December 2018 Newsletter:

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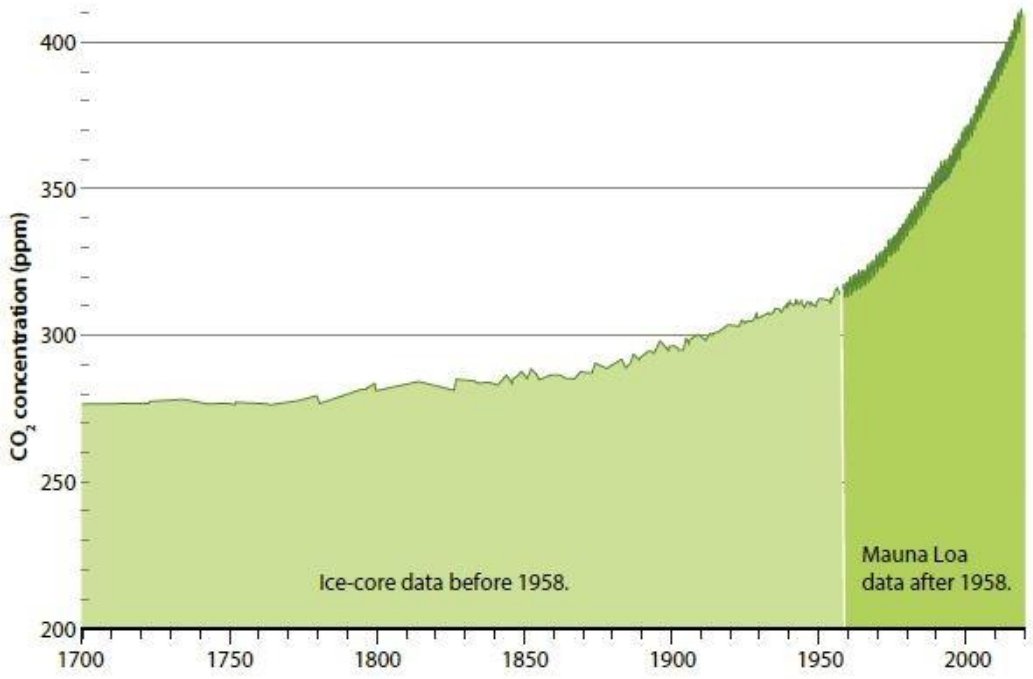
Carbon Dioxide Enrichment in Our Atmosphere and Greenhouses



Carbon dioxide (CO_2) in our atmosphere is dramatically on the rise, and I have experienced it first-hand. An article really struck me that I found in the recently published edition of California Agriculture, "Possible Impacts of Rising CO_2 on Crop Water Use Efficiency and Food Security". There in "figure 1" is a graph depicting the carbon dioxide concentration measured from the year 1700 to the present. It was the dramatic acceleration of atmospheric CO_2 concentration that occurred during my life time that intrigued me **(see the figure).** According to the "State of the Climate" report in 2017, global atmospheric carbon dioxide was 405.0 ± 0.1 ppm in 2017, a new record high.

CO_2 is an essential input for plant photosynthesis, a plant's primary food-making process. I measured CO_2 in greenhouses and in the atmosphere from about 1985 to 1990 when we evaluated the effectiveness of CO_2 enrichment on cut rose productivity and quality in central coast greenhouses. I still have slides (remember them) that indicate the atmospheric CO_2 concentration was 340 ppm!

So what did our CO_2 enrichment evaluation indicate? What is the evidence for or against CO_2 enrichment in greenhouses?

In our first experiment (1985-86) the conventional enrichment method was tested: the greenhouse atmosphere was enriched to 1000 ppm only in the morning and evening when the sun was shining

and greenhouse vents were shut. The data followed: CO_2 enrichment did not improve production or quality of 'Bridal White' cut roses. But some interesting observations directed us to try a different CO_2 enrichment method.

CO_2 monitors within the rose plant canopy demonstrated that CO_2 levels were being depleted to levels as low as 225 ppm during the day, even though vents were opened. Apparently, CO_2 was being absorbed quickly by the leaves and greenhouse air was not moving sufficiently into the plant leaf canopy to replenish the CO_2 to normal levels (at the time, 340 ppm).

A second experiment was set up (1986 -87) to determine if "all day" carbon dioxide enrichment could improve flower production and quality. This time, carbon dioxide was distributed in drip irrigation tubing running along the ground of each production bed. Liquid CO_2 was released as a gas under pressure into the drip tubes when needed. The greenhouse ambient CO_2 level was maintained at about 1000 ppm at sunrise until vents were opened and then again if the vents were closed, up to 2 hours before sunset (as in the 1985-86 experiment). In addition, this time when the vents opened, the CO_2 level *within* the plant leaf canopy was maintained around 350 to 360 ppm. This technique eliminated any reduction of CO_2 under 350 ppm in the leaf canopy, but did not waste much CO_2 since the fresh air around the plant was around 340 ppm and therefore there was no strong diffusion gradient of CO_2 away from the plant. Essentially, the carbon dioxide was only being put where it was being used (near the leaves) and applied only when it was needed.

With this method, from summer to the following late spring, CO_2 enriched rose production increased by 12% over that of the untreated roses. The rose stem length increased about 1-inch above that of untreated roses. These stems had more girth and appeared robust. Flower bud dry weight was greater, so the flowers may have contained more petals or the petal size was larger. At the time, the CO_2 cost was about 18 cents for each extra bud produced. In the heyday of the cut rose business the extra cost may have been worth it, especially during the super profitable Valentine and Mother's Day markets.

The benefit of CO_2 enrichment in climates such as along coastal California is limited because it is difficult to achieve higher than ambient CO_2 concentrations for significant periods of time when the sun is shining. Under conditions of high solar radiation, the necessary prolonged periods of ventilation will limit the potential for CO_2 enrichment. CO_2 application methods and crop species will have an impact on the CO_2 enrichment benefits also. CO_2 delivered directly in and around the leaf canopy has some technical challenges but may have benefits in some crops.

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