97
Oct. 8 1954 to March 18 1955	3 to 9	384	3417	8.90
	10 to 15	1058	9433	8.92
	16 and up	619	5137	8.30

Table 7.--The effect of soil moisture on cut flower life.

Date	Moisture status at time of cutting	Total Flowers	Total Flower Days	Mean cut flower life
Sept. 2, 1953 to May 31, 1954 N=45	Day Watered	639	5081	7.95
	Day after watering	651	5304	8.15
Oct. 8, 1954 to March 18, 1955 N=15	Day Watered	182	1538	8.45
	Day after watering	189	1587	8.40

Chapter V

DISCUSSION

Variations occur in cut flower life from day to day. These variations are not usually of great magnitude, but rise and fall gradually over a period of several days or weeks. The poorest conditions encountered during the course of these experiments produced flowers that kept 6.33 days. Increases in cut flower life up to 12.67 days or 100 per cent over the poorest keeping occurred due to the variable pre-harvest environment. In trying to explain these differences an attempt was made to correlate cut flower life with the light, temperature, and humidity of the plant environment. Some correlations were found which are difficult to explain.

Although many graphs were made comparing cut flower life with light, temperature, and humidity for one or a summation of two, three, or four days prior to harvest, no implications could be drawn from these graphs. Although others have concluded that sugar content of the stems directly affects cut flower life (36), there are differences of opinion as to how the sugar concentration or keeping life is influenced by climatic factors (22, 36, 51). This may be due to the inability of investigators to separate completely the factors involved. As an example it would require extremely elaborate equipment to prevent the temperature and humidity from changing when the sun comes out after a cloudy period.

Other factors that were overlooked, or are unknown may enter and confuse comparisons between sugar content or cut flower keeping and the environmental factors under study. One such factor that was not considered until last was the size of the daily flower harvest. A highly significant correlation was found between cut flower keeping and size of cut for the second year. The medium sized cuts kept .62 days or 7.5 per cent longer than the large cuts.

The number of flowers cut daily depends on weather conditions--large cuts follow bright days and small cuts follow dark days. Unusually large cuts seem to follow a bright day after one or more dark days. These flowers may be physiologically older having required a longer period for opening.

With several exceptions, cut flower life varied inversely with the mean maximum outdoor temperature (Figs. 3 and 4). The only notable exceptions were: October through the first two weeks of November, 1953; the last four weeks in March, 1954; and

