Table 3. Arbitrary quality ratings of flowers harvested from chemically and from biologically controlled plants.

Treatments	Avg/Points/Judge A	B	Mean[z] points
Biological	40	38	39
Bio-Chem	46	38	42
Chem-Bio	42	36	39
Chemical	34	42	38
Check	22	18	20
LSD (1%)			9.0

[z]A 1-6 rating scale used with 54 points possible for 9 flowers/treatment plot.

continually from the bottom to top. Eliminating "nonplant" surface area on benches would increase efficiency of searching. Lacewing larvae scare or knock aphids from the plants thus making constant searching necessary for effective control.

Snapdragons are normally staked or wired. This helps lacewing larvae overcome mobility problems caused by pubescence on the lower stem and flower buds. Also, if release of lacewings were timed correctly, aphid populations could be suppressed before snapdragon buds develop hairs.

In these experiments lacewing larvae were less effective at 21°C than at 24°C the first 2 weeks following a release, but control was effective by the third week at 21°C (Fig. 5). Larvae developed to the 3rd instar stage several days later in the cool than in the warm greenhouses. Searching activity of larvae also appeared to be slower at cooler temp. Response of lacewing larvae was better at 24° than at 21°C, but 21°C is the recommended temp for growing high quality snapdragons. Higher temp could be maintained during vegetative growth stages to increase larvae effectiveness, but temp should be reduced during flower initiation and development.

In summary, lacewing larvae are capable of suppressing aphids below economically damaging populations on snapdragons. An integrated insecticide spray and lacewing program also appears promising. Effects of temp, and perhaps other controllable environmental factors, on lacewing activity needs more study. Also, the economics of different treatments and sampling techniques need to be assessed to improve efficient control in greenhouse snapdragon production.

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Water Uptake Rates by Cut Roses (*Rosa hybrida*) in Light and Dark[1]

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Abstract. The rate of absorption of distilled water by individual 'Forever Yours' cut roses was measured in continuous light (720 ft-c) and total darkness. Maximum water uptake in light (1.5 to 3.5 ml/hour) was found 24 to 48 hour (hr) after harvest followed by a gradual decline, while the lower (0.18 to 0.47 ml/hour) uptake in the dark persisted during the 120 hour study. Alternating 12 hour light and dark periods for 120 hours in a second study showed absorption rates change rapidly from light to dark or dark to light exposure. Statistical correlations were made among cut rose morphological parts and the rate of water uptake. Leaf area was found to be the factor most closely associated with water uptake in both light and dark. Anatomical studies revealed overall tissue degradation in rose stems kept in distilled water 5 days.

Water uptake by cut roses is variable when flowers are fresh with a continual decline as the roses senesce[4]. The quantity of water taken up is important to cut flower life only when transpiration losses exceed uptake and wilting begins. Weinstein (5) found rose petal fresh wt in distilled water increased until the rose was fully open, then decreased until petal abscission. Kuc[3] reported water translocation in cut rose stems decreased steadily until uptake stopped completely at day 5 and fresh wt declined. She concluded that physiological plugging reduced transport through the stem Later Durkin (2) using stem sections reported that plugging of the rose stem vascular system was caused by oxidation of naturally occurring stem tannins by the enzyme, peroxidase.

Our investigation was undertaken to accurately measure the rates of water uptake of individual intact cut roses 'Forever Yours', under constant or alternating light and dark regimes during their vase-life and to determine the contribution of each morphological factor to water uptake.

Materials and Methods

Greenhouse grown 'Forever Yours' roses cut at the commercial harvest stage were immediately placed in water, brought into the laboratory and recut under water to 37.5 cm stem lengths. This procedure insured no air blockage of the conducting tissue. Eight uniform roses each with one 5-leaflet leaf and 1 or 2, 3-leaflet leaves were selected and individual flowers were placed in distilled water in a potometer as shown

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[2]The technical assistance by V. E. Shull, E. R. Emino, G. J. Gogue, and R. L. Hatch and financial assistance by Roses Inc. are gratefully acknowledged.

