MINI-PAM

Photosynthesis Yield Analyzer

The ultimate answer to portability and ease of operation

WALZ

Mess- und Regeltechnik

MINI-PAM

Photosynthesis Yield Analyzer

Features

- Extremely compact design
- Easy operation
- Low power consumption
- Outstanding accuracy
- Dedicated WinControl Windows-software for operation with external PC
- Various leaf-clips with PAR and leaf temperature sensors available

The Photosynthesis Yield Analyzer MINI-PAM specializes in the quick and reliable assessment of the effective quantum yield of photochemical energy conversion in photosynthesis. Like all PAM Fluorometers, it applies pulse-modulated measuring light for selective detection of chlorophyll fluorescence yield. Due to its innovative opto-electronic design and advanced microprocessor technology, the MINI-PAM is extremely compact and at the same time highly sensitive and reliable. Its operation is very easy.

For measurement of photosynthesis yield just one key has to be pressed (START). Then automatically the fluorescence yield (F) and the maximal yield (Fm) are measured, the photosynthesis yield (Y = ΔF/Fm) calculated, the obtained data displayed and stored internally for later analysis. In addition, an extensive MODE-menu is provided for special applications, including determination of fluorescence quenching coefficients (qP,qN and NPQ) and automatic recordings of light saturation curves with quenching analysis.

In conjunction with the Leaf-Clip Holder 2030-B, the photosynthetically active radiation (PAR) and leaf temperature are measured and the apparent electron transport rate (ETR) is calculated. Approximately 1000 yield measurements can be made without recharging the battery and up to 4000 data sets can be stored in the memory.

The WinControl software is provided for data transfer, data analysis and remote instrument control. While in the standard instrument version red measuring light is used, also a version featuring blue (470 nm) measuring light is available.

System Features

MEMORY-Function

The LC-display of the MINI-PAM can be used at the MODE- and at the MEMORY-levels, after pressing the corresponding keys. All data recorded in conjunction with a saturation pulse (START) are automatically stored in RAM-memory with a capacity of 4000 data sets. They can be recalled on the display via the MEM-key and use of the arrow keys. As shown below in (**a**) all relevant parameters are stored with time, date and mark. The kind of information shown in (**b**) is displayed when SET is pressed while at the MEMORY-level.

(**a**)

```
MEM   9:  10:37 12/APR/04
A:      260Y 15.4E  142L
```

(**b**)

```
MEM   9:281F  380M 33.1C
A:      260Y 15.4E  142L
```

MODE-Menu

While the basic operation of the MINI-PAM is extremely simple, the system provides considerable flexibility in the choice of measuring parameters. This is possible with the help of a MODE-menu, the 51 points of which can be selected by the arrow keys (∧∨) or by pressing simultaneously two of the 8 keys. For example, by ON + START the menu-point 13 (see corresponding display below) is activated, starting an actinic illumination period (with intensity and duration being pre-set via menu-points 15 and 14, respectively), at the end of which a saturation pulse is applied (with intensity and length pre-set via menu-points 47 and 46, respectively). This function allows the determination of photosynthesis yield under reproducible, well-defined conditions of light intensity and duration of illumination.

```
 13: ACT+YIELD: OFF<SET>
F: 271   260Y 15.4E  117L
```

For another example, in menu-position 51 a letter from A to Z can be entered as a mark for a particular object. This MARK is entered with every new data set into the MEMORY.

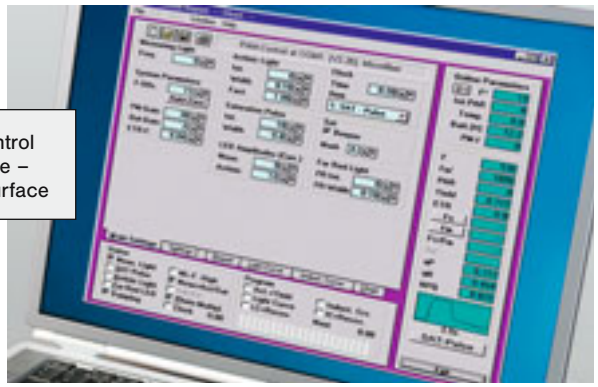
```
 51:  MARK: A       <SET>
F: 271   260Y 15.4E  117L
```