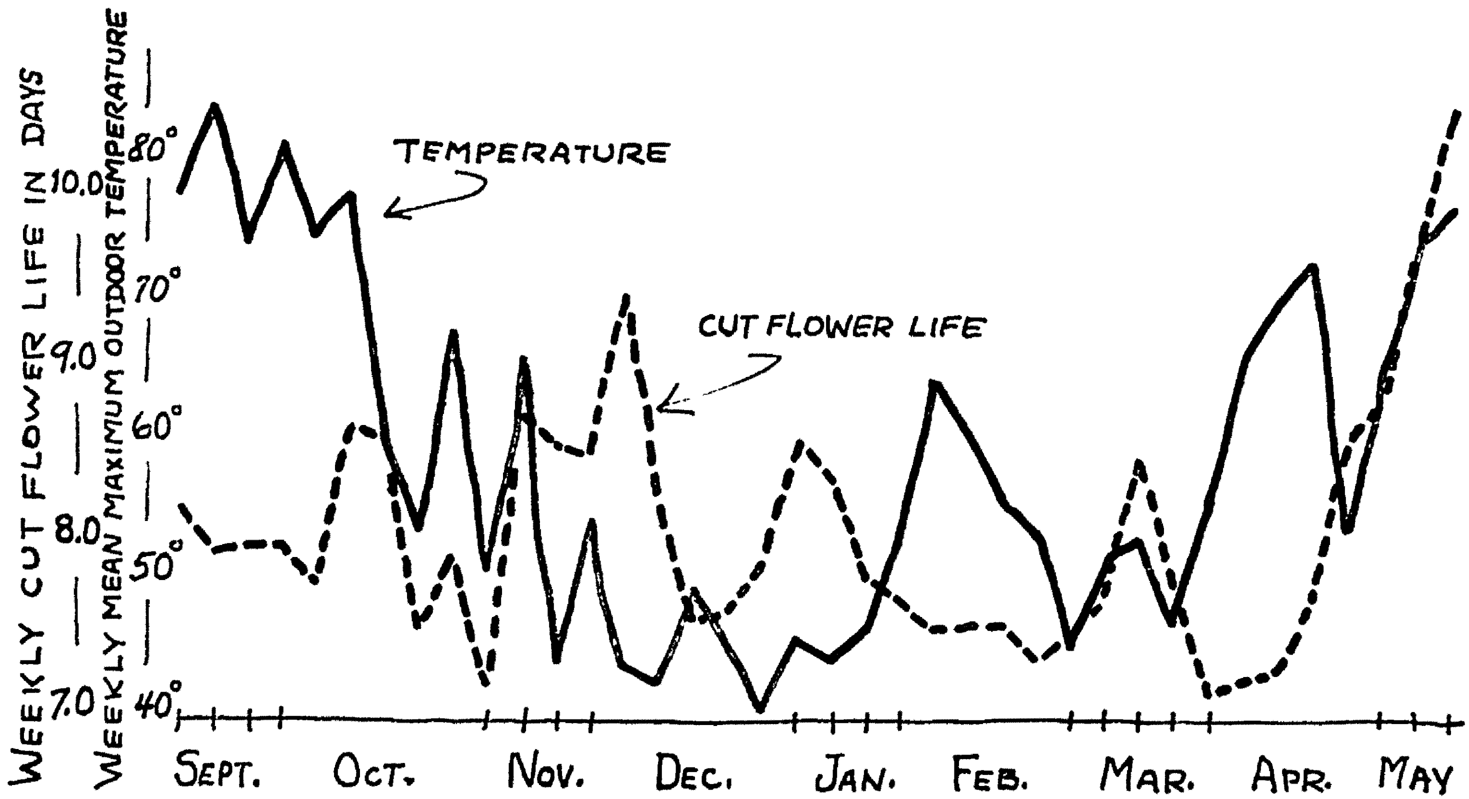

Figure 3. A comparison of mean weekly cut flower life of carnations with mean weekly maximum outdoor temperatures for the period from September, 1953, through May, 1954.

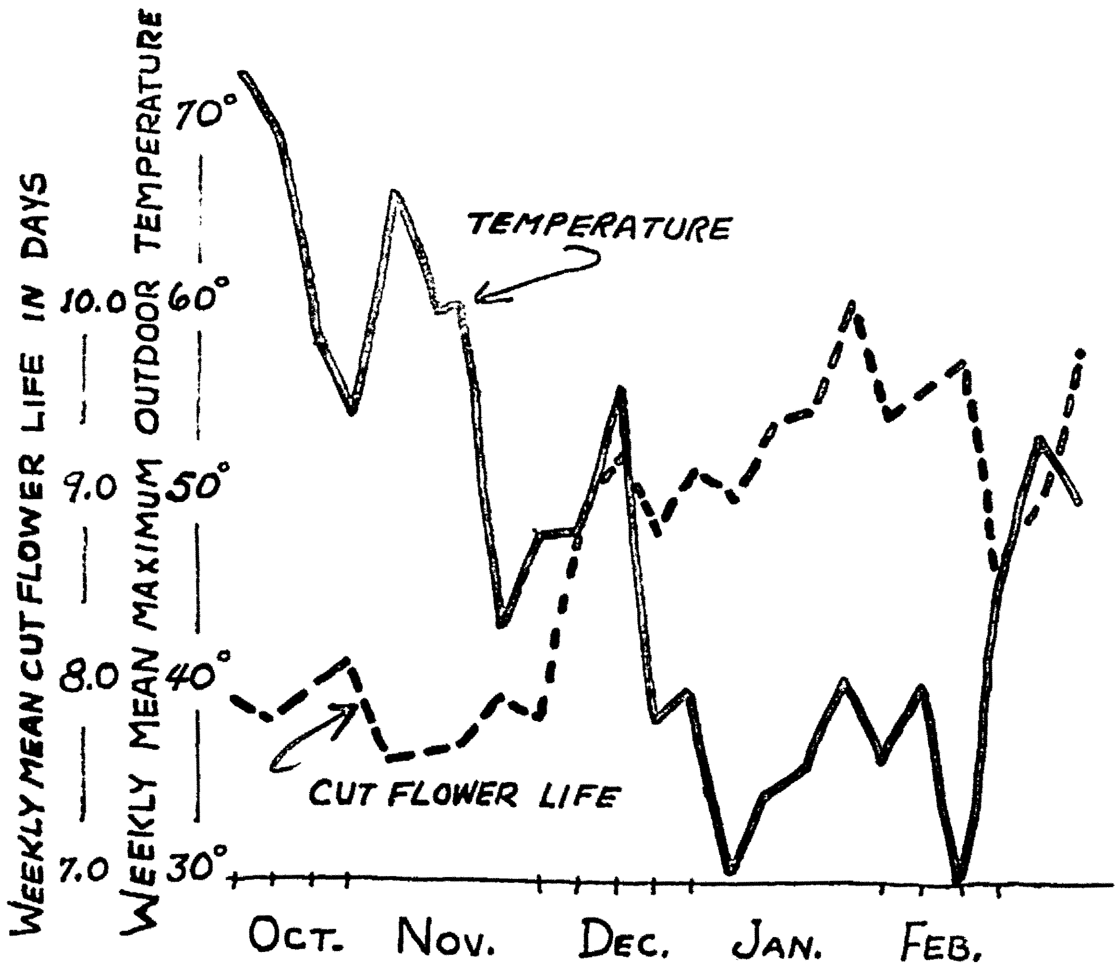

Figure 4. A comparison of mean weekly cut flower life of carnations with mean weekly maximum outdoor temperatures for the period from October, 1954, to March, 1955.

the first three weeks in May, 1954. This temperature measurement would essentially indicate the bright warm periods and the darker cool periods in the greenhouse.