[3]Kuc, Ruth H. 1964. Nitrogen and organic acid metabolism of aging 'Better Times' roses. Ph.D. thesis, Purdue University, Lafayette, Indiana.

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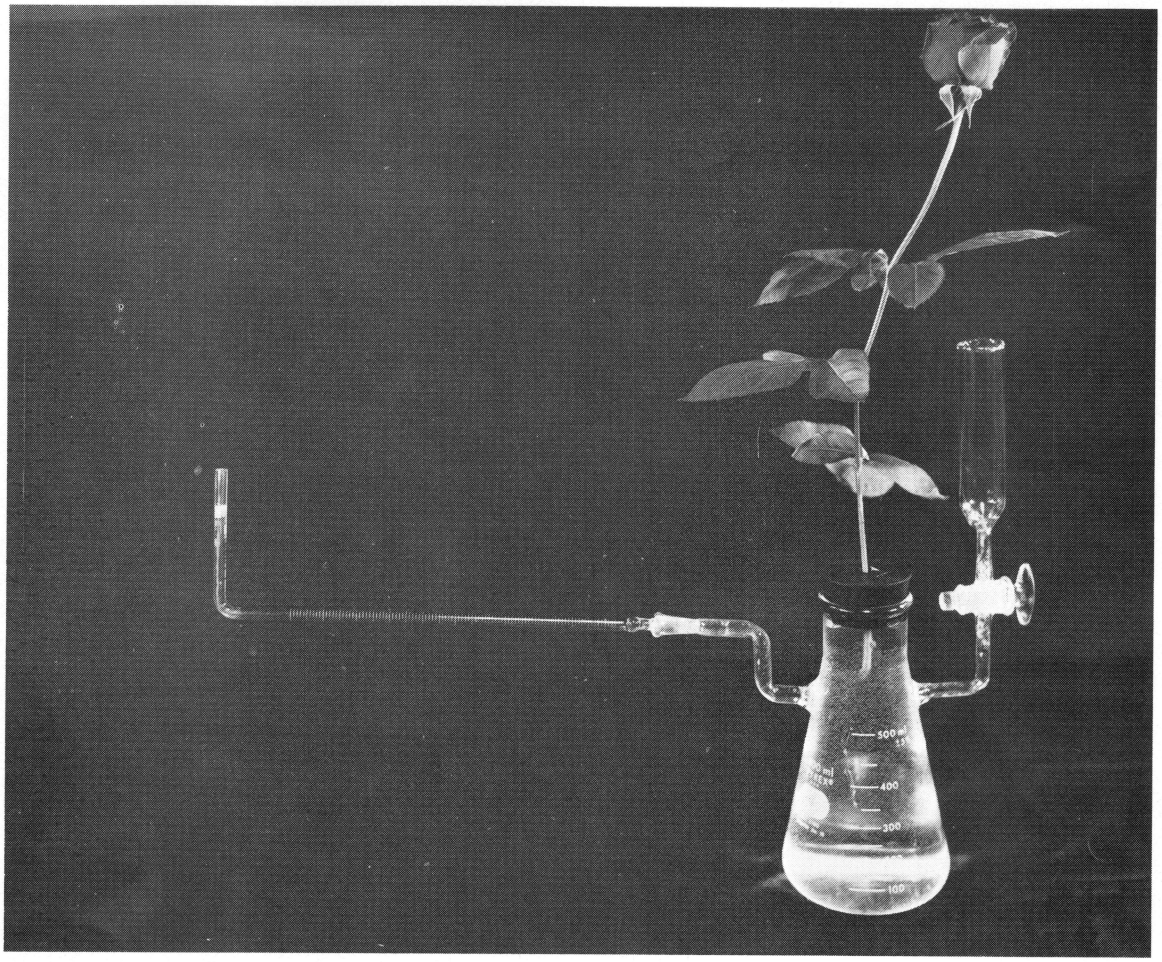

