Colorado Flower Growers Association Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY

Doris Fleischer, Executive Secretary

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Carbon Dioxide Increases Growth of Greenhouse Roses

By W.D. Holley and Kenneth L. Goldsberry

The addition of carbon dioxide to the greenhouse atmosphere from November to May increased yield of roses the first 18 weeks of the year by nine percent. Stem length and head size were increased so that lower grades of roses were reduced and grades from 18-inch up were increased from 57 to 363 percent when compared to a base year.

The greenhouse used in this investigation is 36 feet by 40 feet, having six benches or a total of 750 square feet of bench area. The contents of the greenhouse are approximately 20,000 cu.ft. The rose varieties Red Delight, Pink Delight, Gorgeous, and Better Times planted in four of the benches served as test plants from which yield and grade records have been kept for a number of years. Little or no holiday pinching is done on these plants. They are cut continuously 52 weeks per year.

The year 1959 is used for a base year since solar energy was normal during this winter at approximately 50,000 gram calories per cm^2 from January 1 to May 10.

Goldsberry and Holley (1) published measurements to show the low levels of carbon dioxide in this rose house on days when there was no ventilation. Following this work, carbon dioxide was added to the house a total of 25 days from January 27 to February 28, 1960. CO_2 was also added on four scattered days in March. This CO_2 addition was made during the darkest period on record for this time of the year. Yield of roses in the March-April period following indicated positive results.

Beginning November 4, 1960, and continuing until May, 1961, carbon dioxide was metered into this rose house a total of 130 days. Heaviest application was possible in December, January and February when the house remained closed most of the time. Gas was added by time clock from 9 am to 3:30 pm unless the ventilators were opened. Approximately 1900 cu.ft. of carbon dioxide was added in the 130 days.

Table 1 shows yield and grade of roses from the four benches for the first 18 weeks of the base year 1959, and the two succeeding years. A distinct increase in the longer grades and a corresponding decrease in the shorter grades of roses is indicated from additions of carbon dioxide. When comparing 1961 to the base year 1959--

- 9" roses were reduced by 67 percent
- 12" reduced by 52 percent
- 15" reduced by 12 percent, while
- 18" roses were increased by 57 percent,
- 21" increased by 127 percent, and
- 24" roses were increased by over three-fold.

Total yield for this period increased nine percent.

The addition of about one-third as much carbon dioxide in 1960 gave intermediate results between the base year and 1961.

Table 1. Effects of added carbon dioxide on yield and grade of four varieties of roses the first 18 weeks of the year.

Year	Grade 9"	12"	15"	18"	21"	24"	Total yield	Mean stem length inches	CO_2 added cu ft	Solar energy grm. cal./cm^2
1959	676	1220	1443	897	430	181	4847	14.8	none	50,884
1960	454	1030	1423	1122	582	348	4959	15.8	561	49,833
1961	223	580	1270	1411	966	838	5288	17.7	1899	50,302

The monthly mean CO_2 concentrations in the atmosphere of this house are shown in Fig. 1. These means were calculated from measurements taken at 30 minute intervals with an infra red gas analyzer and include the hours from 9 am to 3:30 pm. Since no gas was added during the 1958-59 year, the curve is probably typical for the CO_2 levels in a rose house in Colorado. The mean concentration is considerably below outside levels and decreases as light increases from December to March. Days sufficiently warm to require ventilation increase this mean since incoming outside air is higher in CO_2 content.

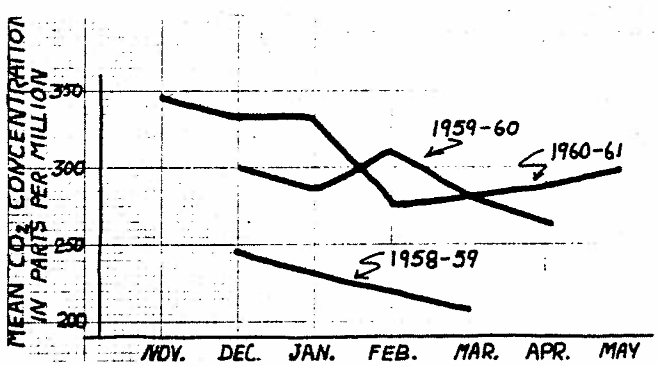

Fig. 1. Mean monthly carbon dioxide concentrations in a rose house for three cropping years. Averages calculated from measurements taken at 30 minute intervals from 9 am to 3:30 pm.

Carbon dioxide was added only 3 days during January, 13 days in February and 4 days in March of 1959-60. Ventilation on all other days tended to keep the average level up near that of outside atmosphere. The mean CO_2 levels for the year 1960-61 were higher than those the preceding year except in February and March. The rate of CO_2 flow was not quite high enough in February 1961. After February the amount of CO_2 added is limited by outside temperatures, if the addition is made only to closed houses.

