Developing the Climate Ready Crops of the Future

An Applications Report from Linde Gases

Carbon dioxide (CO_2), the primary greenhouse gas produced by human activities, is causing global warming and climate change, but higher levels of CO_2 in the air can also assist plant growth and improve their ability to cope with drought and water stress. Against a backdrop of imminent climate change that will affect crops contributing to world food supply, a team of scientists from the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia is focusing their research efforts on producing "climate ready" sugarcane for future generations.

Sugarcane is one of Australia's most important rural industries and export crops are currently worth about AUS$2 billion to the Australian economy. CSIRO Systems Ecologist and Senior Research Scientist Dr. Chris Stokes, who is heading up this research, defines "climate ready" sugarcane as being those varieties developed to anticipate and thrive in future climatic conditions.

CO_2 and Plant Function

The main benefit of CO_2 on plant function relates to the central growth process, photosynthesis, during which the CO_2 combines with water to produce carbohydrates. Many studies have demonstrated that plants exposed to high CO_2 levels in the air use water more efficiently than those grown in normal air. Small pores in the leaves called stomata control both the rate at which CO_2 enters the plant and the plant's water loss.

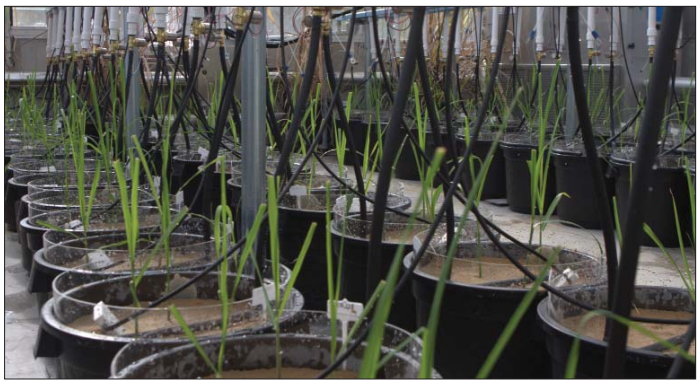
"By increasing the level of CO_2 in the atmosphere, as we are doing in research experiments at moment, the CO_2 gradient into the leaf increases, while the water gradient out of the leaf stays the same," Dr. Stokes says. "In other words, as CO_2 outside the leaf increases, the plant is able to take up more CO_2, without losing more water and this is the basis for plants being able to use water more efficiently.

"This is the response we're trying to understand. We want to capture this benefit as optimally as possible and, based on this understanding, to develop a rapid screening system to screen different varieties of sugarcane to determine how responsive they are to CO_2."

All plant breeding undertaken by Dr. Stokes' team is purely focused on the selection of existing sugarcane genetic stock and does not encroach into the arena of genetic manipulation.

The actual experiments take place in tall growth chambers, high enough to accommodate the fully mature sugarcane plants. These chambers allow CO_2 levels, temperature, and humidity to be regulated, creating an integrated system for measuring patterns of water use and studying plant responses.

With contemporary CO_2 levels at about 400 ppm and ballpark projections suggesting that these levels will have risen to around 550 ppm by 2050, the research team is working with even higher levels of CO_2 in the experimental growth chambers—as high as 700 ppm. Dr. Stokes says this is to obtain a strong response size from atmospheric CO_2 levels that could occur towards the end of the century. The larger treatment effects also allow the research team to observe the differences more clearly. However, each incremental step change in CO_2 will have diminishing benefit to the plant, so once levels exceed 700 ppm, each additional increase will have less and less effect on plants.



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The chambers use a through-flow system, in which air is drawn in on one side and expelled on the other. In this airstream, the team measures the flow rate of air in the chambers. The difference in the CO_2 concentration between the augmented concentration and the outgoing air allows the team to calculate the rate of photosynthesis for the whole chamber at any given time.

Large air blowers mix the air to maintain relatively uniform CO_2 levels, temperature, and humidity within the chambers. From a risk management perspective, the air circulation also prevents any toxic build-up of CO_2 in these enclosed spaces. In addition, CO_2 sensors are located around the chambers as part of a building management system. These sensors operate on a continual basis and are geared to automatically ventilate the area and sound an alarm if the CO_2 rises above a certain level.

Bulk CO_2 Supply

When it came to sourcing CO_2 for the research project, the researchers' fundamental requirements were low levels of plant-active impurities (particularly ethylene), cost, and security of supply. The team selected bulk CO_2 supply from BOC Australia, part of The Linde Group (*linde.com*). In the arenas of agriculture and fishing, BOC works with growers, producers, scientific, and research organizations across the world to help customers lower costs, raise productivity, comply with increasingly stringent environmental legislation, and meet the high quality standards set by supermarkets.

The CO_2 is supplied through gas control equipment from BOC's GASMATIC® range. This range has been designed to deliver a large, uninterrupted supply of CO_2 through a selection of stationary and low-pressure on-site vessels. The GASMATIC® system requires no electric motor and no refrigeration unit and has no moving parts. This form of supply was selected as the simplest and most cost-effective route for the research project.

It was important to the research project that the CO_2 would not introduce ethylene into the growing chamber. The presence of this gaseous plant hormone has the potential to skew experimental outcomes. BOC Australia worked hard to identify a suitable source of CO_2 for this application which fulfilled the low ethylene requirement. ■

For more on this project or Linde's GASMATIC system contact press@linde-gas.com.