iFL Integrated Fluorometer

BioScientific Ltd.

Fluorometer with LCpro-SD broad leaf system
for advanced gas exchange & fluorescence research

The answer to advanced, whole plant physiology research

1. Combined, automated system

2. Advanced plant gas exchange system

3. Powerful chlorophyll fluorometer

The iFL can be used in 3 modes:

1. Combined, automated system
2. Intelligent gas exchange system
3. Powerful chlorophyll fluorometer

1. Combined, automated system

The iFL is an integrated chlorophyll fluorometer and intelligent photosynthesis system, designed to be truly field portable. The iFL system combines the expertise from two world-leading companies in plant science instrumentation: ADC BioScientific Ltd. and Opti-Sciences Inc.

2. Intelligent gas exchange system

For studies into plant gas exchange alone, the iFL may be operated as an independent gas exchange system with full microclimate control.

When the fluorometer is removed, the gas exchange system can be configured to a wide variety of chamber heads including: Broad, Narrow, Conifer, Small leaf, Canopy, Fruit and Soil.

Standard gas exchange experiments can be conducted under ambient or controlled conditions. A/Q and A/Ci protocols are supplied as standard.

3. Powerful chlorophyll fluorometer

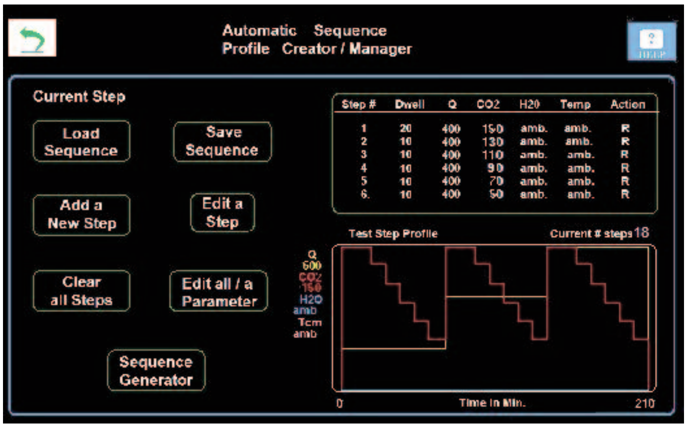
A variety of highly accurate, fluorescence plant stress tests can be performed including:

- Fv/Fm
- Yield (Y)II with Multiflash-Fm' correction
- Rapid light curves
- Quenching protocols
  - Hendrickson model
  - Kramer Lake model
  - Puddle model

The iFL employs the **multiple phase, optimal 7,000µmol m^{-2} s^{-1} saturation flash** technique. Multiflash-Fm' correction ensures the closure of all PSII reaction centres at high light intensities, preventing significant errors in J.

Automated, modulated light adjustment ensures optimal intensities are used for every fluorescence experiment to eliminate potential errors and reduce set up time.

Rapid Light Curves enable the determination of leaf saturation characteristics, required for setting up Laisk protocols and A/Ci curves.



Extensive, calculated parameters:

- Rate of photosynthesis (**A**) and transpiration (**E**)
- Substomatal CO_2 (**Ci**)
- Stomatal conductance (**Gs**)
- PAR (**Q**)
- **A/Ci** curve, **A/Q** curve, **A/Cc** curve
- CO_2 compensation point (Γ^*)
- CO_2 respiration in the light (R_d) by Laisk, Kok or Yin protocols
- Flexas chamber leakage protocol
- Leaf absorptance
- Leaf transmittance
- Mesophyll conductance (g_m)
- CO_2 at site of carboxylation (C_c)
- Electron transport rate (***J***)
- Fluorescence stress tests including: **Fv/Fm**, **Y (II)** with multiflash, quenching tests and Rapid Light Curves

Expert measurement technique

The unique ADC 'differential in time' IRGA design removes the need to constantly balance dual IRGA systems to prevent the calibration of the two cells drifting apart over time.