Measurement of Carbon Dioxide

Instruments for accurately measuring the small amounts of carbon dioxide in the atmosphere are far too expensive for commercial use. Research at Colorado State University has shown that this measurement is not essential to the practice of atmospheric fertilization with carbon dioxide. It is possible to make recommendations of amounts of carbon dioxide to add depending upon light, and whether or not the greenhouse is closed.

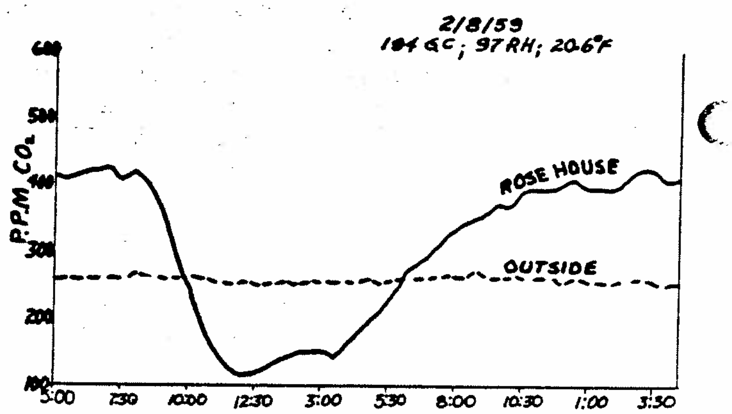

Fig. 2. The carbon dioxide concentrations in a rose greenhouse measured at 30-minute intervals on February 8, 1959. Total solar energy for the day -- 194 grm. cal/cm^2. Mean relative humidity outside -- 97%. Mean outside temperature -- 20.6°F.

A study of the normal daily fluctuations of CO_2 concentration within a closed rose house shows the time of day when CO_2 is most likely to be limiting. Figure 2 shows the hourly concentration on a winter day. The outside temperature was low so the house remained closed, although light was reasonably high for this time of the year at 194 grm cal/cm^2. The level before daylight was around 400 ppm because carbon dioxide accumulates during the night from the respiration of plants and the decomposition of organic matter in the soil. At daylight the CO_2 level began a sharp decline as plants began making sugar. By

10 am the level was approximately equal to that of the outside atmosphere and by 11:30 it had reached 125 ppm, where it remained until 3:30 pm. At near this level growth just about stops as plants are releasing the same amount of CO_2 in respiration that they are using in photosynthesis. As light decreased later in the day, CO_2 again accumulated and remained high during the night.

Amounts to add

Any time between 9 am and 3:30 pm that ventilators are closed the carbon dioxide concentration within the house may be less than that outside. It is during this time of day that the most value can be gained from adding CO_2. From repeated tests and measurements the addition of 2 cu ft of carbon dioxide per hour per 10,000 cu ft of greenhouse should maintain 300 to 500 ppm on a normal to dark day. On brighter days 3 cu ft per hour should be added.

Sources of Carbon Dioxide

Impurities in carbon dioxide can result in plant injury which will more than nullify the benefits. Carbon monoxide and unsaturated hydrocarbons cannot be tolerated in the gas supply even in trace amounts. Dry ice, bottled carbon dioxide and burning charcoal have been tested at CSU as possible sources. An additional source that should not be overlooked is decomposing organic mulches. One ton of corn cobs will eventually release one and one half tons of CO_2. Liquid carbon dioxide in pure form is available in almost all cities.

Application

Several simple flow meters are available to regulate the amount of CO_2. These are easily automated by use of time clocks and solenoids. Liquid carbon dioxide or dry ice in a converter are used as sources. The gas is conveyed from a central location to the house through copper tubing. A pressure reducing valve at the source of supply is used to reduce line pressure to 100 psi. Figure 3 shows a flow meter, solenoid and time clock used for controlling the flow into one area. When ventilators are opened the CO_2 flow is switched off manually in this case. The flow meter is calibrated to deliver a known amount of gas per hour.

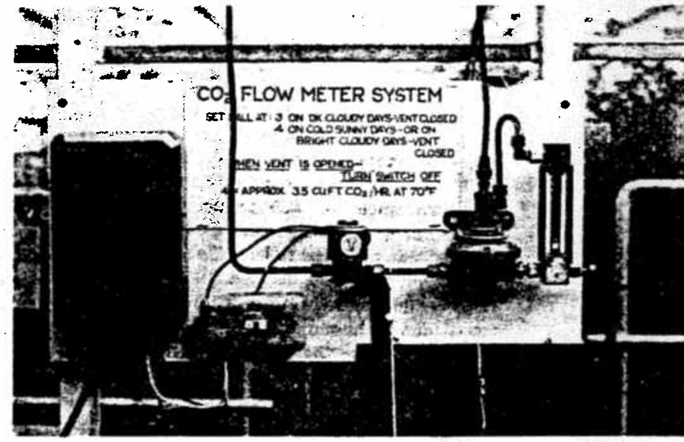

Fig. 3. Flow meter, time clock, manual switch and solenoid used for controlled application of CO_2.

