An automated 25 cuvette gas exchange system for the study of plant responses to ozone

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Introduction

There is a need among ecophysiologists for gas exchange systems capable of rapid sampling and numerous replications. Measurements of temporal and spatial variability within tree canopies, or among replicates of plants in experimental units, are often hampered by difficulty in obtaining sufficient concurrent gas exchange data within a reasonable amount of time. Single cuvette systems take too long to obtain data when there are two or more treatments or locations, resulting in the potential confounding of treatment and time effects. Single cuvette systems are also labor intensive, making them relatively expensive and slow. For ozone researchers, limited measurements of gas exchange with single cuvette systems may not be sufficient to detect what are often subtle responses due to ozone exposure.

There are several systems in the literature that are capable of measuring large numbers of leaves rapidly (Sinclair et al. 1979, McLaughlin 1988). The Sinclair system uses small cuvettes (up to 39 at once), all without climate control. However, it relies on large flow rates through the cuvettes to eliminate the boundary layer resistance, and operates under positive pressure, which would tend to eliminate ozone from the chamber due to the interaction of ozone with the tubing, chamber, and pump blades. McLaughlin (1988) constructed a multi-cuvette system for measuring soybean leaf gas exchange, and later modified it to work on loblolly pine needles. The original system used tubules located adjacent to the underside of soybean leaves, while the pine cuvettes were small glass tubules slipped over the fascicle. The latter design proved superior to the tubules because of the constant boundary layer resistance. Rates in this system were about half those achieved under ideal conditions with a Li-Cor 6200 system. Recently, Teskey (pers. comm.) has used a similar system, dubbed the "Medusa" system, on loblolly pine subjected to either ozone or $C0_2$ treatments. Both systems use negative pressure to create air flow, but neither have cuvettes with stirred air to minimize boundary layer effects, nor use as many cuvettes as the system detailed below.

We describe herein a gas exchange system that overcomes many of the limitations alluded to above, and which is particularly amenable for the study of plant responses to ozone. Additional features of the system include relatively low cost, automated sampling, and ease of use.

Notes to readers

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