Delta-T Devices

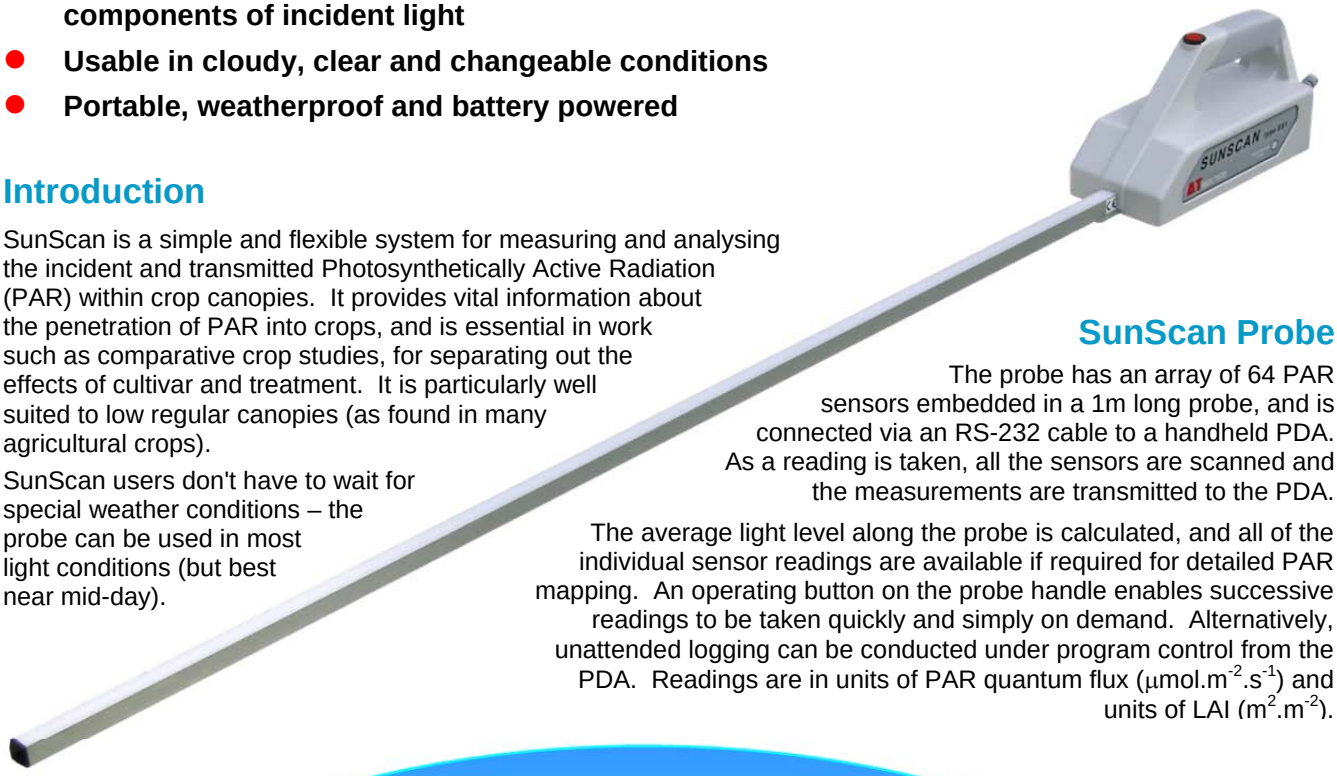
SunScan

Canopy Analysis System - SS1

Portable canopy analysis system for crops

SunScan uses field measurements of PAR in crop canopies to provide valuable information about Leaf Area Index and biomass production.