Fig. 1. Potometers with side arms calibrated to 0.01 ml were used to measure the rates of distilled water uptake by individual cut roses.

in Fig. 1. A side arm calibrated to 0.01 ml was utilized to measure the rate of water uptake. Four potometers were placed in each of 2 controlled environment chambers at constant 20 ± 1°C and 55 to 70% relative humidity (RH). Roses in one chamber received continuous dark during the 120 hr study while those in the second chamber received 720 ft-c of continuous illumination from daylight fluorescent and incandescent lamps. Two and 3 readings hourly were taken on each rose; each reading consisted of the time in minutes and seconds needed for each rose to take up 0.1 ml of water.

In a second study, 8 cut 'Forever Yours' roses were given alternate 12-hr periods of light (720 ft-c) and dark. Four potometers were kept in each controlled environment chamber at 20 ± 1°C and 55 to 70% RH, and the time needed to take up 0.1 ml of water was measured continuously for 120 hr.

Sixty-six freshly cut 'Forever Yours' roses were used in a third study to correlate the morphological factors of each cut rose with its rate of water uptake in light or dark. Each flower was placed in 100 ml of distilled water sealed in a graduated cylinder. Thirty-three roses were placed in each controlled plant environment chamber at 20 ± 1°C and 55 to 70% RH. Flowers received alternate 12 hr periods of light (720 ft-c) and dark during the 72 hr study with total water uptake for individual flowers measured after each 12 hr in light or dark, before reestablishing water levels. At the termination of the study, each individual stem diameter and length, leaf area, and leaf, stem, and flower dry weights were measured.

Data for studies 1 and 2 were analyzed statistically to determine the rate of water uptake in light and dark, and to determine the rate of change with light conditions during the 120 hr study. Data from study 3 were analyzed by a reverse elimination regression statistical procedure to determine the most significant morphological factor correlated with water uptake.

Stem cross-sections from freshly cut roses were compared with those in distilled water for 5 days. Five successive 1 cm segments were removed beginning at the base of each stem Care was taken to insure the selection of similar anatomical segments Each stem segment was killed and immediately fixed in FAA, aspirated overnight and dehydrated (4). Following paraffin infiltration, serial sections of 5 μm were cut, mounted on glass slides, and stained with Safranin - Fast Green before viewing with a bright field microscope.

Results

Water uptake in continuous light by cut roses significantly exceeded those in the dark during a 120 hr period (Fig. 2). Considerable variability in water uptake was found among the individual flowers in the light, but trends were similar with maximum water absorption during the first 48 hr followed by a gradual decline. The gradual decline in water uptake rates for roses in the light was found to be highly significant. The rate of water uptake by cut roses in the dark was not significantly different over the 120 hr period.

Water absorption rates of roses rapidly increased during the first hr of light following 12 hr in the dark, and similarly large reductions in water uptake resulted when lighting was discontinued. Alternating 12 hr of light and 12 hr of dark, approximating natural daily changes, resulted in the water uptake pattern shown in Fig. 3. Water uptake was highest during

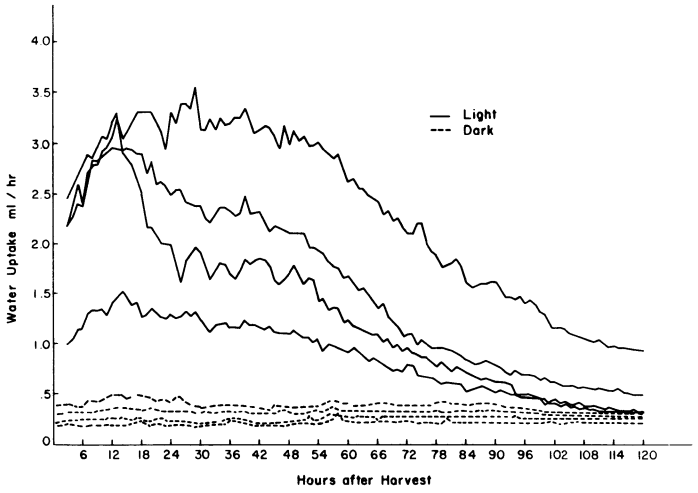

Fig. 2. Water uptake rates in continuous light or dark by individual cut roses during 120 hr.