WinControl software

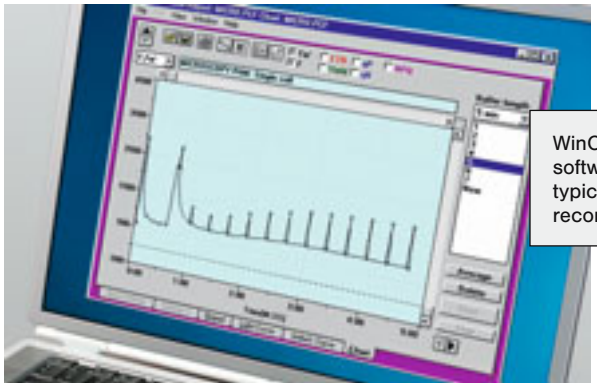
With the help of WinControl, data collected with the MINI-PAM can be transferred on the PC and be further analyzed off-line. All data are written into a Report-file, which is identical with the MEMORY of the MINI-PAM. Data sets are marked and numbered with respect to Light Curves, Induction Curves etc., which can be called on the corresponding display windows.

Light curves show various fluorescence parameters as a function of photosynthetically active radiation (PAR). One (or a combination) of the following parameters may be displayed: F, Fm', ETR, YIELD, qP, qN and NPQ. The same parameters may be also displayed as a function of time during a standard dark-light transition on the Induction Curve window. The Chart-window functions in analogy to a chart recorder or storage oscilloscope with the possibility for off-line signal averaging.

All data can be readily edited, printed-out and transferred into other programs like Excel.