Several hours of automated experimentation can be initiated with one touch of the iFL screen. For example, a complete Laisk protocol may be performed, together with post-processing, directly followed by automated experiments to measure g_m, *J* and C_c (such as A/C_c curves).

Field reliable automation

Some Laisk protocols alone can take more than 4 hours to perform. **The iFL can operate continuously for up to 8 hours from a single charge**, depending in the climate controls in operation. Longer experiments can be completed without the need to change batteries.

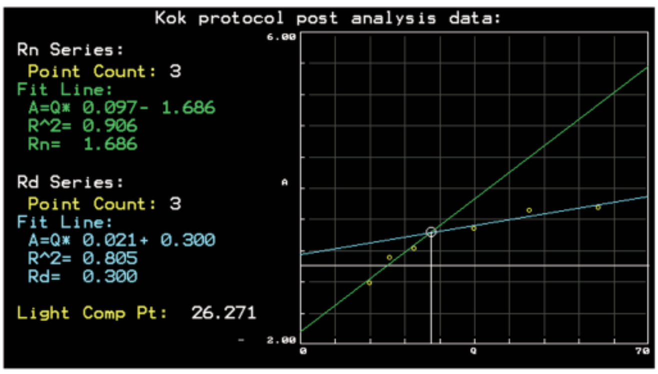
Pre-programmed experimental protocols

Setting up long and detailed experiments is made easy.

A number of pre-programmed protocols are supplied as standard. These include fully automated routines of the Laisk (with van Caemmerer correction), Kok and Yin protocols for the determination of Γ* and Rd, including all post-processing. These determinations may then be automatically transferred to subsequent experimentation for measuring gm, J and C, including A/Ci curves.

Up to 8 protocols may be linked together to run consecutively. New protocols can also be created by editing any of the relevant parameters. New or modified protocols can be saved and recalled for future use.

Whilst the Laisk protocol is most frequently used for determining Γ* and Rd, Kok is sometimes preferred for determining Rd in C4 plants. The more recent Yin protocol offers some potential advantages of being able to work at higher light levels and higher CO_2 concentrations.



The most accurate and reliable data

- Measures leaf absorptance/transmittance
- Measures chamber leakage
- Uses white light to allow chloroplast migration
- Measures leaf temperature by IR sensor

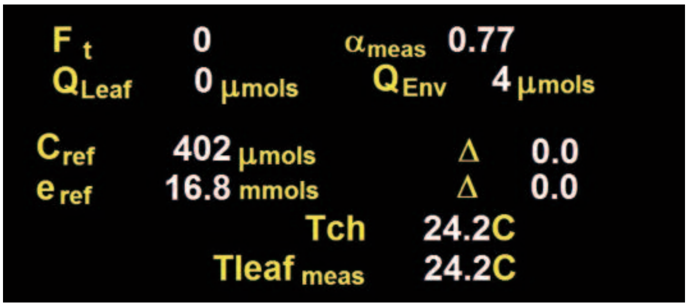
Leaf absorptance/transmittance

The iFL was the first plant physiology system to measure leaf absorptance/transmittance and chamber leakage (Flexas protocol), removing potential errors normally introduced by these variable factors.

Leaf absorptance can vary with plant stress, species, leaf age, chlorophyll content and light intensity. It is widely recommended that leaf absorptance should be measured to avoid potentially significant errors in J, gm and Cc and A/Q curves. The iFL uses RGB sensors above and below the leaf to measure both leaf absorptance and transmittance.

Leaf temperature by IR sensor

For the most accurate data, leaf temperature is measured by a miniaturised IR sensor positioned directly inside the leaf chamber.