the first 2 to 4 hr of the light period with a small decline during the remainder of the period. Generally, minimum water uptake was found 2 to 4 hr after the beginning of a dark period followed by a gradual increase. Water uptake and the effects of alternating light and dark periods diminished over the life of the cut rose. The highest water uptake was achieved in the light and lowest uptake in the dark during day 1 (Fig. 3). During the second day water uptake remained high in the light and frequently exceeded the rates found during the first day, but thereafter uptake rates in the light declined daily. In the dark, water uptake rates increased only slightly from nights 1 to 3, then declined. Highest total water uptake was during the second day (24 to 48 hr), due to the slightly higher water uptake rate during both the light and dark periods.

Leaf area of cut roses was found to be the morphological factor most closely associated with the water uptake rates in both light and dark (Table 1). Flower dry wt were also correlated with water uptake in both dark and light. The analysis of variance (AOV) for overall regression indicated the significance between water uptake and leaf area in light was <0.0005, in dark 0.001, and for combined data <0.0005. The AOV's between water uptake and flower dry wt were 0.001 in light or dark and <0.0005 for combined data. Nonsignificance was found among the other morphological factors and water uptake, except for stem length of flowers in the light.

Table 1. Statistical significance from analysis of variance of correlations between cut rose morphological factors and water uptake rates of 66 'Forever Yours' roses.

Treatment	Stem diameter	Stem length	Leaf area	Dry wt flower	Dry wt leaf	Dry wt stem
	Statistical significance					
Light	N.S.	0.019	<0.0005	0.001	N.S.	N.S.
Dark	N.S.	N.S.	0.001	0.001	N.S.	N.S.
Light & Dark	N.S.	0.036	<0.0005	<0.0005	N.S.	N.S.

The simple correlation coefficients showed all morphological factors measured were positively correlated with water uptake (Table 2). Coefficients between leaf area and water uptake were 0.765 in light, 0.561 in dark and 0.751 for combined data. The next best correlations were between water uptake and flower dry wt, and stem length. The regression coefficients provided data for a formula to predict the mean water uptake rate for a cut rose in light during a 5-day period based on these morphological factors.