WinControl software – user surface

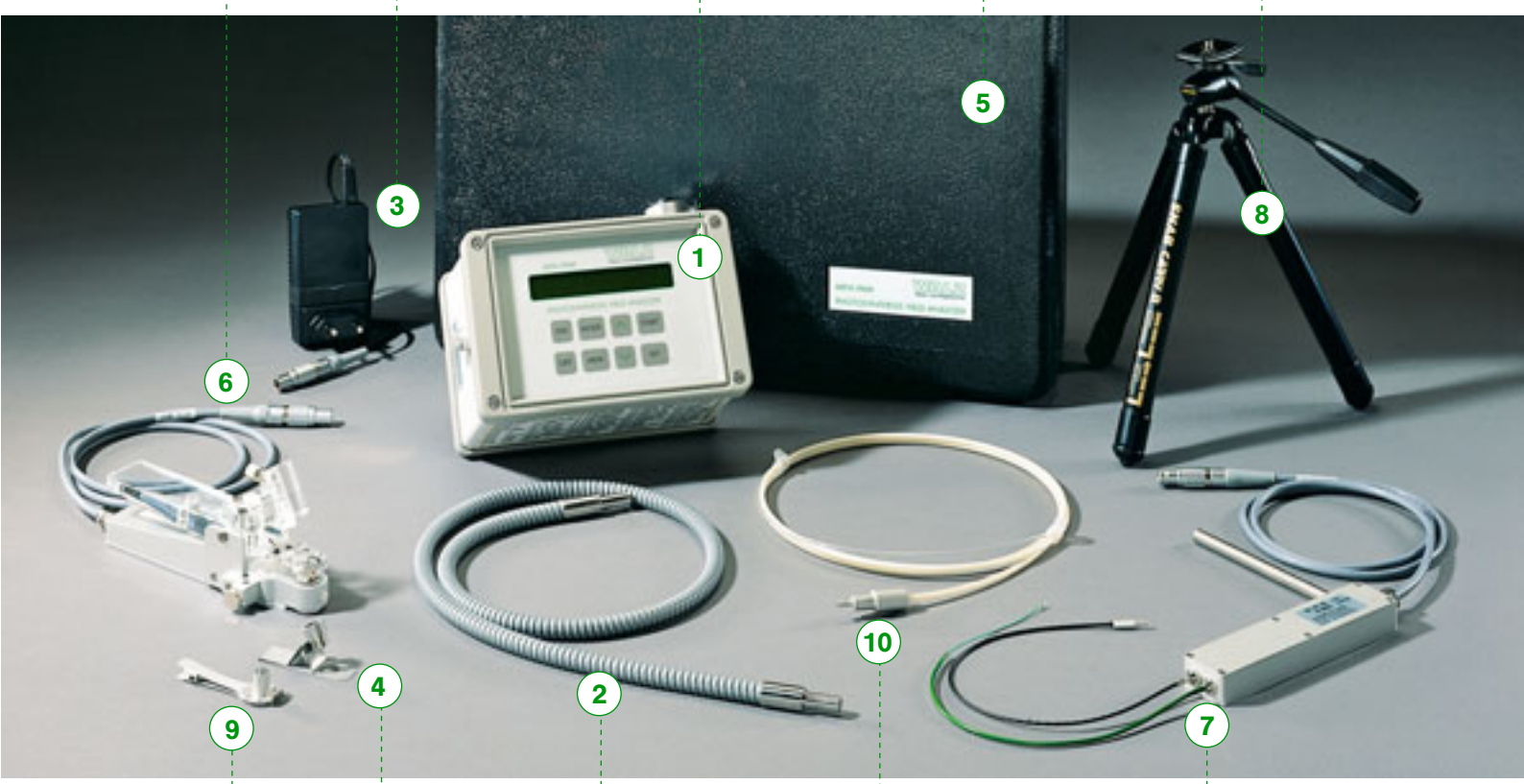


WinControl software – typical Chart recording

System Components

The minimal functional system of the MINI-PAM Fluorometer consists of the **control unit** (1) and the **fiberoptics** (2). The control unit contains a large rechargeable battery (12 V/2 Ah) which enables long operation (approx. 1000 YIELD-measurements) without recharging. The standard system also includes a **battery charger** (3) and a **leaf-clip** (4), all of which are delivered in a custom **transport case** (5).

Additional accessories are available for special applications: The **Leaf-Clip Holder 2030-B** (6) permits simultaneous PAR and °C measurements at the site of fluorescence detection. Use of the **Micro Quantum/Temp.-Sensor 2060-M** (7) is recommended for studies of non-leaf like samples. Both devices (6/7) can be mounted on the **Compact Tripod ST-2101A** (8). For measurements of maximum quantum yield after dark-adaptation the **Dark Leaf Clip DLC-8** (9) is provided, which weighs less than 4 g and features a sliding shutter.



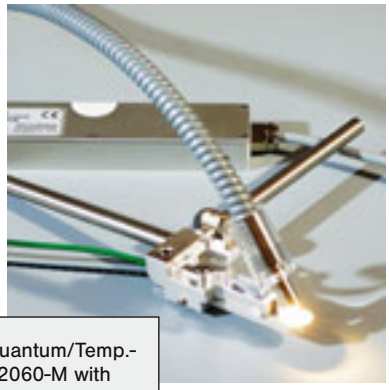
External Halogen Lamp 2050-HB

Although the MINI-PAM features an internal halogen lamp as actinic source, the External Halogen Lamp 2050-HB is recommended for longer periods of actinic illumination. It provides heat-filtered white light which can be steplessly adjusted up to 3000 µmol quanta m^{-2} s^{-1} PAR. An external 12 V supply (e.g. Rechargeable Battery NP-3/12) provides the power. The lamp can be mounted on the Leaf-Clip Holder 2030-B, such that defined PAR-values can be set at the fluorescence measuring site.

Leaf-Clip Holder 2030-B

The main functions of the leaf-clip holder consist in the defined positioning (60° angle and fixed distance, 90° angle optional) of the MINI-PAM fiberoptics relative to the leaf surface and in the measurement of the photosynthetically active quantum flux density (PAR) and of the temperature at the site on the leaf where the fluorescence is also measured. In addition, the leaf-clip holder has a remote trigger pushbutton, which allows the person carrying out the experiments to concentrate fully on the object during measurement.

Leaf-Clip Holder 2030-B and External Halogen Lamp 2050-HB



Micro Quantum/Temp.-Sensor 2060-M with Arabidopsis Leaf Clip 2060-B

Micro Quantum/Temp.-Sensor 2060-M

The micro quantum/temp.-sensor is used to measure the photosynthetically active quantum flux density (PAR) and the temperature in conjunction with the MINI-PAM Fluorometer. The miniature sensors can be attached directly to the fluorescence measuring site without hindering measurements. In this way, the light and temperature conditions can also be reliably recorded with objects which are not leaf-shaped (e. g. crustose lichens and cushions of moss) and for which the Leaf-Clip Holder 2030-B is not suitable.