Before evaluating the results of correlations it must be understood what significance they possess. Simple or total correlations are correlations between two factors in which the influence of other closely associated factors is not separated. In this study a simple correlation between cut flower keeping and temperature will nearly always reflect the light intensity, because light and temperature follow each other closely in an uncooled greenhouse.

Partial correlations separate these closely associated factors and give a better picture. "A multiple correlation coefficient measures the degree to which the dependent variable is influenced by a series of other factors studied" (20).

Total correlations between keeping and light, temperature, and humidity varied from positive and highly significant to negative and highly significant. The keeping-humidity correlations were always negative to the temperature or light correlations with keeping. Conditions which cause good keeping at one time of the year may cause the reverse at another season. No explanation is given for these reversals between periods.

There were no significant partial correlations. Multiple correlations were significant for two different periods when simple and partial correlations were not found. According to these data, then, it may be said that during the Dec. 1, 1953, to Jan. 19, 1954, and Jan. 3 to March 18, 1955, periods, keeping was influenced by a combination of light, temperature, and humidity, but not by any one of these factors alone.

Correlations of this sort would work only if the measured climatic factors affected cut flower keeping in a straight line formula or curve. To try to determine if there was a point at which an increase in light intensity would decrease the cut flower life, the light intensity for each month was arbitrarily divided into five categories. It was expected that the highest light intensities during the fall and spring months would be harmful to keeping, whereas during the winter months highest light would increase the keeping. However, the two monthly periods when cut flower life decreased with the highest light intensities occurred in December of 1953 and January of 1955. Since light-keeping curves for thirteen other months followed no particular pattern, no implications could be drawn from them.

Suggestions for further study

If a study similar to this were to be performed, much more usable information would probably be derived if the light, temperature, and humidity could be separately controlled. The critical leaf temperatures (4, 7, 8, 62) may also be a factor. High light intensities may prove beneficial to keeping, if other factors necessary for photosynthesis are not limiting. These factors would include correct environmental temperature, carbon dioxide concentrations, and adequate moisture supply to the leaves. To supply adequate moisture to the leaves at higher temperatures a high humidity may be necessary to prevent excessive transpiration and wilting.

Higher light intensities than those normally considered safe could possibly be used, if specific injurious rays could be filtered out, thereby preventing tissue injury.

Accurate control of the keeping room environment would be essential in any future experiments. To measure cut-flower life, temperature and humidity should be accurately controlled, water uptake to the flowers insured, and plugging by microorganisms prevented.

Chapter VI

SUMMARY

Flowers were cut from William Sim carnations each morning for the two series of tests covering approximately nine months and six months respectively. After conditioning in a refrigerated cooler, the cut flower life was measured by placing the flowers in a cool basement room. Records were kept of the greenhouse temperature, humidity, watering dates, outdoor light, and mean maximum outdoor temperatures. The results of comparisons and correlations attempted between cut flower life and the measured environmental factors are as follows:

1. Variations in cut flower life occur from day to day.

2. These variations rise and fall gradually over a period of several days or weeks.

3. Increases of up to 6.34 days (100 per cent) over the poorest keeping occurred due to the variable pre-harvest environment.

4. Medium sized cuts kept .62 days or 7.5 per cent longer than large cuts.

5. With several exceptions, cut flower life varied inversely with the mean maximum outdoor temperature.

6. According to these data cut flower life was influenced by a combination of light, temperature, and humidity, but not by any one of these factors alone.

7. It was not found that either the lowest or the highest light intensities adversely affected cut flower life.

8. No difference in keeping was found between flowers cut just before watering and those cut the morning following watering.

Of the various pre-harvest factors investigated it would seem, from these data, that temperature exerts the greatest influence on cut flower keeping. Adequate control of greenhouse temperatures within narrow limits would probably do much to further cut flower life.

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A P P E N D I X

Table A. Mean daily cut flower life with light, temperature, humidity, watering and production records (1953-1954).

Date		Mean keeping in days	Rated light[a]	Mean temperature	Mean relative humidity	Watered	Number of flowers cut
September	2	8.58	4				12
	3	8.22	5				9
	4	8.22	4	60.8	68.8		9
	5	8.00	3	62.3	73.0	X	6
	6	8.00	5	65.8	70.9		6
	7	8.42	4	66.6	73.3		12
	8	8.00	2	65.1	78.7	X	15
	9	8.00	3	64.5	81.0		12
	10	7.33	5	68.7	73.8		9
	11	7.96	5	64.5	77.2		27
	12	8.19	5	64.6	72.4	X	21
	13	8.13	3	68.3	65.0		15
	14	7.83	4	66.2	73.8		18
	15	7.83	3	63.1	72.0		18
	16 }		3	61.6	78.1	X	}
	17 }	7.85	2	61.8	73.1		27
	18	7.75	4	64.5	76.3		12
	19	8.00	3	64.5	71.5		21
	20	8.00	5	62.0	86.1	X	9
	21	8.56	5	58.7	77.1		9
	22	8.33	4	66.2	72.4		12
	23	7.90	5	73.1	47.7		21
	24	7.79	5	64.9	68.7	X	33
	25	8.19	5	61.6	76.4		21
	26	7.93	4	62.9	72.9		15
	27	8.20	4	63.7	71.4	X	30
	28	8.38	3	61.8	72.5		21
	29	7.67	4	65.0	61.4		15
	30	7.57	5	63.3	75.7		21
October	1	7.67	4	62.9	76.3	X	21
	2	7.19	4	64.5	72.5		21
	3	7.63	3	58.7	73.1		24
	4	7.93	5	60.5	79.8		15
	5	7.71	5	59.5	78.8		24
	6	8.46	5	58.7	79.2	X	24