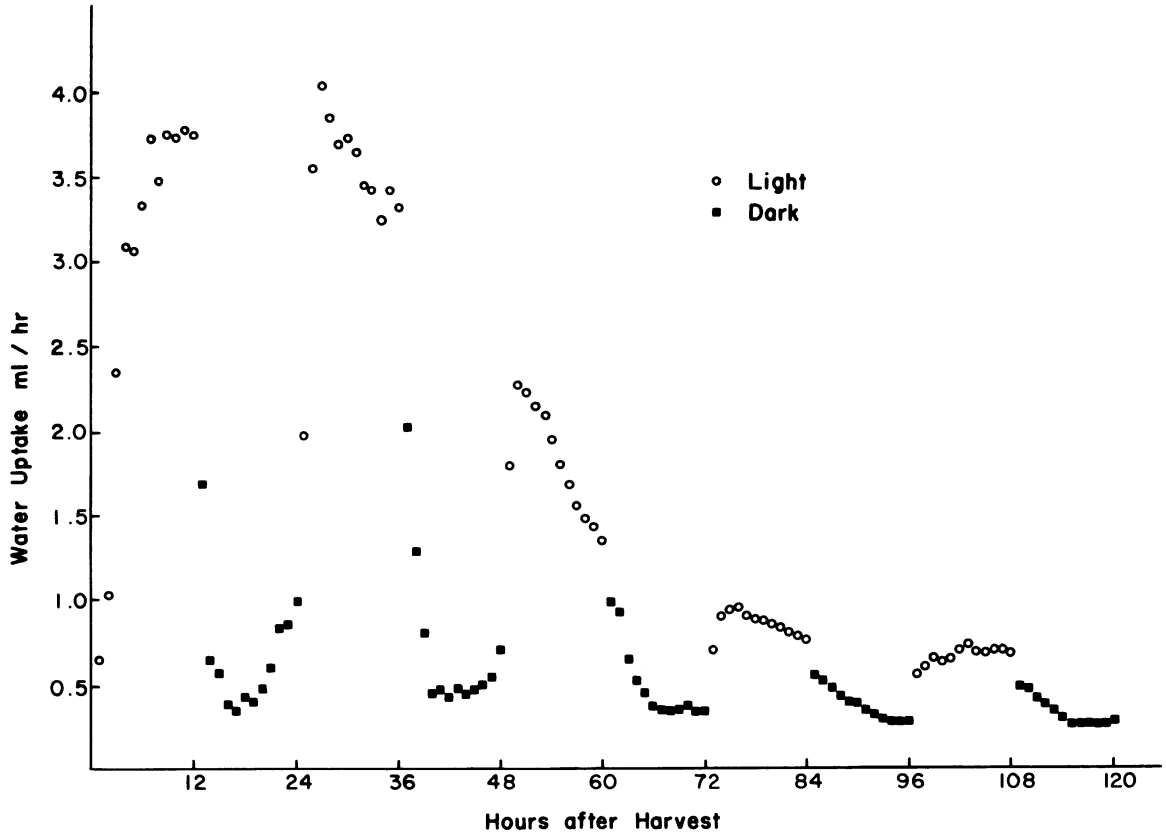

Fig. 3. Mean water uptake of 8 cut roses during alternating 12-hr periods of light and dark.

WA = -29.352 + (15.34 x FW) + (0.799 x SL) + (0.1035 x LA)
WA = mean water uptake rate (ml/hr) in light during 5 days.
FW = flower dry wt (g)
SL = stem length (cm)
LA = leaf area (cm^2)

Cross sections of rose stems taken at the water level, approximately 25 cm below the flower, revealed marked changes in cellular integrity from 0 days (Fig. 4A) to 5 days

Table 2. Correlation of water uptake rate with morphological factors of 66 'Forever Yours' roses.

Treatment	Stem diameter	Stem length	Leaf area	Dry wt flower	Dry wt leaf	Dry wt stem
	Simple correlation coefficients[z]					
Light	.569	.649	.765	.695	.612	.579
Dark	.478	.387	.561	.559	.478	.556
Light & Dark	.570	.621	.751	.692	.591	.594

[z] r values exceeding 0.312 are significant at 0.01.

