Comparison of acclimation time using CIRAS-4 and CIRAS-3 Portable Photosynthesis Systems

To understand photosynthetic responses under different environmental conditions, researchers often measure growth rate, chlorophyll fluorescence, or pigment levels. However, CO_2 assimilation and leaf gas exchange parameters directly measure photosynthetic performance and underlying mechanisms. By using a portable photosynthesis system, changes in CO_2 and H_2O from leaf samples are detected, and photosynthetic parameters (e.g., photosynthetic rate, stomatal conductance, and transpiration) are calculated automatically. CIRAS-3 and CIRAS-4, from "PP Systems," are renowned as powerful portable photosynthesis systems that are easy to operate and suitable for high-level plant physiology research. During measurements, both CIRAS-3 and CIRAS-4 can fully control environmental factors such as light intensity, light spectrum, CO_2 concentration, temperature, and humidity. Both systems also allow for instantaneous measurements under specific environmental conditions and conducting response curves (light response curve and A/C_i curve).

The most important trait of using a photosynthesis system is to guarantee accurate and reliable measurements. Additionally, versatile control of environmental conditions and data visualization can help researchers perform effectively. In this study, CIRAS-3 and CIRAS-4 were compared in terms of measurement time, parameter stability, data visualization, and versatility of environmental control. The results highlight key factors from a researcher's perspective when measuring photosynthesis and analyzing data.

The uppermost fully expanded leaves of sweet basil plants were used to measure the photosynthetic rate (A), and the changes were recorded every 10 seconds. Twelve plants were grown under the same conditions and measured with either CIRAS-3 or CIRAS-4. A 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ LED light intensity and 400 $\mu g \cdot L^{-1}$ CO_2 concentration were maintained during all measurements. When the leaf cuvette is opened and then closed to clip a leaf sample, the photosynthetic rate often decreases to a negative value due to the influx of ambient CO_2. Thus, measurement time was recorded from when the value reached zero and started to increase.

The CIRAS-3 took approximately 3 minutes to reach the plateau (stable reading) of A; however, the CIRAS-4 took less than a minute to stabilize photosynthetic rate (Fig. 1). Shorter measurement times with CIRAS-4 not only improved the convenience of measurements but also allow for increased measurement replication. Leaf gas exchange measurements are time-consuming, so researchers usually measure part of the replications due to time constraints. Especially in field or greenhouse conditions where environmental factors are fluctuating, the plant samples need to be measured in a short time under similar environmental conditions. Using CIRAS-4

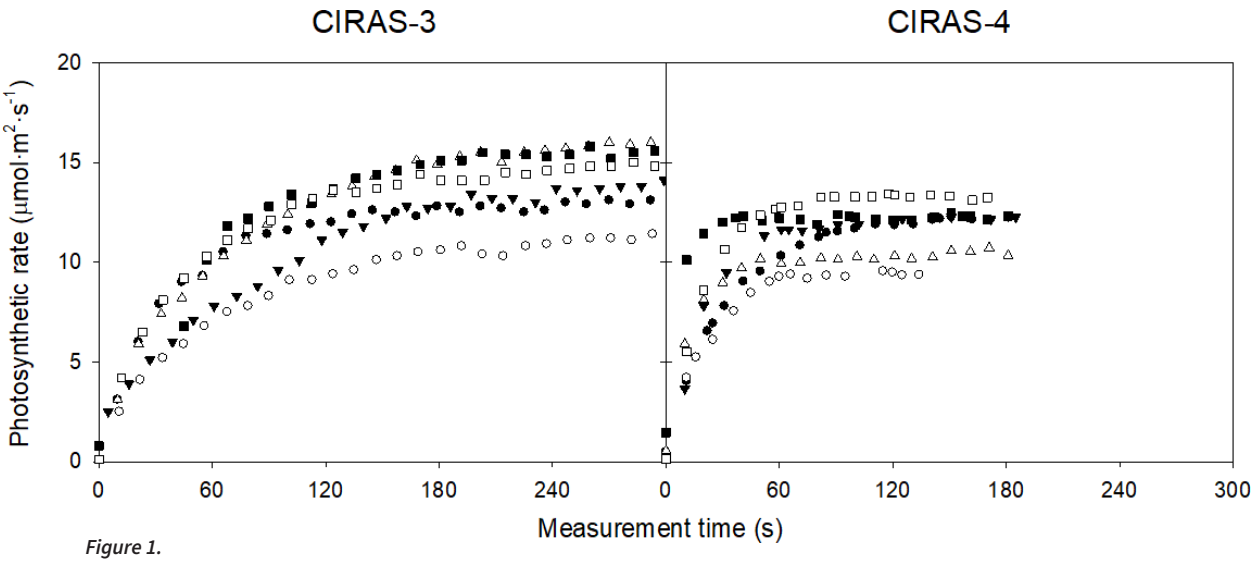

Figure 1.