Arabidopsis Leaf Clip Holder 2060-B

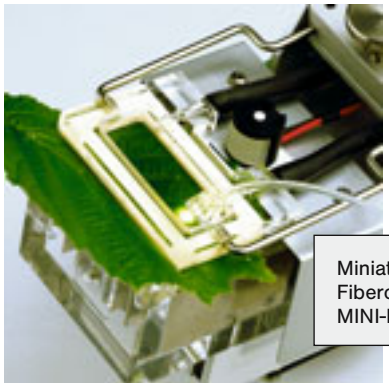
This leaf clip holder was especially designed for small leaves like Arabidopsis leaf. Both miniature sensors (light and temperature) of the Micro Quantum/Temp.-Sensor 2060-M can be attached to it. Like the standard Leaf Clip Holder 2030-B, it also provides an attachment for the MINI-PAM fiberoptics at 60° angle relative to the leaf surface.

Dark Leaf Clip DLC-8

Weighing less than 4 g the dark leaf clip can be attached to a leaf for a long time period without causing it any damage, in order to create defined conditions of dark-adaptation. Measurements are carried out using the MINI-PAM fiberoptics and opening a sliding shutter on this device. This leaf clip is especially suited for measuring Fv/Fm and induction kinetics in the field.

Miniature Fiberoptics MINI-PAM/F1

In addition to the standard fiberoptics (5.5 mm active diameter) a miniature fiberoptics (2 mm active diameter) is available for small spot measurements (**10**), in particular in conjunction with Portable Photosynthesis Systems. Due to its exceptional sensitivity, the signal quality and accuracy of YIELD-determinations by the MINI-PAM are excellent even with the 2 mm fiberoptics. Combined measurements of fluorescence and gas exchange provide outstanding complementary information on the photosynthetic performance of a plant.



Miniature Fiberoptics MINI-PAM/F1

Performance

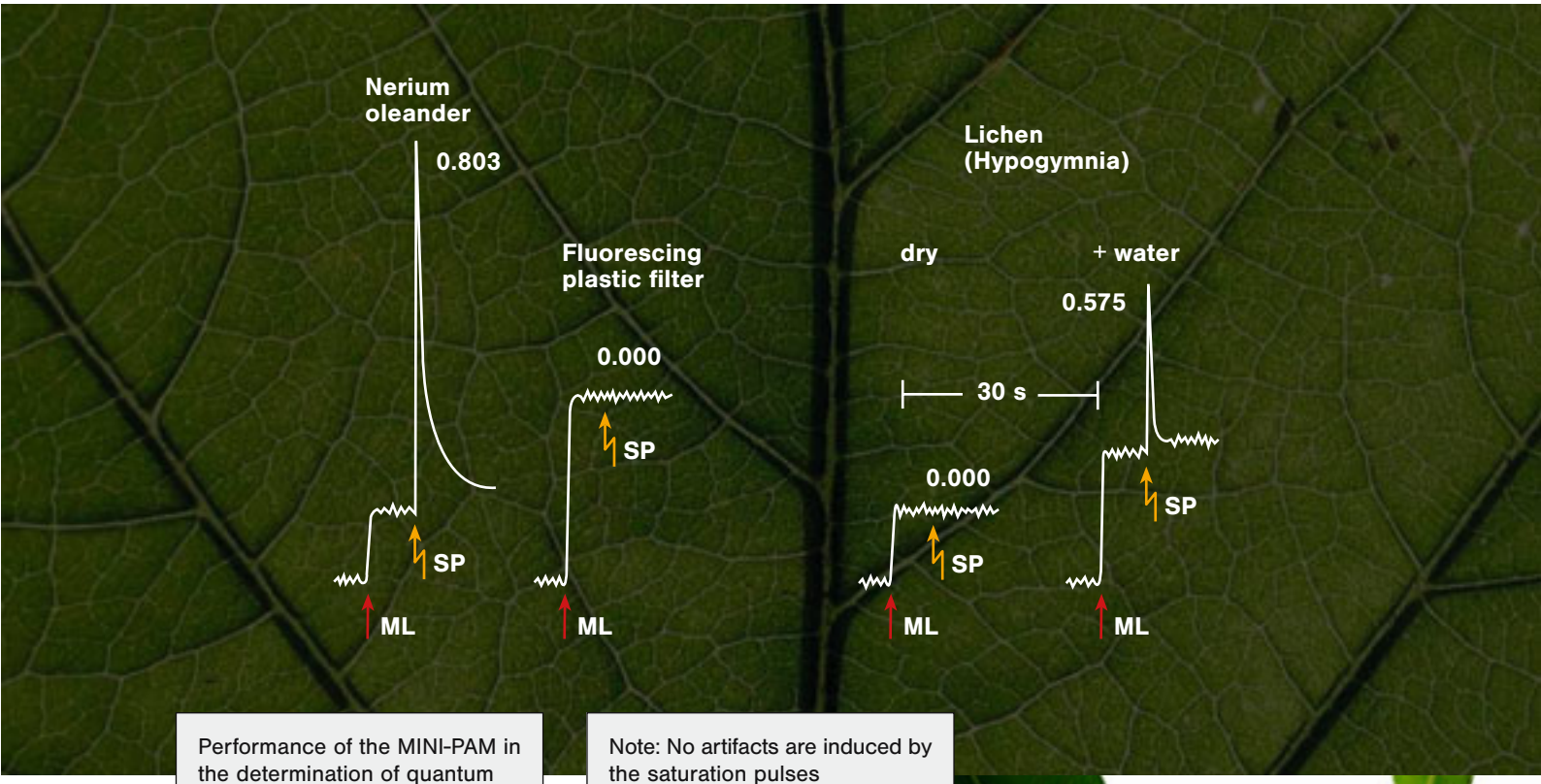
Performance in Determination of Quantum Yield

