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DESIGN AND OPERATION OF A MULTIPLE-CHAMBER GAS-EXCHANGE SYSTEM FOR PLANT COMMUNITIES

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Measuring whole-plant CO_2 gas exchange is a powerful technique, but cost and lack of commercially available chambers for whole plants often limit its use. We developed a 10-chamber gas-exchange system and it continues to evolve as a tool to investigate plant-environment interactions. Each chamber, constructed of clear acrylic plastic (Lexan™), is 0.5 m x 0.4 m x 0.9 m (L x W x H) permitting plant canopies to be studied. The chambers are housed within a larger walk-in growth chamber lit with six pairs of 1000 W HPS lamps providing up to 750 μmol m^{-2} s^{-1} at bench height. Within each of the ten chambers, cooling coils positioned in front of a small fan further cool the chamber air and control humidity. A 75 W resistance heater within a given chamber interfaced with a data logger maintain temperature set points to ±0.2°C. Furthermore, root-zone temperature is controlled separately to maintain a root-zone temperature set point for each chamber. Individual deep-batch, aerated hydroponic systems positioned within the chambers are typically used and can be managed (pH and refill) without the need to open the chambers. Air flow to each chamber is controlled by separate mass flow meters positioned outside the walk-in unit. CO_2 is controlled on the main air line feeding into the chambers with a mass flow controller. A single pump is connected to a solenoid manifold and samples air from each chamber for one minute every ten minutes. Air samples are passed through a set of gas analysers and, with the flow rate, photosynthetic or respiration rates can be calculated to give a total of 144 measurements for each chamber every 24-h period. Current studies focus on how temperature and light influence respiration and carbon use efficiency of crop plants (ratio of daily growth to gross photosynthesis). The use of small chambers permits multiple, *replicate* canopies to be evaluated in a range of temperatures (range of 20°C with separate root-shoot control), light (0 to 750 μmol m^{-2} s^{-1}), relative humidity (~30% to 100%), and nutrition in a single study. The total cost of materials required for this system, including sensors for gas exchange, is about US$35,000.