Table A (continued)

Date		Mean keeping in days	Rated light[a/]	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
October	7	8.44	5	60.5	79.4		18
	8	8.27	5	61.2	75.3		33
	9	8.22	4	62.2	75.8		12
	10	8.00	3	61.6	73.9		21
	11	8.60	5	60.8	81.2	X	30
	12	8.27	3	56.4	80.6		15
	13	8.33	4	57.6	82.7		9
	14	8.08	5	60.0	77.2		24
	15	8.83	5	59.1	80.0		18
	16	8.47	4	60.0	76.2		15
	17	8.93	4	58.7	80.0	X	27
	18	8.90	5	59.8	75.8		21
	19	8.70	4	60.0	78.5		30
	20	8.57	3	56.4	83.1		23
	21	7.53	4	56.0	81.0		36
	22	7.42	1	53.7	83.5		24
	23	6.33	1	54.5	87.5		6
	24	7.08	2	56.2	82.8		12
	25	6.80	3	56.2	76.9		30
	26	8.67	4	57.5	79.2	X	6
	27	8.07	3	57.6	84.3		30
	28	8.71	5	59.7	76.3		24
	29	7.95	5	61.0	75.6		39
	30	8.44	4	58.8	80.2		27
	31	7.86	5	58.7	81.0		21
November	1	7.46	5	59.0	75.0	X	24
	2	7.50	3	58.0	83.7		18
	3	7.33	2	53.3	87.4		18
	4	7.44	1	53.9	85.6		9
	5	6.67	2	54.1	83.5		12
	6	6.83	4	53.0	81.7		12
	7	6.33	4	56.6	73.8	X	3
	8	6.33	5	58.0	63.4		9
	9	7.33	5	58.9	71.7		9
	10	7.79	3	56.3	76.1		24
	11	7.73	3	55.0	77.7		15
	12	8.57	5	58.7	77.0		30
	13	8.67	5	58.7	77.5		9
	14	9.00	4	58.5	78.1	X	24

Table A (continued)

Date	Mean keeping in days	Rated light[a/]	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
November 15	8.67	5	58.5	80.1		21
16	8.80	5	58.0	79.3		15
17	9.87	5	58.1	76.4		15
18	9.24	1	53.5	85.0		21
19	9.00	1	53.0	79.1		3
20	7.89	2	55.8	72.5		18
21	8.00	3	53.7	73.9		5
22	8.00	2	55.1	73.8	X	3
23	9.28	2	54.6	84.3		18
24	8.00	5	54.5	73.9		24
25	8.67	5	55.4	79.0		18
26	8.17	4	56.3	78.1		6
27	8.00	3	56.2	88.2		15
28	8.17	5	56.0	79.0		12
29	8.42	5	57.0	75.3	X	24
30	8.56	4	54.6	82.0	X	18
December 1	9.33	5	53.9	72.6		18
2	9.33	4	54.7	83.3		15
3	9.33	4	54.3	81.4		12
4	10.17	3	53.7	80.6		12
5	8.67	5	53.7	81.9		9
6	9.00	4	54.3	76.1		9
7	9.78	4	55.8	79.3		9
8	9.89	3	53.7	81.6		18
9	9.83	3	54.8	77.7		6
10	9.42	4	54.1	79.2	X	12
11	7.83	4	52.5	77.3		6
12	7.33	3	54.3	81.7		9
13	8.07	5	56.2	79.7		15
14	8.07	3	55.3	79.0		15
15	7.73	2	54.6	88.3		15
16	7.33	1	54.1	89.1		15
17	7.22	5	55.4	79.4		9
18	7.08	5	56.2	79.7		12
19	7.33	4	56.4	83.5		15
20	8.67	5	55.6	83.9		15

Table A (continued)