Photosynthetic rate was measured (n = 6) until it reached to a stable value. Each shape represents each basil plant. The A values were measured using either CIRAS-3 (left) or CIRAS-4 (right).

with shorter measurement time allows researchers to either increase sample numbers or minimize environmental variations. Although this trial was conducted solely with sweet basil at a specific growth stage, the findings provide meaningful insights into the importance of stability time in data collection and experimental design.

Additionally, CIRAS-4 calculates and measures certain parameters (e.g., photosynthetic rate and stomatal conductance) with six decimal places, unlike CIRAS-3, which uses only one decimal place. Higher sample numbers, lower environmental variations, and increased significant figures have the potential to improve statistical power and reliability of obtained data.

CIRAS-4 has a stability criteria function that indicates when the parameters become stable and ready to be measured. Additionally, CIRAS-4 has improved data visualization function, which can plot multiple parameters in a time series chart allowing researchers to monitor the changes and stability of the parameters during the measurement (Fig. 2). Without these functions, observations might be subjective and less accurate.

Lastly, the versatility of environmental control in CIRAS-4 improves the measurement process in dynamic environmental conditions. CIRAS-4 allows users to easily manipulate environmental settings at any time. This function is particularly useful in fluctuating greenhouse conditions, as researchers can adjust the temperature and humidity conditions of the leaf cuvette according to dynamic changes (e.g., greenhouse window opening/closing, sudden changes in heating/cooling systems) during measurement. As far-red light has gained importance in recent years for plant growth and development, photosynthetic responses to far-red light have been investigated by many researchers. CIRAS-4 can tailor both light intensity and light spectrum, consisting of red, green, blue, white, and far-red light in percentage, allowing users to compare photosynthetic responses under diverse light conditions.

In conclusion, the CIRAS-4 offers significant improvements over the CIRAS-3 in terms of measurement time, parameter stability, data visualization, and environmental control versatility in sweet basil. These enhancements can lead to more efficient and accurate photosynthesis research, particularly in dynamic environmental conditions. Similar comparisons are needed for other leafy greens, even though we anecdotally observed similar results with other crops such as lettuce.

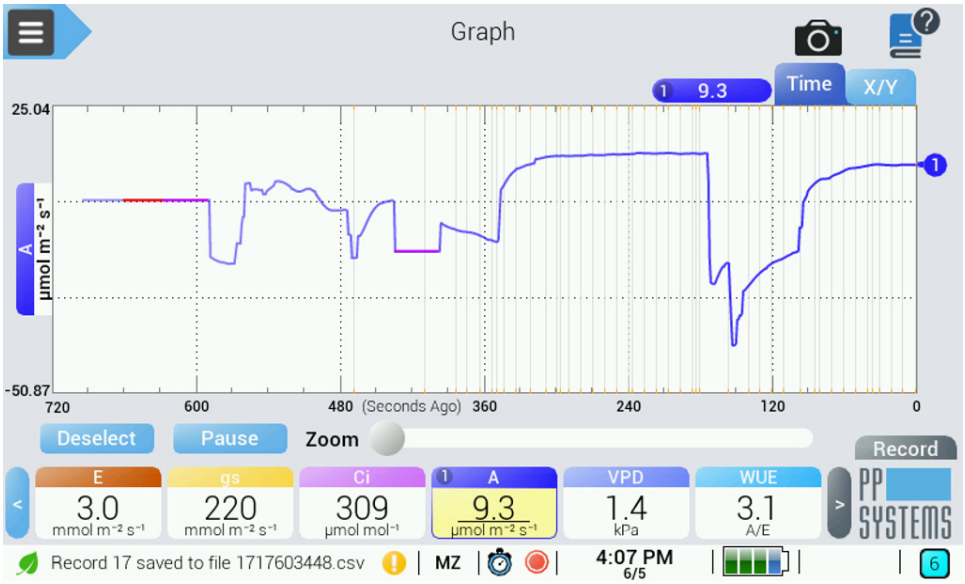

Figure 2.
Photosynthetic rate changes over time can be monitored and visualized in real-time using the CIRAS-4.

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If you would like to learn more about this application or speak with one of our experienced technical staff, please feel free to get in direct contact with us via any of the contact information listed below:

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