Since CO_2 and air are near the same weight they diffuse together readily. This makes distribution of CO_2 among plants relatively simple. Perforated copper or vinyl tubing has been used in several experiments. One outlet for every 100 rose plants will probably give excellent distribution in a closed house. One perforated plastic tube down the middle of each bench and attached to support wires has been suggested, however this is probably more than is needed for good distribution. Should further research indicate benefits from adding CO_2 to open or partially open houses, a tube for each bench will probably be advisable.

Literature cited

1. Goldsberry, Kenneth L. and W.D. Holley. Carbon dioxide in the greenhouse atmosphere. Colorado Flower Growers Assn. Bul. 119. 1960.

From THE FREEMAN *February 1959*

RICH MAN'S TAX POOR MAN'S BURDEN

HAROLD BRAYMAN

FEW PEOPLE realize it, but 84 per cent of all the revenue obtained by the personal income tax comes from the basic 20 per cent rate and only 16 per cent of the revenue arises from progression. If the income presently taxed in excess of 50 per cent were taxed only at that rate, the direct loss in revenue to the government would be just $734 million, which is approximately one per cent of federal revenue collections.

If all progression were to stop, the encouragement to new enterprise would be so great that, after a slight time lapse, net returns to the government would increase because of an expanding economy and higher revenues from greater economic activity.

Let me illustrate. Although I shall not identify him by name, but refer to him only as Mr. X, this is an authentic case of a wealthy man who was approached by a group of people who wanted him and some associates to put up approximately $7,500,000 for a pulp and paper mill, which they proposed to build in the South a few years ago when there was an intense shortage of paper.

This was the equity capital in a total investment of $25 million, the rest of which a financial corporation was prepared to lend. The pulp supply had been located, the project had been carefully engineered. and it showed the probability of earnings on the total investment, after interest on the senior capital, of $2,500,000 a year. That would have been a 33 per cent return on the $7,500,000 risk capital investment – a very attractive proposal.

But the 91 per cent income tax to which Mr. X and his associates were liable compelled them to turn it down. They pointed out that if they undertook the project, it would mean first that the $2,500,000 annual earnings would be subject to a 52 per cent corporate tax. And then, with a normal payout of about 50 per cent of earnings in dividends, he and his associates would have had left, after paying their own taxes, a net return of 67 cents per $100 of investment – just two-thirds of one per cent. If the entire earnings were paid out in dividends, the net return would be only 1.4 per cent. "No, thank you," he said. "We couldn't take the risk to get that kind of a return." The plant never was built, and the paper it would have made is being imported from Canada.

Now, let us see who was hurt in this instance. Not Mr. X. He eats just as well as if he had gone into this venture. But the 500 to 700 people who would have been employed in the small Southern town where the plant would have been built, and which town, incidentally, needed economic stimulation, have been seriously hurt. Some of them certainly don't eat as well because the 91 per cent tax removed all incentive from Mr. X. The small businessmen and the people of the town have been seriously hurt, because they didn't get the stimulation of a new plant with all the payroll and all the purchases that it would have made in this community.

Now, how did the government make out? Did it get any more taxes out of Mr. X? Not a dime. But if the high-bracket tax rate had been low enough to tempt Mr. X and his associates, and the project had gone through, the government would have received a 20 per cent income tax revenue on the earnings of the 500 to 700 people thus employed. It would have received a corporate tax of 52 per cent on all earnings of the corporation, and income taxes from Mr. X on any dividends declared. And this would have been not just for one year but would have gone on continuously year after year.

The point is that, when you discourage initiative, you put brakes on the economy which hurt everyone – hurt government which doesn't receive revenue, hurt people who are not employed, and hurt small businessmen who don't get the stimulation of increased sales.

Every day across this country, instances such as this occur by the scores, if not by the hundreds, although most of them involve smaller amounts and fewer people. The fact is that people in these high brackets are not interested in acquiring income subject to such a tax if they have to take any risk at all to get it.

The 91 per cent rate hurts most, *not* the people who pay it or who even pay 50 per cent or 40 per cent or 30 per cent, but the people who never come within the length of the George Washington Bridge of paying it at all – the poorest and the most desperate in the country – those who are out of jobs because of this tax. • • •

Mr. Brayman is Director of Public Relations, E. I. du Pont de Nemours and Company. This article is excerpted from his address of November 7, 1958, before the Public Relations Society of America.

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FIRST CLASS