The design and performance of the MINI-PAM has greatly profited from previous long-standing experience with the PAM-101/102/103 Fluorometer and the PAM-2000 Portable Fluorometer. Despite of its miniature size, the MINI-PAM displays the same exceptional sensitivity and selectivity as these well proven instruments.

Actually, with respect to the ease and accuracy with which it measures the effective quantum yield of photosynthesis (ΔF/Fm according to Genty et al. 1989), the MINI-PAM can be considered superior.

This is mainly due to the fact, that the MINI-PAM has been specifically optimized for such measurements, whereas e.g. no recording of rapid kinetics is intended. The outstanding performance in yield measurements can be judged from the following exceptional features:

- Saturation pulse intensity extending up to 18000 µmol m^{-2} s^{-1} PAR.
- Extremely low measuring light intensity in "burst"-mode, allowing correct determination of maximal yield using dark-adapted samples.
- Single measurement accuracy of 0.5 % and, as shown in the original recordings below, no artifacts when applying saturation pulses (SP) to fluorescing, inactive samples.



Performance of the MINI-PAM in the determination of quantum yield with different types of active and inactive samples. ML, measuring light on; SP, application of a 0.8 s saturation pulse of 10000 µmol m^{-2} s^{-1} PAR. The numbers denote the recorded YIELD-values. Analog recording of fluorescence yield by chart-recorder.

Note: No artifacts are induced by the saturation pulses (ΔF/Fm=Y=0.000), even if such inactive samples display high fluorescence yield. This is essential for reliable YIELD-determination, particularly in studies of samples which can reach zero yield under natural conditions, like lichens when drying out.

Technical Specifications

Basic System

Photosynthesis Yield Analyzer MINI-PAM

- **Measuring light:** Red LED, 650 nm (standard version) or blue LED, 470 nm (MINI-PAM/B), standard intensity 0.15 µmol m^{-2} s^{-1} PAR; modulation frequency 0.6 or 20 kHz; Auto 20 kHz function; burst-mode, 1/5 integrated intensity
- **Halogen lamp:** 8 V/20 W blue enriched, λ<710 nm, max. 6000 µmol m^{-2} s^{-1} PAR with continuous actinic illumination, max.18000 µmol m^{-2} s^{-1} PAR during saturation pulses
- **Signal detection:** PIN-photodiode protected by long-pass filter (λ>710 nm in standard version, λ>650 nm in MINI-PAM/B); selective window amplifier
- **Data memory:** CMOS RAM 128 kB, providing memory for up to 4000 data sets
- **Measured parameters:** Fo, Fm, Fm', F, Fv/Fm (max. yield), ΔF/Fm' (yield), qP, qN, NPQ, PAR and °C (using Leaf-Clip Holder 2030-B or Micro Quantum/Temp.-Sensor 2060-M), ETR (i.e. PAR x ΔF/Fm')
- **Display:** 2 x 24 character alphanumerical LC-display with backlight, character size 4.5 mm
- **User interface:** 2 x 4 tactile key-pad
- **PAR measurement:** 0 to 20000 µmol m^{-2} s^{-1} PAR, in steps of 1 µmol m^{-2} s^{-1} PAR, using 2030-B or 2060-M
- **Leaf temperature measurement:** -20 to +60 °C, in steps of 0.1°C, using 2030-B or 2060-M
- **PC-terminal operation:** Via RS 232 interface using WinControl software
- **Data output and transfer:** Analog output 0 to 4 V, data transfer on PC via RS 232 using WinControl software
- **Power supply:** Internal rechargeable battery 12 V/2 Ah, providing power for ca. 1000 yield measurements; automatic power/off when not used for 4 min; Battery Charger MINI-PAM/L (90 to 260 V AC)
- **Operating temperature:** -5 to 45 °C
- **Dimensions:** 19 cm x 13 cm x 9.5 cm (L x W x H)
- **Weight:** 2.05 kg