- **Measures incident and transmitted PAR in plant canopies**
- **Direct display of Leaf Area Index (LAI)**
- **Unique BF5 Sunshine Sensor reference measures Direct and Diffuse components of incident light**
- **Usable in cloudy, clear and changeable conditions**
- **Portable, weatherproof and battery powered**



Introduction

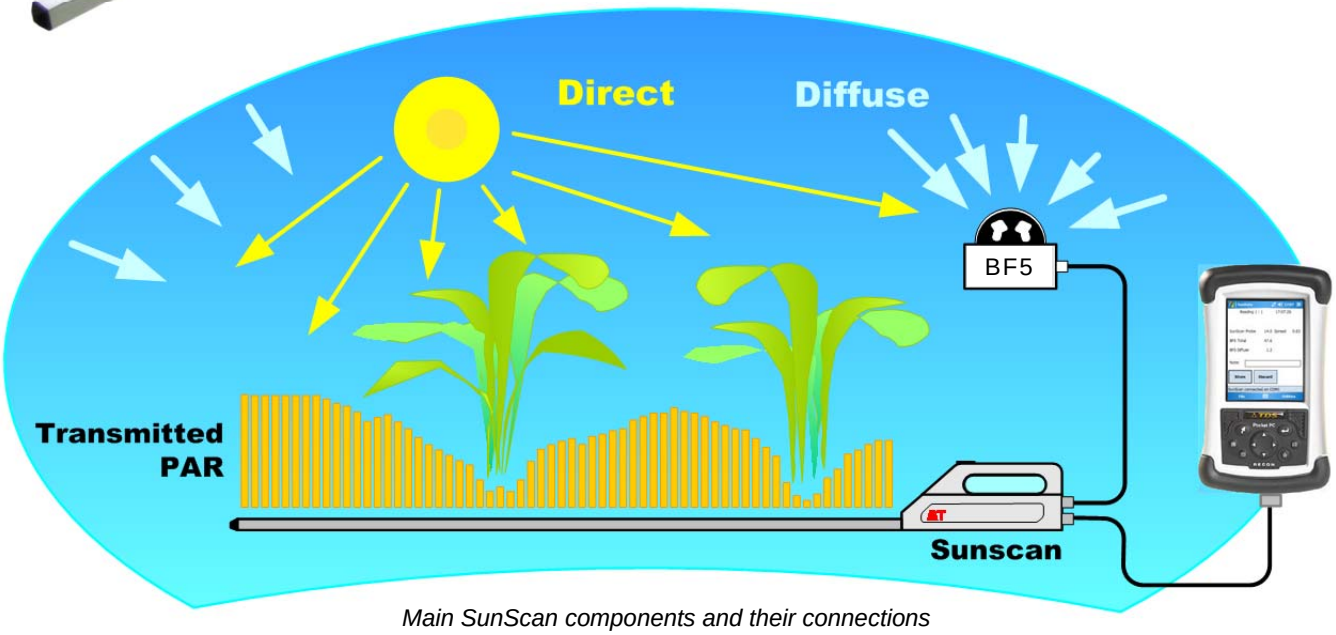
SunScan is a simple and flexible system for measuring and analysing the incident and transmitted Photosynthetically Active Radiation (PAR) within crop canopies. It provides vital information about the penetration of PAR into crops, and is essential in work such as comparative crop studies, for separating out the effects of cultivar and treatment. It is particularly well suited to low regular canopies (as found in many agricultural crops).

SunScan users don't have to wait for special weather conditions – the probe can be used in most light conditions (but best near mid-day).

SunScan Probe

The probe has an array of 64 PAR sensors embedded in a 1m long probe, and is connected via an RS-232 cable to a handheld PDA. As a reading is taken, all the sensors are scanned and the measurements are transmitted to the PDA.

The average light level along the probe is calculated, and all of the individual sensor readings are available if required for detailed PAR mapping. An operating button on the probe handle enables successive readings to be taken quickly and simply on demand. Alternatively, unattended logging can be conducted under program control from the PDA. Readings are in units of PAR quantum flux ($\mu mol.m^{-2}.s^{-1}$) and units of LAI ($m^2.m^{-2}$).