Date		Mean keeping in days	Rated light[a]	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
December	21	7.73	2	53.1	79.7	X	15
	22	7.33	4	55.1	77.5		12
	23	7.78	4	56.5	76.1		9
	24	7.67	5	57.1	80.0		6
	25	7.00	5	55.2	78.8		9
	26	7.27	5	55.2	82.8		15
	27	8.33	5	54.5	84.3		15
	28	7.13	4	54.6	79.4		15
	29	8.25	4	55.0	81.4		12
	30	7.40	5	55.4	80.0		15
	31	7.08	3	54.9	81.2	X	12
January	1	7.17	1	54.2	83.3		6
	2	6.78	5	55.0	81.3		9
	3	8.93	3	54.6	80.7		15
	4	8.17	5	52.8	81.6		12
	5	8.81	4	56.2	87.5		16
	6	9.00	5	56.4	80.7		6
	7	8.42	1	54.6	88.7		12
	8	8.67	5	55.0	76.5		9
	9	8.67	2	54.0	82.4		15
	10	8.00	5	55.0	80.7	X	6
	11	7.67	4	54.5	79.8		9
	12	9.40	2	54.1	81.7		15
	13	8.33	3	55.0	78.1		12
	14	8.39	5	55.6	81.9		18
	15	8.75	4	54.8	81.6		12
	16	8.39	4	56.3	80.0		18
	17	8.33	5	55.7	83.1		15
	18	8.50	5	56.4	85.0		18
	19	8.15	3	55.0	84.3		20
	20	8.24	4	52.5	82.7	X	21
	21	7.96	5	54.8	77.7		27
	22	7.94	5	55.8	80.5		18
	23	7.83	3	55.2	81.1		12
	24	7.92	4	57.6	81.3		12
	25	7.50	3	54.1	82.2		6
	26	6.58	3	55.0	81.4		12

Table A (continued)

Date	Mean keeping in days	Rated light a/	Measured light	Mean temper- ature	Mean relative humidity	Watered	Number of flowers cut
January 27	7.00	5		56.2	79.3		12
28	8.13	3		55.8	80.0		15
29	8.07	3		54.8	85.1		15
30	7.72	4		56.6	85.8		18
31	7.60	4		56.8	81.8		27
February 1	7.28	5		56.5	59.4		18
2	7.87	5		58.8	73.4		25
3	7.89	5		56.5	75.1	X	18
4	7.47	5		62.5	72.1		15
5		4		56.2	79.4		
6	7.20	5		53.9	79.8		36
7	7.83	4		54.5	76.3		12
8	6.89	5	b/	59.8	72.5		9
9	7.47	5		59.3	70.6	X	15
10	8.00	4	20.4	55.6	78.1		33
11	7.53	4	20.2	53.8	53.9		31
12	7.47	4	22.2	57.5	74.4		21
13	7.67	4	21.4	60.0	78.0		15
14	7.33	5	23.0	58.1	75.0		18
15	7.60	4	21.6	57.0	77.5	X	15
16	7.28	3	19.6	56.0	76.5		18
17	7.67	5	23.5	58.6	76.5		9
18	7.14	4	21.3	58.3	74.4		21
19	7.33	5	24.1	56.5	75.4		9
20	7.87	3	18.5	56.1	75.6	X	27
21	7.61	3	20.6	57.5	81.3		18
22	7.53	4	24.1	56.3	79.2		15
23	7.92	3	20.2	56.5	75.4		12
24	7.39	4	25.9	58.6	76.1		18
25	6.93	2	19.2	57.5	78.1	X	15
26	7.22	3	18.7	56.7	83.3		18
27	7.27	3	20.0	55.9	77.2		15
28	7.20	2	19.2	56.4	76.1		15
March 1	7.94	1	11.2	54.5	80.6		18

Table A (continued)

Date		Mean keeping in days	Rated light a/	Measured light b/	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
March	2		4	22.5	55.5	76.2		
	3	7.33	4	26.9	56.8	73.8		15
	4	7.58	5	28.0	56.7	73.8		12
	5	7.27	5	28.9	58.0	86.8	X	15
	6	7.47	5	29.2	60.2	70.8		26
	7	7.47	3	20.4	58.0	79.9		37
	8	7.53	3	23.9	57.7	76.1		15
	9	7.27	2	18.2	58.3	81.1		38
	10	8.00	3	27.7	59.1	75.3	X	12
	11	7.47	2	12.8	54.8	81.6		26
	12	7.27	1	7.5	52.7	78.5		15
	13	7.60	5	29.8	57.7	67.1		20
	14	7.73	5	30.0	56.4	68.8		15
	15	8.22	4	30.7	56.4	73.1	X	9
	16	8.00	3	25.4	58.5	77.3		15
	17	8.53	3	26.3	58.4	75.3		25
	18	8.67	2	15.9	55.7	79.4	X	12
	19	8.53		21.8	56.3	82.2		28
	20	8.47		15.2	56.5	88.3		27
	21	8.50		12.8	57.4	83.9		15
	22	8.53		19.6	56.2	86.7		15
	23	8.53		7.1	54.9	91.2		23
	24	8.39		9.6	54.8	90.6		18
	25	8.47		19.7	56.0	81.6		27
	26	7.50		26.7	57.2	79.3	X	12
	27	7.67		33.2	59.2	74.5		30
	28	7.67		28.3	57.5	75.6		33
	29	7.47		12.2	56.7	81.4		25
	30	7.18		2.4	55.0	82.9		17
	31	7.13		30.0	57.5	79.6	X	15
April	1	7.13		34.4	58.5	74.2		24
	2	7.00		33.8	60.6	75.3		29
	3	7.33		29.8	61.4	79.0		29
	4	7.00		29.4	63.3	77.5	X	34
	5	7.00		30.7	61.3	71.5		30
	6	7.28		36.8	63.8	69.6		18