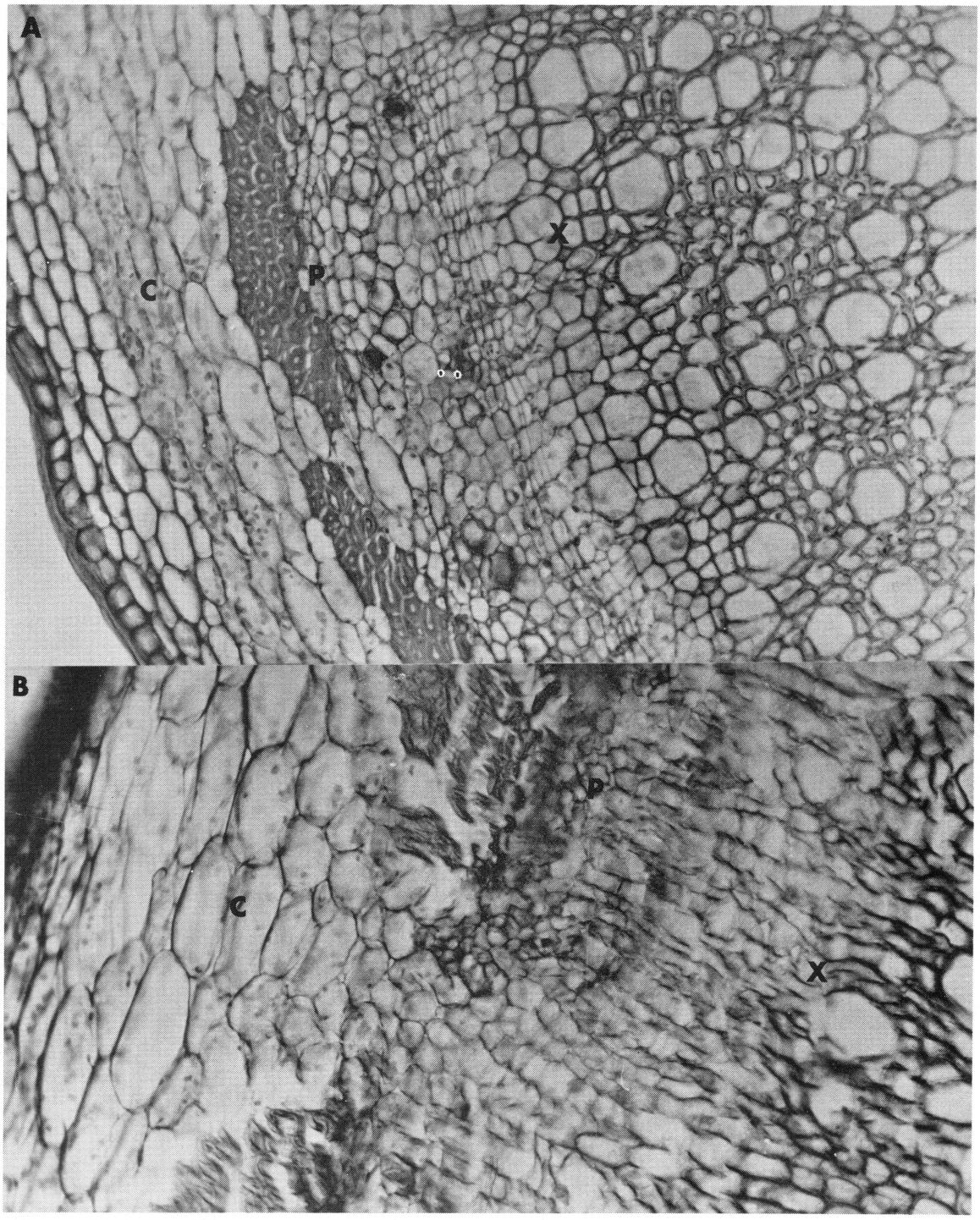

Fig. 4. Cross sections of cut 'Forever Yours' rose stems taken at the water line. A) Control, stem tissue segment removed and fixed immediately after harvest. B) Stem tissue segment removed and fixed 5 days after harvest; magnification 725 times. C, cortex; P, phloem; X, xylem.

(Fig. 4B) after harvest. In the freshly cut rose, all tissues, cells and other organelles are sharp and easily identifiable, i.e., cortex, phloem, xylem, fibers, and chloroplasts (Fig. 4A). After 5 days in distilled water, the tissues were disorganized and were difficult to identify (Fig. 4B).

Discussion

Cut roses held in continuous light for 5 days had maximum water uptake 12 to 48 hr after harvesting. This initial rapid uptake was followed by a gradual decline over the vase life of the rose. There has been considerable speculation as to the nature of this decline in water uptake since it may result in wilting of the petal or wilting of the pedicel resulting in a condition called "bent neck," or it may cause premature senescence. Recent studies have indicated that cut roses may form "physiological" plugs in the vascular tissue which can greatly reduce water uptake and shorten flower life (1, 2, 3). Although water uptake of cut roses kept in continuous light declined after 48 hr in our study, a comparison of the vascular tissue from stem sections 1 to 5 cm from the cut end of 5-day old flowers showed no major breakdown of vascular tissue or any evidence of vascular blockage. Continuous measurement of water uptake revealed no abrupt decline in water uptake in roses kept in continuous light as might be anticipated from the formation of stem tannins or pectin degradation blocking substances.