Main SunScan components and their connections

SunScan Canopy Analysis System

SunScan Probe (radio version) and PDA, with radio-linked BF5 Sunshine Sensor mounted on tripod

SunScan System choices

SunScan is modular and expandable. Researchers can specify a system that suits their own performance requirements and budget:

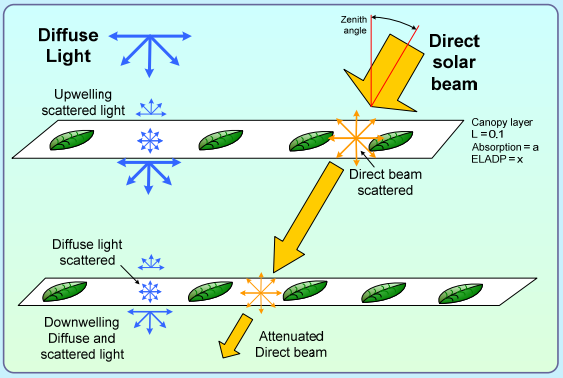
System type	Features and advantages
SS1-COM Complete System *This is the complete package of SunScan items, including SunScan Probe, SunData Software, PDA, Sunshine Sensor type BF5, tripod and carrying case.*	The full system provides a powerful canopy analysis tool. It can instantly calculate LAI, measure PAR interception using either spot readings or unattended logging, and measure sunflecks.
SS1-COM-R4 Complete System with Radio Link *Includes a radio link between the modified SunScan Probe and the BF5 Sunshine Sensor.*	The radio link has a range of 100 to 200m and replaces the cable between the SunScan Probe and BF5 - particularly useful in taller canopies or where readings are required at widely spaced locations.
SS1-STD3 Standard System *The Standard System comprises the SunScan Probe, SunData Software and PDA.*	The Standard System is able to make the full range of SunScan measurements, including LAI. The probe has to serve as its own above-canopy reference, so requires steady light conditions.

SunScan Canopy Analysis System

SunData software modelling

SunScan uses a sophisticated model of light transmission through a uniform canopy, based on work by Campbell (1985), and Norman and Jarvis (1975) and taking into account the following factors:

- **Direct & Diffuse incident light**
- **Leaf PAR absorption**
- **Canopy Leaf Angle Distribution**
- **Canopy Leaf Area Index**
- **Solar zenith angle**
- **Transmitted fraction**



Solar zenith angle is calculated from the actual time, latitude and longitude. **Leaf Angle Distribution** and **Leaf Absorption** are estimated by the user. All other variables necessary to calculate LAI are measured directly.

Because the relative contributions of direct and diffuse incident light are measured at the same time as the transmitted PAR, readings can be made in a wide range of daylight conditions. However we advise against taking measurements when the sun is strong and near the horizon, when large errors may occur. The assumptions and calculations made in the SunData Software are fully explained in the user manual, along with practical advice on how to use the system effectively.

Sunshine Sensor type BF5

SunScan features a unique optional reference sensor which measures the direct and diffuse components of light simultaneously above the canopy.
The special shading pattern of the dome[1] is matched to an array of photodiodes in such a way that at least one photodiode always sees an unobstructed solar disc and at least one is always in full shadow.

The BF5 uses this information to calculate whether the sun is shining and to measure the direct and diffuse components of solar radiation, avoiding the need for the shade ring adjustments required with conventional diffuse light sensors (levelling is the only adjustment required).

[1] Patent numbers EP 1012633, US 6417500.

Data analysis and storage

Rugged PDA type RPDA2

The RPDA2 is an exceptionally robust handheld PDA which collects and analyses readings from the SunScan Probe. Raw readings, and derived functions such as LAI, can be displayed, reviewed and stored in the field by the SunData Software; groups of readings can be averaged if required. Readings are stored in the internal memory which holds >1 million readings, or in widely available CompactFlash cards which provide removable data storage. Collected data can be transferred easily to a PC.

Rugged PDA with the Holster belt type SS1-HB1

Unattended logging with RPDA2

The SunData Software can automatically take readings and averages from the SunScan Probe, at user-defined intervals from 1 second to 24 hours. This can be used for example to obtain diurnal readings of canopy light interception at a particular location.

Radio link

The radio link connects the SunScan Probe and the BF5 reference sensor, eliminating the need for a long connecting cable. The link operates over the 434MHz licence-free frequency and can transmit up to 250m line-of-sight or 100m to 200m in vegetation. The radio link system comprises an add-on module for the BF5 reference sensor (BF5-RL4) and a specially modified SunScan Probe (SS1-RL4).

