

# Practicing Safe CO<sub>2</sub>

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Carbon Dioxide (CO<sub>2</sub>) is a colorless, odorless gas. At low concentrations, it has been used to safely enrich the greenhouse atmosphere to accelerate the growth of crops. However, at high concentrations it can damage crops and is potentially lethal to humans. This note is intended to provide advice for the safe use of supplementary CO<sub>2</sub>.

Although CO<sub>2</sub> supplementation has been safely and routinely used for many years in commercial horticulture, the potential for mishap should be recognized and guarded against. Both manual and automated CO<sub>2</sub> monitoring and delivery systems can be safely and accurately employed if regular maintenance and safety inspections are employed, and the potential dangers are understood.

## PLANT SAFETY

Plants are generally much more sensitive than humans to sustained exposure to high levels of CO<sub>2</sub>. At levels exceeding 1000 ppm, young tomato plants may exhibit foliar inrolling and increased purple pigmentation, and cucumber leaves may be burned or bleached. In general, supplementation beyond 800-1000 ppm has not been shown to be beneficial or cost effective for most greenhouse grown crops.

## HUMAN SAFETY

Human breath contains about 40,000 ppm CO<sub>2</sub>, or about 40 times the maximum sustained exposure level recommended for plants, so humans have a far greater tolerance to CO<sub>2</sub> concentrations. However, acute human toxicity occurs at about 100,000 ppm, and above 50,000 ppm, people may experience dizziness and loss of consciousness. Prolonged exposures above 20,000 ppm should be avoided.

## SOURCES OF SUPPLEMENTARY CO<sub>2</sub>

There are two principal sources of CO<sub>2</sub> supplementation in commercial greenhouses: combustion of natural gas or propane, or the dosing of liquid CO<sub>2</sub>. Each have their own safety considerations.

### CO<sub>2</sub> from Combustion

When burned efficiently, low sulfur propane and natural gas produce water vapor and CO<sub>2</sub> as their combustion byproducts. If for some reason the combustion is incomplete, a host of other undesirable materials may be produced. These include carbon monoxide, nitrous oxides, ethylene and ethylene-like compounds, and other hydrocarbons. High levels of carbon monoxide are hazardous to humans, and ethylene can be damaging to crops at very low levels. The best way to avoid all of these problems is to ensure the proper operation of CO<sub>2</sub> burners and generators at all times. Make sure you have regular inspections of your burners by a qualified technician, particularly before starting them up for a new growing season. Corroded components, cracks, and spider nests in the gas/air mixing ports are common causes of equipment malfunctions.



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An adequate oxygen supply is required for all combustion devices. Whenever the supply of oxygen is restricted or depleted, incomplete combustion can result. For example, stand-alone CO<sub>2</sub> generators are commonly used as a backup source of heating. Under cold, tightly sealed conditions, when they are being used primarily for heating, burners may produce excessive levels of CO<sub>2</sub> and deplete the O<sub>2</sub> levels in the compartment unless they are provided with a fresh air supply. Be very careful when using non-vented CO<sub>2</sub> generators under these conditions.

Whenever flue gases are extracted from boilers, the boiler must be in excellent operating condition. One way to ensure this, is to use a CO (carbon monoxide) detector in the flue gas stream. Significant levels of carbon monoxide are an indication of incomplete combustion, and there is a high likelihood that other incomplete combustion products such as ethylene may be present as well. Therefore, when operating properly, an atmospheric or fan powered boiler should produce very low levels of carbon monoxide (< 50 ppm in the exhaust stream). In addition, a CO<sub>2</sub> sensor in the growing environment(s) should be used for alarm purposes, and optionally for control.

## Liquid CO<sub>2</sub>

Liquid CO<sub>2</sub> is usually stored in large pressure vessels and introduced as a gas into the greenhouse environment by electronically operated valves. A potential overdose could occur if a valve malfunctions, is accidentally left in the manual on position, or if there is a break in the line. To minimize the potentially dangerous effects of such a malfunction, a mechanical restrictor or pressure safety valve must be used at the tank outlet to ensure that the maximum possible flow rate from the CO<sub>2</sub> system is no greater than the maximum required flow rate under normal dosing conditions. A pressure safety valve will also reduce or cut off the flow if a drop in line pressure indicates a line break. Physical restricters should also be used in the branch lines for each enclosed compartment. In addition, a CO<sub>2</sub> sensor in the growing environment(s) should be used for alarm and shutdown purposes, and optionally for control.

For maximum human safety, you may wish to use one sensor system for dosing control, and another, independent sensor unit for alarm and shutdown purposes.

If you're currently using CO<sub>2</sub> supplementation or planning to use it, take some time to consider these safety issues.

## SAFETY CHECKLIST

- Does your CO<sub>2</sub> burner have adequate air for combustion?
- Do you service your equipment each year prior to operation?
- Do you regularly inspect your CO<sub>2</sub> distribution system and valves?
- Is your system physically designed (i.e. flow restricters) to prevent overdose?
- Do you have a contingency for system failures?
- Do you perform regular safety inspections on your dosing equipment?
- Do you have alarm sensors to warn you of possible problems?
- Are the alarm sensors in good working order?
- Do your workers understand what these alarms mean?

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