Table A (continued)

Date		Mean keeping in days	Measured light b/	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
April	7	6.93	35.1	61.7	72.4	X	30
	8	7.06	32.8	61.8	76.2		18
	9	7.47	27.7	60.9	73.9		39
	10	7.58	35.1	61.0	72.4		12
	11	6.80	33.1	61.1	77.3		21
	12	7.33	30.9	61.4	77.6	X	15
	13	7.78	35.6	64.2	73.3		9
	14	7.13	14.7	60.0	74.3		31
	15	7.17	33.7	58.7	75.3		12
	16	7.07	38.7	61.0	65.2		15
	17	6.92	39.2	66.2	65.1	X	12
	18	7.27	32.2	65.0	57.9		34
	19	7.87	23.8	60.2	75.2		28
	20	7.33	27.4	61.0	79.4	X	12
	21	7.25	23.1	60.0	78.1		12
	22	7.67	39.0	60.3	77.7		6
	23	7.47	31.9	63.5	73.1		15
	24	7.07	36.9	64.5	66.6		15
	25	7.89	24.0	64.2	79.7	X	9
	26	8.83	39.0	63.6	70.8		6
	27	8.58	35.0	63.5	73.1		12
	28	8.75	35.1	63.8	71.5		12
	29	9.00	7.7	58.0	76.8	X	6
	30	9.00	9.2	55.6	84.4	X	6
May	1	7.33	11.2	55.2	82.7		3
	2	8.67	26.3	56.3	78.5		6
	3	8.33	30.4	57.5	82.6		9
	4	8.33	22.5	59.9	80.6	X	3
	5	9.00	35.6	62.5	73.1		12
	6	9.33	15.0	58.9	74.3	X	6
	7	8.33	18.0	58.4	86.4		3
	8	8.75	39.7	52.8	73.3		12
	9	9.17	16.9	59.8	76.7		6
	10	9.00	10.6	58.4	87.2	X	6
	11	8.33	12.3	57.4	87.4		6
	12	9.67	41.5	64.8	70.8		3

Table A (continued)

Date		Mean keeping in days	Measured light b/	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
May	13	9.44	19.8	65.3	66.7	X	9
	14	9.00	26.9	64.7	72.3		6
	15	9.67	29.4	66.0	67.1		15
	16	9.60	23.7	65.1	71.3		15
	17	10.56	42.5	65.1	75.5	X	9
	18	10.13	41.5	68.0	68.7		15
	19	10.50	43.1	70.6	70.9		12
	20	9.72	25.9	69.8	62.3		18
	21	9.92	33.9	72.0	63.9	X	12
	22	11.22	19.0	65.0	67.6		18
	23	9.92	37.3	59.5	84.7		12
	24	10.65	35.9	62.6	68.2		17
	25	11.27	38.1	66.2	62.7		23
	26	11.40	33.8	65.1	75.4	X	18+
	27	10.93	42.7	66.4	58.8		18+
	28	11.13	44.5	66.6	40.8		31
	29	12.20	41.0	65.2	58.3		20
	30	12.67	39.0	68.3	64.7		20
	31	11.00	42.8	68.1	57.6		20

a/ Light visually rated from 5 (sunny) to 1 (cloudy).

b/ Measured light was taken directly from daily recording charts and measurements are relative within years only. Temperature and humidity were recorded at plant level by a Foxboro hygrothermograph. Temperature is in degrees F and humidity in per cent of saturation.

Table B. Mean daily cut flower life with light, temperature, humidity, watering and production records (1954-1955).

Date		Mean keeping in days	Measured light b/	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
October	4		6.5				

Table B. (continued)

Date	Mean keeping in days	Measured light b/	Mean temper- ature	Mean relative humidity	Watered	Number of flowers cut
October 5		14.9	62.0	93.5		
6		4.5	57.0	95.4		
7		16.4	61.0	92.2		
8	8.33	16.9	66.8	88.4	X	15
9	8.13	15.5	66.8	84.9		15
10	7.89	13.2	63.0	86.6		9
11	7.83	16.8	62.9	85.8		6
12	7.67	16.8	61.9	80.0		4
13	7.67	16.1	57.9	86.3		9
14	7.44	21.3	58.0	85.8	X	9
15	7.22	21.0	57.9	82.5		9
16	7.25	21.0	62.7	84.5		12
17	8.11	20.7	64.9	82.5		18
18	8.07	14.9	60.0	88.0		15
19	7.80	20.0	66.5	79.6		19
20	8.11	19.5		85.0		9
21	8.00	19.2		87.3	X	21
22	7.42	19.4	61.0	85.8		12
23	8.20	18.7	62.0	86.8		20
24	8.40	3.9	56.0	93.0		20
25	8.00	8.3	55.9	93.0		12
26	7.93	13.1	56.2	89.8		23
27	8.07	17.3	58.6	85.7		19
28	7.89	16.1	58.8	88.4		9
29	7.33	16.4	58.1	86.8	X	12
30	7.73	16.9	60.0	88.5		15
31	7.89	10.5	56.5	88.0		18
November 1	7.67	15.8	58.6	84.9		9
2	7.40	15.8	60.0	85.8		28
3	7.00	15.9	59.0	88.5		15
4	7.00	15.2	59.7	91.4		18
5	7.25	14.5	61.0	87.9	X	12
6	7.20	15.3	62.7	88.7		15
7	7.53	15.2	62.0	87.2		23
8	7.61	13.2	60.1	88.0		18

