COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Photosynthesis in Roses

I. Effect of Light Intensity

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Growth and yield of greenhouse crops result from increases in dry matter formed in the process of photosynthesis. This process involves the simplified formula:

$$6CO_2 + 12H_2O \xrightarrow[\text{solar radiation}]{\text{energy from}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

This is a chemical process which is limited by a number of factors. Temperature, water stress, leaf age, CO_2 concentration, and light energy from the sun are the primary factors, and of these, light is usually most important.

Much work has been done on the effects of light on growth and yields of roses, and this has been found to be the dominant factor controlling variability. Radiant energy from the sun is the primary driving force in the photosynthetic reaction. This study was designed to observe the rate of photosynthesis in roses as it varied with light intensity.

Materials and Methods

The cultivar Forever Yours was used. Normal greenhouse conditions of temperature, humidity, and nutrition were provided with a CO_2 concentration of 500 p.p.m. (normal atmospheric concentration is 300 p.p.m.). Leaves tested were as nearly equal in age as possible, and all plants were treated equally.

The method of determining the photosynthetic rate involved the use of radioactive carbon (^{14}C) in the CO_2. Using the apparatus shown in Figure 1, a part of the leaf was exposed for a short time to the radioactive CO_2. The leaf takes in $^{14}CO_2$ much the same as it takes in normal atmospheric CO_2. As in the photosynthesis formula, depending upon conditions, some of the $^{14}CO_2$ was taken into the leaf and incorporated into sugars. After exposing the leaf to the $^{14}CO_2$, that portion of the leaf that was exposed was immediately removed and the incorporated ^{14}C was removed by digestion. The amount of radioactivity digested from the leaf was determined and served as a direct measure of the CO_2 uptake rate.

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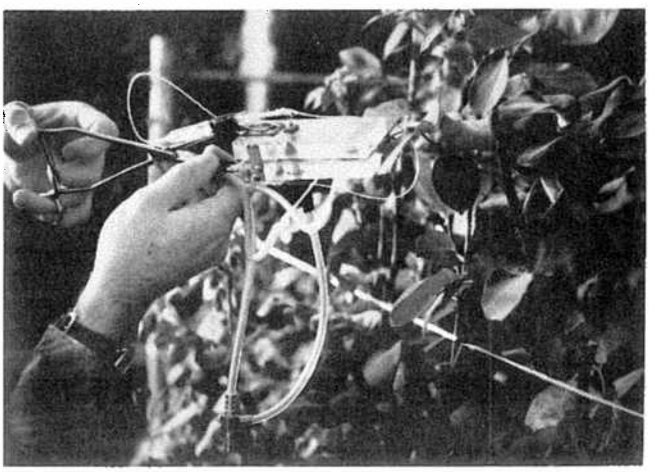

Figure 1. Device used for exposing leaf to radioactive CO_2. When clamp is closed, the gas begins to flow over the leaf. CO_2 is absorbed, and after a time, the clamp is opened and flow immediately stops. The treated area is removed and the amount of radioactivity is determined.

Results and Discussion

Figure 2 is a plot of CO_2 uptake versus increasing light intensity under the environmental conditions of winter. This was probably due to a food buildup within the plants. If healthy blind stems were pinched shortly after the new shoots from their tops had started, which would give the stem some time to accumulate carbohydrates, some of these might return salable flowers.

Forever Yours roses in full production were used. Blind shoots appearing healthy were hard pinched to remove the terminal and any abnormal appearing eyes at one or two nodes below the top. This left a potentially healthy eye at the node of a good five-leaflet leaf. Two sets of pinches were made, referred to as P_1 (first pinch on November 16, 1973) and P_2 (second pinch on January 4, 1974). The P_1 pinches were made on those stems with diameters from 0.09 to 0.21 inch. All of the P_2 blind stems had diameters greater than 0.15 inch. Table 1 shows the pinches made.

Best Stem Diameters To Pinch

Data from P_1 are presented in Table 2, and data from P_2 are shown in Table 4. In determining what stem diameters to pinch to return the highest yields with acceptable quality, Table 3 was arranged from P_1 data. Overall, P_1 yielded 39 flowers from 61 pinches, or a 64% return. Table 3 breaks this down further, and one can see that, by considering those stem diameters larger than 0.14 inch, percent returns increased to 68.3%. For comparison, P_2 was designed to use only those blind stems with the larger stem diameters. Overall yields from P_2 were 18 flowers from 30 pinches, or a return of 60% as compared to the 68.3% from P_1 for stems with the same diameters.

No significant differences between returns from differing stem diameters could be found; thus one might assume that hard pinching all blind stems would return equal yields and quality. However, blind stems with diameters less than 0.13 inch returned 45.5%, and flower quality was slightly lower than that

Table 1. Frequency of hard pinches by stem diameters on both pinch dates.

Stem diameter (in.)	Number pinched P_1	P_2
less than 0.12	7	—
0.12-0.13	4	—
0.13-0.14	9	—
0.14-0.15	6	—
0.15-0.16	9	9
0.16-0.17	9	9
0.17-0.18	9	9
greater than 0.18	8	3
TOTAL	61	30

Table 2. Data recorded from P_1.

