

Online Extras

Plants Have No Teeth - Or Do They?

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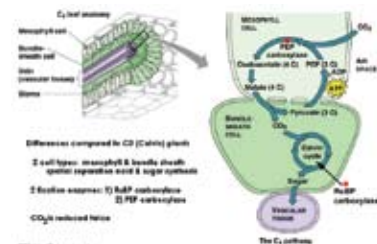
The Optimal Range of CO₂

With CO₂ enrichment above the 350 to 385 ppm CO₂ range found in the atmosphere, plants can produce more carbohydrates for structural purposes and energy conservation, thereby growing more rapidly and larger. Depending on the plant species, enriching with CO₂ under ideal conditions (perfect temperatures, bright lights, no moisture stress), shows benefits up to 1200 to 1600 ppm CO₂. Raising CO₂ above this maximum usable level can cause stomata to close as CO₂ mimics ABA. At overdose levels near 10,000 ppm CO₂, plants grow stunted and malformed due to the exaggerated ABA - CO₂ interaction. (Recall that ABA is the "senescence hormone," which normally makes plants stop growing, drop leaves and become dormant).

The Carbon to Nitrogen Ratio

Generally feeding plants more CO₂ will also increase their mineral nutrient requirements in order to keep up with the higher growth rate. More specifically, healthy growing plants try to maintain an optimal carbon to nitrogen balance in their tissues, so with an increase in CO₂ there is a corresponding need to boost nitrogen levels in the crop's fertigation regimen. If a plant is starved for nitrogen then CO₂ enrichment will not be as effective; for example, if nitrogen levels are so low that protein and enzyme synthesis are decreased, then RuBisCO enzymes levels will also decrease, inhibiting CO₂ from being assimilated at all.

One can measure the carbon to nitrogen ratio at an analytical laboratory by testing the amount of free sugars (for carbon) and the amounts of free amino acids (for nitrogen) in plant tissues. This ratio in a plant will increase as it grows, and a sophisticated grower may know how the ratio is related to the crop's age, and how to target this in the crop's cultural program. Young crops with little photosynthetic tissue require more nitrogen than carbon to grow, so often CO₂ enrichment is not started until plants have grown big enough to benefit from higher amounts of it. Metaphorically the ratio we could have nitrogen as 'gravy' and CO₂ or carbon as the 'mashed potatoes.' There is a point where too much gravy overrides and unbalances the nutritive value of the CO₂ regimen. But conversely without gravy, no carbon gets chewed or swallowed by assimilation.

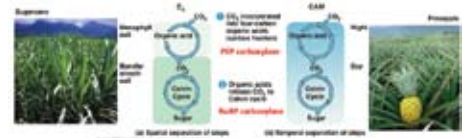


Micro and secondary nutrient feed rates will also be affected by elevated CO₂. Faster growth rates and CO₂ enrichment can induce chlorosis if growers don't also increase feed rates of second-

ary and micronutrients. When enriching with CO₂, higher growth rates dilute nutrient reserves in tissues, and excessive amounts of carbohydrates (CH₂O's) that are made in leaves are exported rapidly to other parts of the plant, like fast growing tips, newly set fruit and to roots. These tissues use and store CH₂O's, but when these extra sugars are exported from the leaves where RuBisCO and photosynthesis are occurring at high rates, there is a tendency for the sugars to take certain minerals away with them creating mineral deficiencies in the older leaves. If these nutrients become deficient, then the most mature and photosynthetically active leaves become chlorotic from lack of these cationic nutrients. Sometimes growers may have to back down the CO₂ enrichment if chlorosis cannot be averted with increased mineral nutrition.

Temperature and CO₂ Assimilation

A meal of CO₂ should be delivered to plants when temperatures are warmer than average, as this is when the RuBisCO enzyme works best.



This is true for all enzymatic processes. Growers have been known to increase their grow room temperatures by 2°C to 3°C when enriching with CO₂. Interestingly, RuBisCO tested in-vitro was found to be quite heat tolerant, with its response to temperature linear. Warmer temperatures up to 45°C continually increase RuBisCO's CO₂ assimilation rate.

However, keep in mind that photochemistry (chlorophyll and energy capture into ATP and NADPH), is actually not tolerant to warmer temperatures. In a typical terrestrial plant, the 'battery-charging' side of photosynthesis slows down as temperatures warm up past 20°C, so plants have developed other ways to quench excess heat produced from photochemistry, namely via chlorophyll fluorescence. Chlorophyll-fluorescence is assisted by transpiration whenever stomata are open. An example of the infrared glow of chlorophyll-fluorescence is shown in figure one. This is a heat-shedding light emitted by all intact chloroplasts after they absorb PAR.

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