Table B. (continued)

Date		Mean keeping in days	Measured light b/	Mean temper-ature	Mean relative humidity	Watered	Number of flowers cut
November	9	7.60	14.2	60.1	88.7		22
	10	7.83	14.5	62.5	86.2		12
	11	8.20	12.0	58.1	89.0	X	15
	12	8.00	12.8	59.3	84.7		15
	13	7.67	4.5	56.7	90.8		23
	14	8.33	13.1	61.5	79.2		6
	15	7.67	7.5	56.9	84.0		23
	16	7.67	11.7	58.9	87.9		9
	17	7.27	12.6	57.8	81.7		29
	18	7.47	11.7	57.3	89.6		18
	19	7.73	11.8	59.0	89.7		24
	20	8.07	11.3	60.3	83.0	X	18
	21	7.93	10.5	57.3	86.5		15
	22	7.73	11.1	59.9	87.0		21
	23	7.47	10.8	58.8	90.2		19
	24	7.33	10.5	56.4	89.4		15
	25	7.73	9.1	57.7	92.9		25
	26	7.80	10.5	56.7	86.3		15
	27	7.75	9.1	56.7	80.9		12
	28	8.53	9.1	54.9	85.8		15
	29	7.89	4.2	54.2	90.5	X	9
	30	7.78	9.7	56.2	89.0		9
December	1	7.92	11.3	56.9	85.8		12
	2	8.00	11.3	57.8	86.0		12
	3	7.67	7.7	56.1	94.0		21
	4	7.80	5.4	55.4	96.3		15
	5	7.75	9.1	56.9	91.7		12
	6	7.58	9.7	56.4	90.3		12
	7	7.78	10.6	58.4	89.3		9
	8	8.13	10.6	55.8	78.5		15
	9	8.11	10.5	56.2	81.0	X	9
	10	8.80	9.7	57.2	87.7		15
	11	9.17	9.0	56.4	93.0		6
	12	8.83	10.2	56.4	87.7		6
	13	9.25	8.5	55.9	92.2		12

Table B. (continued)

Date		Mean keeping in days	Measured light b/	Mean temper- ature	Mean relative humidity	Watered	Number of flowers cut
December	14	8.75	9.8	56.2	84.9		12
	15	8.67	9.7	58.1	87.0		15
	16	9.22	8.9	55.8	85.5	X	9
	17	8.50	8.9	55.6	87.5		12
	18	9.60	9.4	57.0	83.4		15
	19	10.00	9.7	58.4	80.7		12
	20	9.56	10.6	58.6	87.1		9
	21	9.67	10.6	58.4	86.8		15
	22	9.13	10.6	58.7	87.5		15
	23	8.71	8.9	58.2	91.7	X	14
	24	8.67	9.7	57.8	92.2		9
	25	8.73	8.3	57.3	93.8		15
	26	8.75	6.2	55.4	96.2		12
	27	8.56	6.7	54.9	89.1		9
	28	9.20	10.7	56.2	81.4		15
	29	8.89	8.9	56.7	85.0		9
	30	9.11	10.8	55.9	91.4		9
	31	8.33	9.1	56.4	85.4		15
January	1	9.20	10.3	56.1	88.5		15
	2	9.73	10.6	57.0	91.3		15
	3	9.13	10.6	57.2	93.8	X	20
	4	9.60	9.1	56.4	90.7		25
	5	9.73	2.1	55.4	94.7		20
	6	8.60	5.5	57.3	88.8		18
	7	8.73	11.7	56.5	85.5		15
	8	8.93	10.8	55.4	86.5		18
	9	8.67	10.7	57.0	86.8		19
	10	8.33	11.1	56.1	87.2		12
	11	9.47	10.6	54.0	87.7		15
	12	9.33	10.5	55.1	87.5	X	15
	13	9.58	11.2	57.8	86.2		12
	14	9.80	11.3	55.8	88.8		15
	15	10.25	11.0	56.4	82.5		12
	16	9.56	7.2	54.5	92.4		18
	17	8.67	7.7	55.1	92.6		9

Table B. (continued)