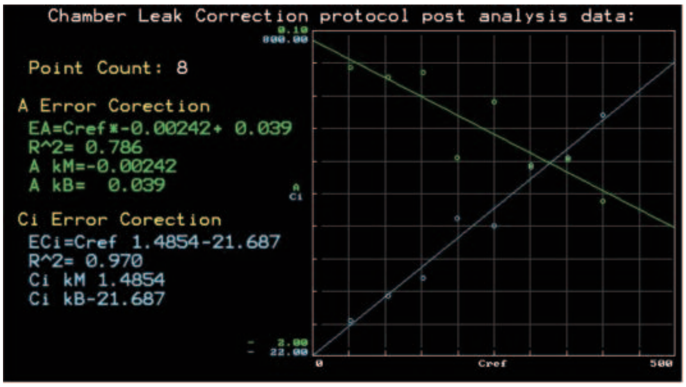


Leading technological innovations:

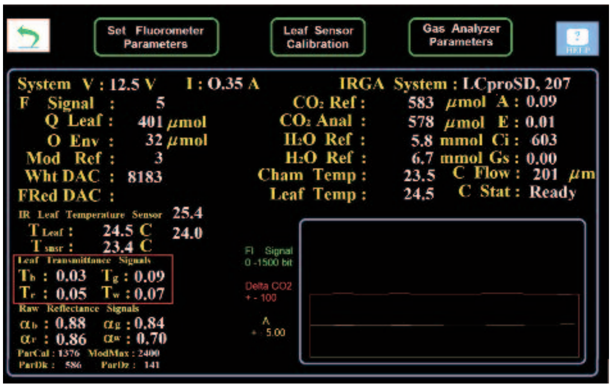
- Leaf absorptance measurement
- White and RGB LED light unit options
- Humidity control above ambient
- "Walk-away automation"
- Automated post-processing of data required for the Laisk, Kok, Yin and Flexas chamber leakage protocols
- Leaf temperature measurement by IR sensor
- Internal and external PAR sensors for flexibility
- Up to 8 hours of battery life in the field

The Flexas chamber leakage protocol

This protocol allows the researcher to test specific plant material in the chamber. The iFL automatically applies corrections for gas leakage to later experiments.



Enables chloroplast migration



The iFL features a white actinic light with an intense blue spectrum to ensure that chloroplast migration occurs as in nature. This prevents potentially significant errors in quenching protocols and in certain gas exchange experiments.

Versatile and truly portable

With a total weight of only 5.2kg, the iFL is a truly portable and versatile instrument for field, greenhouse and laboratory-based research.

The iFL system allows up to 8 hours' worth of measurements to be taken on the supplied, fully charged battery. Interchangeable SD cards allow limitless data collection, and the ability to swap cards between users or projects, readily and easily.

The iFL can conduct standard gas exchange experiments under ambient or controlled conditions, with full chamber climate control.

The iFL can perform a variety of highly accurate fluorescence plant stress tests including:
Fv/Fm, Yield (Y) II with Multiflash-Fm' correction, Rapid Light Curves and a selection of quenching protocols, including Hendrickson model, Kramer lake model and Puddle model.

Colour, touch screen display

A large, colour, touch screen display makes the iFL both interactive and simple to use. Set up is easy whether loading or editing an existing protocol, or building a new protocol. Real time data, calculations and graphs are clearly presented on screen. Sub-menu screens can be expanded to full screen size for viewing.

Gas exchange measurements can be presented in either ppm/mbar or μmol mol^{-1}/mmol mol^{-1}.

Data, protocols and graphs can be stored on the internal 2GB flash memory or on SD card. Data is downloaded either directly from the SD card or via USB. For class or group presentations the iFL features a video HDMI output.

A teaching tool

Both ADC BioScientific Ltd. and Opti-Sciences are proud of a long-standing ability to design the easiest to use gas exchange and chlorophyll fluorescence devices.

The iFL is not only a powerful research tool but is also ideally suited to teaching plant physiology to groups in the field.

The robust and intuitive design allows less experienced users and those new to the techniques to interact confidently with the iFL system.