Stem diameters (in.)	Total pinches	Flowers returned	Percent return	Average length (in.)	Average weight (oz.)
less than 0.13	11	5	45.5	21.2	9.4
0.13-0.14	9	5	55.5	24.2	10.1
0.14-0.15	6	5	83.3	23.6	9.6
0.15-0.16	9	5	55.5	24.7	10.3
0.16-0.17	9	6	66.7	25.7	12.4
0.17-0.18	9	6	66.7	27.3	12.1
greater than 0.18	8	6	75.0	26.9	12.3
TOTAL	61	39			
MEANS			64.0	25.0	10.9

Table 3. Yield data from selected stem diameters from P_1.

Stem diameters pinched (in.)	Percent flower return	Average length (in.)	Average weight (oz.)
All stems	64.0	25.0	10.9
All larger than 0.13	66.0	25.4	11.2
All larger than 0.14	68.3	25.7	11.4

Table 4. Data recorded from P_2.

Stem diameters (in.)	Total pinches	Flowers returned	Percent return	Average length (in.)	Average weight (oz.)
0.15-0.16	9	7	77.8	23.2	11.2
0.16-0.17	9	3	33.3	21.0	[illegible].4
0.17-0.18	9	6	66.7	23.9	9.6
greater than 0.18	3	2	66.7	25.8	12.1
TOTAL	30	18			
MEAN			60.0	23.4	10.4

this experiment. The units of CO_2 uptake are in milligrams of CO_2 absorbed per square decimeter of leaf area per hour (1 dm^2 = about 16 sq. in. and 1000 mg = 0.04 oz.). Light units are in foot-candles, full sunlight being about 10,000 ft.-c.

As seen in Figure 2, CO_2 uptake rates increased as light increased. At about 3400 ft.-c., or just over 1/3 full sunlight, the photosynthetic rate peaked. This may be called the light saturation point, or that light intensity beyond which no more increases in CO_2 uptake were seen, under this set of conditions. The graph shows a decline past 3400 ft.-c., indicating that conditions were not as favorable for photosynthesis.

It was found that the main factor causing this decline in CO_2 uptake was increasing water stress in the plants. It is commonly known that as light increases during the day, thereby increasing the drying of the air in the greenhouse, water losses increase. Water absorption at the roots is not fast enough to make up for the water lost from the leaves. The higher the light intensity, the greater the effect, and consequently, the increasing water stress begins to limit photosynthesis.

This further substantiates the need for shading glasshouse grown roses during the summer months. If too much light is present, water stress will cause a decline in CO_2 uptake, as well as leaf burn and slight symptoms of wilt in young growth.

Under normal CO_2 levels (300 p.p.m.), it has been speculated that rose leaves are light-saturated at about 2500 ft.-c. In this work (with 500 p.p.m. CO_2), the saturation point was found to be 3400 ft.-c., suggesting that rose leaves are capable of using more light energy if the CO_2 concentration is increased. This has been found true in potatoes. As CO_2 levels in the air increased, the light saturation point (peak of photosynthesis curve, such as in Figure 2) increased in potatoes, and the quantity of photosynthesis also increased. If roses were under CO_2 levels even higher

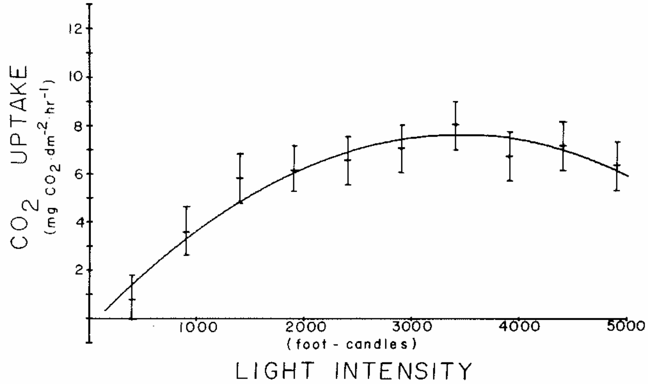

Figure 2. Rose photosynthesis as it varies with increasing light intensity under normal greenhouse conditions and 500 p.p.m. CO_2. The vertical bars show the amount of variation encountered. Any two means are significantly different from one another at the 5 percent level if their "tails" do not overlap. (Average number of samples per mean = 10.8.)

than 500 p.p.m., it is expected that the saturation point in Figure 2 would shift more to the right, peaking at a higher light intensity, and the rates of CO_2 uptake would also be higher. Work on this is scheduled to be done at Colorado State University.

Summary

The main point to consider is that photosynthesis is affected by many factors. All the factors act together to influence CO_2 uptake, and a change in one is usually accompanied by a change in another. The key factor, however, is light intensity, because it affects not only photosynthesis, but also temperature, humidity, and water loss from the soil and the plant. The results suggest that greater light utilization may be achieved by increasing CO_2 concentrations. Where CO_2 is injected, increasing care should be used in applying shade to greenhouses.