# Elevating Carbon Dioxide in a Commercial Greenhouse Reduced Overall Fuel Carbon Consumption and Production Cost When Used in Combination with Cool Temperatures for Lettuce Production

Greenhouses are typically heated during the winter to maintain winter markets or meet spring consumer demand. Well-sealed and insulated greenhouses reduce the amount of heat loss to the environment, but also prevent atmospheric $CO_2$ from replenishing supplies drawn down within the greenhouse. The drawdown of $CO_2$ within a closed system is often ignored and could lead to plant growth problems. Supplemental $CO_2$ can be added to counteract the $CO_2$ drawdown within the greenhouse; however, it is not known how the use of supplemental $CO_2$ fits within the framework of sustainable crop production. The objective of this research was to compare 'Grand Rapids' lettuce (*Latuca sativa*) growth within a low-temperature greenhouse supplemented with $CO_2$ against lettuce growth in a more traditional warm, well-insulated greenhouse without $CO_2$ injection. The Virtual Grower software was used to compare cost, fuel use, and carbon (C) consumed because of heating and $CO_2$ supplementation between the two greenhouses.

Carbon dioxide concentration was maintained at 500 ppm in the supplemented greenhouse, while the control greenhouse averaged between 200 and 300 ppm $CO_2$ on sunny days. Supplemental $CO_2$ counteracted any temperature effects on growth, as at forty-five days after planting, harvested lettuce plants were larger in the cooler, $CO_2$-controlled house (Figure 1). Dry weight was also substantially greater in plants from the cooler, $CO_2$-controlled house (Figure 2). Total cost of maintaining a cooler greenhouse with supplemental $CO_2$ was approximately 3% less than maintaining a warmer greenhouse with no additional $CO_2$, and C consumption decreased by 7% in the cooler, $CO_2$-controlled greenhouse (Table 1).

These results indicate that it is possible to save money, heating energy, and carbon from heating in certain situations where supplemental $CO_2$ is used. Though more investigation into the use of $CO_2$ for accelerated plant development in lower temperatures and the possibility of $CO_2$ sinks forming in plant production systems is needed, the use of $CO_2$ enrichment should be considered as having a viable role in sustainable production systems.

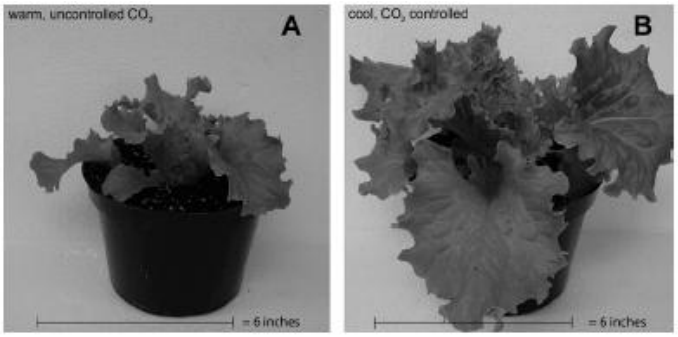


Figure 1. Lettuce plants after 45 d of growth in a greenhouse maintained at 65 °F [18.3 °C (warm)] with no carbon dioxide ($CO_2$) control (A) or in a greenhouse maintained at 62 °F [16.7 °C (cool)] with a $CO_2$ set point of 500 ppm (B). $CO_2$ in the warmer greenhouse was consistently 100 ppm lower than the cooler greenhouse and on sunny days, up to 300 ppm lower; 1 ppm = 1 mmol·mol$^{-1}$, 1 inch = 2.54 cm.

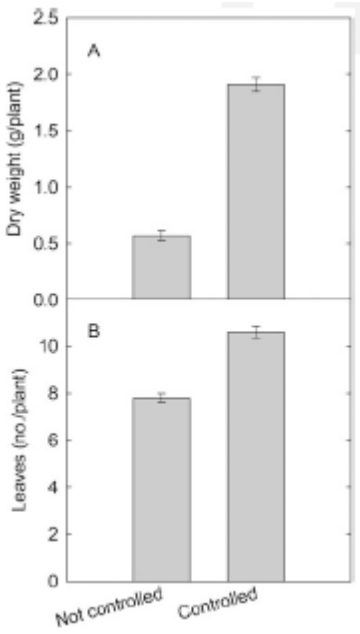


Figure 2. Average dry weight (A) and leaves per plant (B) of lettuce plants harvested after 45 d from greenhouses maintained either at 65 °F (18.3 °C) with no carbon dioxide ($CO_2$) control (not controlled) or in a greenhouse maintained at 62°F (16.7 °C) with a $CO_2$ set point of 500 ppm (controlled). Averages of each are significantly different ($P < 0.0001$) based on Student's paired t test of means. Error bars represent +/- 1 SE of mean; 1 g = 0.0353 oz, 1 ppm = 1 mmol·mol$^{-1}$.

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Table 1. Costs of fuel and carbon (C) consumed during the 90-d winter production period for the control and carbon dioxide ($CO_2$)-elevated greenhouses that were maintained at a constant 65 or 62 °F (18.3 or 16.7 °C), respectively. The 90-d period spanned from 1 Dec. to 28 Feb.

| Treatment | Cost of propane ($) | C from propane (lb)[z] | C from elevated $CO_2$ (lb) | Cost of elevated $CO_2$ ($) | Total C from propane and $CO_2$ (lb) | Cost from propane and $CO_2$ ($) |
|---|---|---|---|---|---|---|
| Uncontrolled $CO_2$, 65 °F | 15,147 | 92,169 | 0 | 0 | 92,169 | 15,147 |
| Elevated $CO_2$, 62 °F | 13,871 | 84,405 | 1200 | 931 | 85,605 | 14,802 |

[z]1 lb = 0.4536 kg.

Frantz, J.M. 2011. Elevating carbon dioxide in a commercial greenhouse reduced overall fuel carbon consumption and production cost when used in combination with cool temperatures for lettuce production. HortTechnology. 21:647-651.