Greenhouse growing with CO_2 goes green

CO_2 for crop growth: good for the environment, good for business

By Stephen B. Harrison

Fresh vegetables, salads and fruit crops such as tomatoes, cucumbers, capsicum peppers, lettuce and strawberries are extensively grown in commercial greenhouses in countries such as the Netherlands and New Zealand. In this environment, light, water, temperature, nutrient supply and carbon dioxide (CO_2) levels are controlled to create growing conditions that optimise both crop yield and quality.

Annual worldwide production under glass continues to grow year-on-year, driven largely by investment in smart vertical farming techniques in hot and arid countries, such as Australia and Saudi Arabia. In cold climates it has been, and remains, common practice to burn propane or natural gas in the greenhouse to generate the required heat and to elevate the CO_2 levels to enhance crop growth. In warmer countries this heat addition is not always required and independent CO_2 dosing from a bulk supply is therefore common.

In cooler climates the use of green technologies to replace fossil fuel combustion in the greenhouse industry is also an emerging trend. Carbon capture and re-use, biomass combustion, solar power and geothermal energy are all extensively used.

Carbon dioxide dosing - healthy crop growth, healthy business growth

Elevated levels of carbon dioxide during the 'daylight' growing hours enhance plant growth. In greenhouses, the growth rate and development of most plants can be improved by controlling CO_2 concentrations at levels of around 800 ppm (parts-per-million). This is approximately twice as much as the natural concentration of CO_2 in natural ambient air.

Each incremental increase in CO_2 levels above around 800 ppm has diminishing benefit to the plants. Despite these diminishing returns, some operators control the CO_2 levels at 1,200 ppm to fully exploit the potential of CO_2 addition.

Optimised CO_2 levels in greenhouses raise productivity and crop yields considerably. In addition, they also improve the quality of the crop. When the CO_2 level in the greenhouse is optimised, the plants will produce uniform fruit, salads and vegetables of the best quality. So, CO_2 can maximise both the crop yield and the sales price for the harvest. Extensive use of CO_2 in the greenhouse industry is also a high-growth application of CO_2 as an industrial gas. The largest greenhouses consume tens of tonnes per day of CO_2 and rank amongst the largest users of liquid CO_2 worldwide.

Arid desert greenhouses

Light is essential in the greenhouse for photosynthesis and plant growth. And, its importance in greenhouse farming stretches beyond that. The most modern farms, which are being built in hot, sunny arid countries, are also reliant on the sun's energy for their general operation.

For example, on many farms in the Middle East and North Africa, photovoltaic solar panels are used to produce electrical power that is required for various services to the greenhouse, such as chillers for temperature control and pumps to operate reverse-osmosis (RO) membrane desalination plants. This RO technology tends to be the most cost-effective way to produce irrigation water for the farm.

In Australia, a major local tomato grower has installed a 127m high concentrated solar power (CSP) tower. This is used for seawater desalination for irrigation and to generate steam for heat and the production of electrical power in a turbine. This cutting-edge technology uses a computer-controlled array of mirrors to reflect sunlight to the top of the CSP tower where the intense heat is used to boil water. Since these growing methods do not burn fossil fuels, there is no combustion exhaust-gas source for CO_2 enrichment in the greenhouse and supply of CO_2 with bulk liquid deliveries is therefore common.

Dosing in cooler climates

A notable leading country in the supply of pure CO_2 for greenhouses is the Netherlands. Ranking second in the world for food exports, after the US, greenhouse crop production in the Netherlands, which is a very small country, is extremely intensive. This combination of high demand in a compact location has led to the development of a pipeline supply of CO_2 from two major sources to the multitude of greenhouses that are located between Rotterdam and Amsterdam.

One of the many refineries at Pernis, in the port of Rotterdam, is a major feed to this pipeline. The CO_2 is a by-product of a steam methane reformer (SMR) that is used for syngas production. A bioethanol plant nearby is the other major source. CO_2 is a by-product of the fermentation process that is integral to the ethanol production. This carbon capture and re-use (CCR) application is helping the local economy achieve environmental targets for CO_2 emissions reductions. Furthermore, under the EU Emissions Trading Scheme (EU ETS) there are significant cash benefits to be achieved through effective carbon management.

Geothermal energy for greenhouse heating is the latest green technology to be used in this sector. In Germany, which ranks third in global food exporting countries, just behind the Netherlands, geothermal energy generated by the Kirchweidach project in the southern part of the country is being used to provide heat for the 20-hectare greenhouse farm operated by Josef Steiner. Similar projects are under consideration in the Netherlands.

Geothermal heat is ideal for greenhouse use because the temperature of the water coming to the earth's surface is warm enough for heating purposes but is rarely high enough for electrical power production.

It is also possible to burn natural gas or LPG to create both heat and CO_2, which in cooler countries such as New Zealand might be an attractive combination. TJ Croeser, Sales Manager at the industrial gases supplier Coregas in New Zealand, commented, "Dosing of carbon dioxide to the greenhouse can be from a CO_2 burner generator, from a pure carbon dioxide source. Greenhouse CO_2 generators are often simple LPG burners, which produce CO_2 and heat from combustion of the LPG. However, enhanced flexibility and improved dosing control can be achieved by using carbon dioxide gas, which can be supplied by Coregas in New Zealand in bulk liquid tanks, gas cylinder packs or single cylinders."

Gas detection

To control the CO_2 level in the greenhouse, an NDIR sensor is typically used. The target set point will generally be 800 ppm of CO_2. When the sensor detects a reduced CO_2 level in the greenhouse it will activate the CO_2 dosing system. When the required CO_2 level has been achieved, the measured value will increase, and the control system will shut off the CO_2 supply.

1,200

Some operators control CO_2 levels at 1,200 ppm to exploit its potential on crop growth

"Optimised CO_2 levels in greenhouses raise productivity and crop yields significantly"

In professional greenhouses, the gas detection sensors will be fixed, so it is not possible for the end-user to take the CO_2 gas detector out of the greenhouse into clean pure air and run an auto calibration based on the normal CO_2 concentration in ambient air. So, a specialty gases calibration gas mixture cylinder containing, for example, 800 ppm CO_2 in a balance of nitrogen can be used to calibrate the sensor close to its measured value. A cylinder of high purity nitrogen can be used to set the zero reading on these gas detectors.

And with the last word to Croeser of Coregas NZ on the topic of safety, "Let's put the undisputed economic benefits of CO_2 dosing to one side for a moment and get down to brass tacks… there is nothing more important in that greenhouse than the gas detection and alarm system. Every employee relies on it for their safety."

"Carbon dioxide is invisible and does not have a noticeable smell, so a dangerous concentration can't be detected by humans until it's too late. That's why we offer only the best quality NATA-certified calibration gas mixtures for gas detector sensor calibration applications."

ABOUT THE AUTHOR

Stephen B. Harrison is a consultant at sbh4 GmbH and Principal, Germany at Nexant E&CA. He was previously global head of Specialty Gases & Equipment at Linde Gases and has 28 years of experience in industrial gases. Harrison will discuss Greenhouse CO_2 at **gas**world's CO_2 Summit in March.

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