Request a FREE Desktop Plant Stress Guide

This free guide includes the most recent and accepted research on chlorophyll fluorescence used to detect specific types of biotic and abiotic plant stress. A comprehensive reference list is also provided, all within a compact booklet. Request to sales@adc.co.uk

Discover the applications

The iFL system is used for a wide variety of applications, from investigating the physiological response of conifer seedlings to drought events (Mosel J.E., 2016) to exploring the genetic and physiological, climate adaptations of quaking aspen trees in North America (Burke Thomas Greer, 2017).

The combination of gas exchange and fluorescence data is a powerful tool, enabling comprehensive plant data collection in the field.

World-leading innovation

The iFL system has made several key features available to researchers for the first time, causing a shift in the utilisation of plant physiology devices:

- Humidity control above, below ambient or maintained at ambient condition
- Automated protocols, which can run for several hours
- iFL battery life is maintained confidently for as many as 8 hours
- Post-processing of data
- Direct readings given out of gm (stomatal conductance) and related parameters
- FM' correction
- Stable intensity light source

Trustworthy measurement

The iFL features Infra-Red Temperature Sensing, which does not require contact to be made with a leaf.

The given reading is an average leaf temperature, over a larger area than a point measurement.

No contact with the leaf is necessary, which avoids altering the planarity of the leaf by manual placement of a thermistor. Any small changes to leaf planarity would result in significantly larger changes in measured parameters, particularly light intensity.

The iFL contains a single IRGA, which performs automatic zeroing with every measurement, to correct any drifting. This technique allows excellent data to be maintained without disrupting a set of measurements.

Elevated CO_2 control

Now with greater capacity for elevated CO_2 control. An additional soda lime column increases capacity and continuous experimentation time in the field.

When performing a widely used "A/Ci curve", it is important to maintain other, chamber environment parameters such as water vapour. The chemical column containing iron sulphate provides a 'wetter' with integral thermistor, for monitoring and controlling the humidity of the leaf chamber. The full, chamber environment control provided by the gas exchange system is ideal for producing A/Ci curves.

Selected publications

1. Latif, A., Ahmad, R., Ahmed, J., Shah, M. M., Ahmad, R., & Hassan, A. (2023). **Novel halotolerant rhizobacterial strains mitigated the salt stress in-vitro and in-vivo and improved the growth of tomato plants**. *Scientia Horticulturae*, *319*, 112115. https://doi.org/10.1016/J.SCIENTA.2023.112115
2. Hnilicka, F., Lysytskyi, S., Rygl, T., Hnilickova, H., & Pecka, J. (2023). **Effect of Short-Term Water Deficit on Some Physiological Properties of Wheat (Triticum aestivum L.) with Different Spike Morphotypes**. *Agronomy 2023, Vol. 13, Page 2892*, *13*(12), 2892. https://doi.org/10.3390/AGRONOMY13122892
3. Tarricone, L., Gentilesco, G., Amendolagine, A. M., Mazzone, F., Roccotelli, S., & Masi, G. (2023**). Cover crops and rootstocks interaction on vine performances of organic 'Autumn Pearl' table grape: first results of OLTRE.BIO research project**. *Acta Horticulturae*, *1370*, 181–187. https://doi.org/10.17660/ACTAHORTIC.2023.1370.23
4. Chun, H. C., Lee, S., Gong, D. H., Kim, W.-C., Lee, S.-H., & Jung, K. Y. (2022). **Growth Characteristics and Physiological Responses of Soybean (Glycine max L.) under Excessive Soil Moisture Stress**. *Korean Journal of Soil Science and Fertilizer 2022 55:3*, *55*(3), 185–197. https://doi.org/10.7745/KJSSF.2022.55.3.185
5. Afsar, S., Bibi, G., Ahmad, R., Bilal, M., Naqvi, T. A., Baig, A., Shah, M. M., Huang, B., & Hussain, J. (2020). **Evaluation of salt tolerance in Eruca sativa accessions based on morpho-physiological traits**. *PeerJ*, *8*, e9749. https://doi.org/10.7717/PEERJ.9749/SUPP-2
6. de Moraes, D. H. M., Mesquita, M., Bueno, A. M., Flores, R. A., de Oliveira, H. F. E., de Lima, F. S. R., Prado, R. de M., & Battisti, R. (2020). **Combined Effects of Induced Water Deficit and Foliar Application of Silicon on the Gas Exchange of Tomatoes for Processing**. *Agronomy 2020, Vol. 10, Page 1715*, *10*(11), 1715. https://doi.org/10.3390/AGRONOMY10111715
7. Still, C. J., Sibley, A., Page, G., Meinzer, F. C., & Sevanto, S. (2019). **When a cuvette is not a canopy: A caution about measuring leaf temperature during gas exchange measurements**. *Agricultural and Forest Meteorology*, *279*, 107737. https://doi.org/10.1016/J.AGRFORMET.2019.107737
8. Chiuta, N. E., & Mutengwa, C. S. (2018). **Response of Yellow Quality Protein Maize Inbred Lines to Drought stress at Seedling Stage**. *Agronomy 2018, Vol. 8, Page 287*, *8*(12), 287. https://doi.org/10.3390/AGRONOMY8120287