Fiberoptics MINI-PAM/F

- **Design:** Randomized 70 µm glass-fibers forming single plastic shielded bundle with stainless steel adaptor ends
- **Dimensions:** Active diameter 5.5 mm, outer diameter 8 mm, length 100 cm
- **Weight:** 180 g

Battery Charger MINI-PAM/L

- **Input:** 90 to 264 V AC, 47 to 63 Hz
- **Output**: 19 V DC, 3.7 A
- **Operating temperature:** 0 to 40 °C
- **Dimensions:** 15 cm x 6 cm x 3 cm (L x W x H)
- **Weight:** 300 g

Transport Case MINI-PAM/T

- **Design:** Plastic case with custom foam packing
- **Dimensions:** 42.5 cm x 34 cm x 13.5 cm (L x W x H)
- **Weight:** 1.9 kg

Accessories (optional)

Leaf-Clip Holder 2030-B

- **Micro quantum sensor:** Selective PAR measurement, 0 to 20000 µmol m^{-2} s^{-1} PAR
- **Thermocouple:** Ni-CrNi, dia. 0.1 mm, -20 to +60 °C
- **Power supply**: Via MINI-PAM (5 V /4 mA)
- **Output:** PAR, 0 to 1000 and 0 to 20000 µmol m^{-2} s^{-1} PAR (0 to 2.5 V each); Leaf temperature, -20 to +60 °C (0 to 0.8 V); Remote trigger button
- **Cable length:** 100 cm
- **Dimensions:** 17 cm x 5.7 cm (max.) x 8 cm (max.) (L x W x H)
- **Weight:** 310 g

Arabidopsis Leaf Clip 2060-B

- **Dimensions:** 7.6 cm x 4.9 cm (max.) x 5.2 cm (max.) (L x W x H)
- **Weight:** 65 g

Dark Leaf Clip DLC-8

- **Design:** Clip made of aluminum with felt contact areas and sliding shutter (closure)
- **Dimensions**: 6.5 cm x 2 cm (max.) x 1.5 cm (max.) (L x W x H)
- **Weight**: 3.6 g

External Halogen Lamp 2050-HB

- **Light intensity:** max. 3000 µmol quanta m^{-2} s^{-1} PAR, stepless setting
- **Power supply:** 12 V/max. 1.6 A e.g. via Battery NP-3/12
- **Weight:** 250 g

Miniature Fiberoptics MINI-PAM/F1

- **Design:** Single plastic fiber with adapter for MINI-PAM
- **Dimensions**: Active diameter 2 mm, length 150 cm

Micro Quantum/Temp.-Sensor 2060-M

- **Micro quantum sensor:** Selective PAR measurement, 0 to 20000 µmol m^{-2} s^{-1} PAR
- **Thermocouple:** Ni-CrNi, dia. 0.1 mm, -20 to +60 °C
- **Power supply:** Via MINI-PAM (5 V /4 mA)
- **Output:** PAR, 0 to 1000 and 0 to 20000 µmol m^{-2} s^{-1} PAR (0 to 2.5 V each); Leaf temperature, -20 to +60 °C (0 to 0.8 V)
- **Cable length:** 100 cm
- **Length of sensor cables:** 30 cm
- **Dimensions:** 16 cm x 3 cm x 1.7 cm (L x W x H)
- **Weight**: 220 g

Compact Tripod ST-2101A

- **Adjustable height:** in steps between 24 cm and 87 cm
- **Weight:** 400 g

High Quality Instrumentation for Plant Sciences

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2.114c/01.2007