Date		Mean keeping in days	Measured light b/	Mean temper- ature	Mean relative humidity	Watered	Number of flowers cut
January	18	9.11	11.3	56.1	88.2		9
	19	9.11	11.3	56.2	85.8		6
	20	9.25	11.2	56.4	86.3		12
	21	9.33	10.6	55.1	85.7	X	6
	22	8.33	11.9	55.3	83.6		9
	23	8.93	7.7	54.5	86.0		15
	24	9.89	11.0	55.4	89.9		9
	25	9.67	11.1	57.2	88.2		9
	26	9.33	9.4	56.2	91.9		17
	27	10.60	8.9	55.4	91.7		15
	28	10.50	11.1	57.8	86.5		12
	29	9.67	12.6	57.0	90.3		15
	30	10.78	9.7	56.9	92.9	X	9
	31	9.75	7.5	55.6	94.3		12
February	1	10.40	11.3	57.0	92.7		15
	2	10.27	4.5	54.9	95.6		17
	3	9.33	7.6	55.4	80.5		9
	4	9.33	11.7	56.2	86.3		15
	5	9.42	14.2	57.4	84.7		12
	6	9.89	14.8	57.8	83.4		9
	7	9.63	12.0	56.9	85.8		16
	8	8.87	15.3	59.1	84.3		22
	9	9.53	10.2	56.7	91.4		15
	10	9.67	14.2	56.2	82.3		9
	11	9.67	15.5	59.0	81.6		15
	12	10.44	8.3	55.2	91.0		9
	13	10.20	15.5	59.2	87.3		15
	14	9.83	12.8	58.4	90.8		18
	15	10.11	7.2	56.9	96.1		9
	16	9.00	15.8	59.1	90.8		9
	17	9.87	12.4	58.6	92.2		15
	18	10.20	4.2	54.8	93.3		15
	19	10.27	2.5	54.3	83.0		15
	20	10.00	15.0	57.0	71.9		9
	21	9.75	16.4	57.8	77.0		12

Table B. (continued)

Date		Mean keeping in days	Measured light b/	Mean temper-ature	Mean relative humidity	Number of flowers cut
February	22	9.56	16.1	59.0	78.0	8
	23	9.25	14.0	58.4	86.4	14
	24	9.00	17.1	58.8	76.2	12
	25	8.20	15.8	59.7	73.8	25
	26	8.60	5.8	55.9	85.5	24
	27	8.83	15.0	57.8	80.6	14
	28	8.53	16.0	57.2	64.2	21
March	1	8.60	17.4	60.5	75.6	17
	2	8.80	12.6	56.4	77.9	28
	3	9.08	17.7	58,4	80.3	13
	4	8.78	12.4	58.8	79.6	10
	5	9.33	17.1	58.4	80.7	4
	6	9.60	14.4	57.4	77.9	15
	7	9.22	18,3	58.4	80.3	8
	8	8.78	18.9	61.8	76.8	12
	9	8.56	18.7	62.6	70.5	9
	10	8.80	15.5	58.5	81.0	11
	11	9.13	19.4	59.5	69.4	15
	12	9.17	18.3	60.9	75.1	12
	13	9.89	13.4	60.2	78.4	7
	14	10.40	16.4	58.1	80.6	7
	15	9.53	6.2	60.3	80.3	11
	16	10.42	15.5	59.0	82.2	10
	17	10.67	21.0	57.4	83.8	10
	18	10.73	13.2	60.2	77.1	15

b/ Measured light was taken directly from daily recording charts and measurements are relative within years only. Temperature and humidity were recorded at plant level by a Foxboro hygrothermograph. Temperature is in degrees F and humidity in per cent of saturation.

Table C.--WEEKLY RANGE OF KEEPING ROOM TEMPERATURES.

1953	
Sept. 1	67-72
Sept. 8	67-69
Sept. 15	66-68
Sept. 22	66-68
Sept. 29	66-68
Oct. 6	68-70
Oct. 13	67-69
Oct. 20	67-69
Oct. 27	68-70
Nov. 3	67-69
Nov. 10	67-69
Nov. 17	65-69
Nov. 24	66-68
Dec. 1	66-68
Dec. 8	64-68
Dec. 15	63-67
Dec. 22	64-66
Dec. 29	64-66
1954	
Jan. 5	65-67
Jan. 12	64-65
Jan. 19	64-68
Jan. 26	67-68
Feb. 1	66-68
Feb. 7	68
Feb. 14	64-68
Feb. 21	64-65
Feb. 28	60-70
March 7	69-72
March 14	69
March 21	67-69
1954	
March 28	66-69
April 4	70-72
April 11	-----
April 18	70-73
April 25	67-70
May 2	66-68
May 9	66-68
May 16	66-69
May 23	64-66
May 30	64-67
June 6	66-69
June 13	66-69
Oct. 17	68-69
Oct. 24	68
Oct. 31	67-69
Nov. 7	68-70
Nov. 14	68-70
Nov. 21	68-69
Nov. 28	66-68
Dec. 5	66-68
Dec. 12	65-66
1955	
Jan. 2	64-66
Jan. 9	64-66
Jan. 16	64-66
Jan. 23	65-66
Jan. 30	63-65
Feb. 6	64-65