Online resources

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For the investigation of plant, soil and atmospheric interactions, ADC BioScientific Ltd. expertly produce a wide range of portable, user-friendly and cost-effective devices, from photosynthesis to soil respiration systems. We are committed to enabling carbon cycle research worldwide through quality instrumentation and local, technical support.

ADC BioScientific Ltd. also supply: Leaf Area Meters, Chlorophyll Content Meters, Advanced Fluorometers, Automated Soil CO_2 Exchange Systems, Portable Soil Respiration Systems and Field Gas Analysers.

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iFL Technical Specification

Gas exchange system

Measurement range, technique and control:

CO_2:	0-3000ppm, 1ppm resolution Infrared gas analyser. Differential, open system with auto zero. Programmed control 0-2000ppm
H_2O:	0-75mbar, 0.1mbar resolution dual laser trimmed, fast response sensors. Programmed control above and below ambient, dependent on ambient conditions.
PAR:	External 0-3000µmol m^{-2} s^{-1} Silicon photocell. Programmed control 0-7500µmol m^{-2} s^{-1} Internal leaf chamber PAR sensor 0-7500µmol m^{-2} s^{-1}
Temperature:	
Leaf:	-5ºC to 50ºC IR sensor
Chamber:	-5ºC to 50ºC precision thermistor Programmed control typically +/- 14ºC from ambient
Flow rate:	100-500ml min^{-1}

Fluorometer Module

Excitation sources:	
Saturation pulse:	White LED with 690nm filter 0-7,500 µmol m^{-2} s^{-1}
Modulating light:	660nm LED with 690nm short pass filter
Actinic light:	White LED 0-2,000µmol m^{-2} s^{-1}
Far red:	740nm LED
Blue/red/green absorptance sensors	
Detection method:	Pulse modulation
Automated setting of modulated light intensity:	Adjustable On/Off
Automated Multi-Flash Fm’ correction:	Adjustable On/Off
Detector:	PIN photodiode with 700 - 750nm filter
Sampling rate:	10 to 10,000 points per second, dependent on phase of test
Test duration:	Adjustable 20 seconds - 4,000 hours

Integrated System

Data storage:	2GB internal memory for thousands of data sets and traces. Removable SD cards
Digital output:	SD cards, USB and HDMI
User interface:	Large, colour, menu driven, graphic touch screen display (14.5cm x 8.5cm)
Battery:	7.0Ah 12 V lead acid battery. Up to 8 hours of battery life as iFL system
Console total:	31cm x 11cm x 24cm, 5.2kg (incl. battery)
Leaf Chamber:	30cm x 8cm x 16cm