SunScan specifications

SunScan Probe type SS1	
Active area	1m x 13mm wide, sensor spacing 15.6mm
Spectral response	400 - 700 nm (PAR)
Measurement time	120 ms
Maximum reading	2500 mol.m^{-2}.s^{-1}
Resolution	0.3 mol.m^{-2}.s^{-1}
Linearity	better than 1%
Accuracy	10%
Analogue output	1 mV per mol.m^{-2}.s^{-1}
Serial interface	RS232, 9 pin female 'D' connector
Environmental	IP65, 0 - 60° C working temp
Size & Weight	1300(l) x 100(w) x 130(h) mm, 1.7kg
Power	4 x AA Alkaline cells (lifetime up to 1 year)

Sunshine Sensor type BF5	
Output sensitivity total & diffuse	1 mV / mol.m^{-2}.s^{-1} PAR cosine corrected
Accuracy	Total 12% Diffuse 15% } 10 mol.m^{-2}.s^{-1}
Temperature range	-20 to + 50 C with alkaline batteries
Range	0 - 2500 mol.m^{-2}.s^{-1} (total & diffuse)
Spectral response	PAR (400-700 nm)
Power	2 x AA Alkaline cells (lifetime up to 1 year)
Input voltage	5 - 15V DC (powered from SunScan)
Size & Weight	120 x 122 x 95mm, 635g

Rugged PDA type RPDA2	
Screen	¼ VGA sunlight readable
Operating system	Windows Mobile 6
Display options	a) LAI b) PAR average c) ALL individual sensor readings
Environmental	IP67, -30°C to 60°C, 1.2m drop test
Power	Rechargeable battery, 12h continuous use
Memory	>100 MB available
Size & Weight	165 x 95 x 45mm, 450g

Calibration

The SunScan Probe (SS1) and Sunshine Sensor (BF5) are calibrated under a standard light source against an accurate PAR quantum sensor traceable to national standards. The spectral and cosine responses of the sensors approximate to the ideal response (graphs available on request), but fall off at the extremes of the range.

Under most normal daylight conditions errors due to the deviation are small, but it is possible, for example under artificial light, to find larger errors in the absolute values measured. Because the BF5 Sunshine Sensor and SS1 Probe are closely matched, this has minimal affect on the canopy calculations which are based on ratios of incident and transmitted light.

Delta-T can also supply **HemiView**, a system for obtaining and processing hemispherical images of plant canopies. If your research involves high irregular canopies such as forests, please download a HemiView data sheet.

Ordering information

SunScan systems

All systems are based on the main components listed below.

SunScan Complete System type SS1-COM SunScan Probe, SDA2 SunData Software, RPDA2, Sunshine Sensor type BF5 with cables type BF5-SS1-05 and EXT/8W-05, Tripod and Carrying Case.

SunScan Complete System with Radio Link type SS1-COM-R4 as above with BF5-RL4 and SS1-RL4.

SunScan Standard System type SS1-STD3 SunScan Probe, SDA2 SunData Software and RPDA2.

Main components

SunScan Probe type SS1 including alkaline batteries and user manual (technical manual on CD).

SunScan Probe with radio link type SS1-RL4

SunScan Radio Module type BF5-RL4 radio link transmitter for attachment to BF5 sensor

SunData Software type SDA2

Rugged PDA type RPDA2 Recon X-Series PDA including rechargeable battery, comms cable and carrying case.

Sunshine Sensor type BF5 including user manual (NB requires cable type BF5-SS1-05 for use with SS1 Probe or type SP-BF/w-05 for use with data logger. For extension cables see below).

Telescopic Tripod type SS-TD for mounting BF5.

Carrying Case type SCC1 for SunScan Probe and accessories.

Optional items

Holster belt for PDA and SS1 type SS-HB1 for hands-free operation of PDA type RPDA2 and temporary parking of the SunScan Probe.

Extension cables: both the BF5-SS1-05 and SP-BF/w-05 cables can be extended with the EXT range of cables **EXT/8W-05**, **EXT/8W-10** and **EXT/8W-25** (5, 10 and 25m).

Logger cable type SP-BF/w-05 for SunScan Probe connection to a data logger (not for use with RPDA2).

Upgrades

Please enquire for upgrades to radio link capability or from BF3 to BF5 sensor or from Data Collection Terminal type DCT2 to the rugged PDA type RPDA2.

For spares, recalibration and consumables please enquire.

Dynamax

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