# USE OF $CO_2$ IN COLD GREENHOUSES

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Should carbon dioxide ($CO_2$) enrichment of greenhouse atmospheres be discontinued when temperatures are lowered? No!

When severe cold weather occurs, some growers have lowered temperatures to conserve fuel knowing full well that growth will slow down. They then reason that the crops will not benefit from $CO_2$ enrichment so why spend the money for gas. Neither plant physiologists nor greenhouse engineers can agree with this.

From an engineering viewpoint, $CO_2$ does not cost anything. The heat from the gas and accumulation of solar energy at the higher day temperatures practiced with $CO_2$ enriched atmospheres reduce fuel consumption sufficiently to pay for the propane or natural gas used to produce the $CO_2$. This is detailed in the Connecticut Greenhouse Newsletter 77:18-19, January 1977.

From a physiologist's viewpoint, plants do respond to atmospheric enrichment at lower temperatures although the response may be less than at normal temperatures. The following paragraphs treat several arguments substantiating why $CO_2$ should be used even when temperatures are below normal.

The process of photosynthesis is somewhat insensitive to low temperature. In greenhouse crops the limiting factor in photosynthesis is most frequently light or carbon dioxide ($CO_2$) in correlation with the temperature. Greenhouse crops are generally grown at the maximum temperature possible that is commensurate with the food (photosynthate) available in their tissues for an acceptable quality and rate of growth. Lower temperatures generally improve quality but delay production.

Dr. Enoch (1977) has found that the rate of photosynthesis during the day is not influenced in carnation by the temperature of the preceeding night.

Plant growth may be reduced by many factors such as water stress, lack of photosynthate and temperature. Water stress often occurs when roots (and soil) are cold. Lack of photosynthate may be attributed to inadequate translocation, low light and/or insufficient $CO_2$. It is possible to virtually eliminate $CO_2$ as a limiting factor through enrichment of the greenhouse atmospheres to 1000-1500 ppm.

It may be argued that when temperatures are low the slow growth rate will place less demand on atmospheric $CO_2$ supplies and that $CO_2$ will not be as limiting. This is confounded by another plant response, stomatal closure at reduced temperatures which would reduce $CO_2$ diffusion into the stomates. Early in the morning $CO_2$ in the leaf from nighttime respiration will be sufficient. But it could be rapidly depleted and increased levels in the atmosphere would be necessary to permit adequate diffusion of $CO_2$ through the partially closed stomatal apertures.

An opposing factor is the solubility of $CO_2$ (and oxygen) in plant tissues at low temperatures. Solubility is inversely related to temperature. A leaf will probably contain more $CO_2$ when night temperatures are decreased. (Leopold and Kriedemann, 1975). One might argue that $CO_2$ injection may be delayed in the morning following cold nights. This may be valid on a dark day. But when light is available, the $CO_2$ in the tissues is rapidly depleted and the stomatal apertures may not open sufficiently to allow adequate $CO_2$ diffusion into the leaf. Remember that high overnight $CO_2$, low air temperature and cold soil induced water stress all combine to suppress stomatal opening.

A review of the literature discloses some references that may be appropriate for $CO_2$ enrichment at low growing temperatures. Discussing apparent photosynthesis, Miller (1938) states that low temperature coefficients are typical of photochemical reactions (they do not decrease as fast as other chemical reactions when the temperature is lowered). Furthermore "...when light intensity is low, temperature has little effect..." Bidwell (1974) states that "At low temperatures...$CO_2$ concentration is important in regulating photosynthetic rate because it directly influences the dark reactions, which are temperature sensitive." Unfortunately, the references on actual growth in $CO_2$ enriched greenhouse atmospheres stress increasing daytime temperatures. Perhaps some reader can supply further information.

In summary, if the temperature is maintained below that generally considered optimal for a crop, photosynthate should accumulate faster when the atmosphere is enriched by $CO_2$. Quality should improve. And growth should increase.

References

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Enoch, H.Z. 1977. Personal communication.

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