The consistent pattern for water uptake during the vase life of cut roses in light and the capacity to predict water uptake from the leaf area, flower dry wt, and stem length tend to support the hypothesis that the reduced water uptake after 36 to 48 hr results from natural physiological changes.

The identification of physical blocking substances by earlier workers (1, 2, 3) can be explained on the basis of our anatomical studies combined with the techniques of those investigators in measuring water uptake. The water uptake rates demonstrated in earlier work (1, 2, 3) showed a sharp break in the amount of water passing through a stem segment removed from the cut rose. Such an abrupt change in water flow would, in fact, suggest a physical blockage. The loss of cellular integrity and tissue degradation we observed in the cross sections of cut rose stems suggest that the relatively high vacuum others placed on stem segments (1, 2, 3) would result in "plugs" forming in the vascular tissue. One would expect a high percentage of conducting cells to be plugged under these conditions, whereas, measurement of water uptake as we described would not artificially induce stem blockage. The fact that the rate of water uptake in our system could be turned off and on by alternating dark and light periods coupled with a gradual decrease in water uptake during the light period was strong evidence against a natural physical block.

The observation of blocking "plugs" which stain positive for pectins, etc. (2) can be explained in the same manner; the degraded tissues drawn into most of the conducting elements by the high vacuum would stain positively for pectins and lignins.

Cut roses placed in alternating 12 hr periods of light and dark were capable of doubling water uptake rates in the light within 1 to 2 hr after a dark period. The roses retained this capacity for 72 to 96 hr after harvest. The reduced capability of cut roses to absorb water during each succeeding period of light suggests either a progressive blockage of the rose stems, or a natural physiological slowing down of the cut rose, or a combination of both.

Cut roses kept in the dark had much lower uptake rates than those in light over the duration of the experiment and rates remained uniform under a constant environment. As 12 hr light and dark periods are alternated, the uptake rates during the light periods consistently decline to the level of cut roses held continuously in the dark. During the dark cycle of days 1 and 2, a gradual increase in water uptake occurred after equilibrium had appeared to be achieved. Cut roses kept in the dark retained their water absorbing capacity better than those in continuous light and were thus able to sustain a better balance between water uptake and loss.

"Bent necks" in roses under our conditions occurred usually between 96 and 120 hr under continuous light. Examination of the hourly water uptake rates of the turgid and bent neck roses indicated that this condition developed during the gradual decline, but was not preceded nor accompanied by a rapid decrease in water uptake. The loss in rose petal and pedicel turgidity in a constant environment with a declining water uptake indicated that reduced uptake rather than excessive water loss was responsible. The uniform decline during and preceding the expression of bent neck indicated the water loss had exceeded uptake for a period prior to its appearance. Some roses had good turgidity but were found to have less water uptake than others with semi-wilted petals and bent neck. Roses kept in the dark never developed bent neck. A rose with "bent neck" in continuous light recovered full turgidity when placed in the dark, only to develop the condition again when returned to light. This substantiated again the necessity for water uptake to equal or exceed water loss from the rose, according to its turgidity status.

The significant effect of light on the rate of water uptake by cut roses suggests a possible close relationship between water uptake and cut flower transpiration rate. Light controls cut-flower stomate behavior, as in intact plants, and significantly influences water loss by transpiration when cut flowers are turgid. If cut roses in light lose turgidity because of micro-organisms, blocking substances, or excessive transpiration, then stomate closing would further reduce water uptake as is evidenced by the low rate of water uptake in the dark. Undoubtedly, other environmental factors influence transpiration and modify uptake rates if vascular blockage by micro-organisms is not a factor.

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