



Photon  
Systems  
Instruments

Professional Instruments  
for Plant Science, Biotechnology  
and Agriculture

PSI NEWS

Issue **21**

Welcome to Issue 21 of the PSI NEWS.  
This Issue is dedicated to

## Plant Growth and Cultivation

PSI offers a suite of products for plant growth and cultivation all of which highly provide precise and stringently controlled growth conditions.

- **LED Light Sources**
- **Growth Rooms**
- **Growth Chambers**
- **Research Greenhouses**
- **Incubated Shakers**





### *Content*

<b>LED Light Technology</b> .....	3
<b>Comparison of <i>Arabidopsis</i> Growth under Different Light Sources</b> .....	4
<b>LED Light Sources</b> .....	5
<b>Growth Rooms</b> .....	7
<b>Cultivation Banks</b> .....	8
<b>Walk-In FytoScope</b> .....	9
<b>Step-In FytoScope</b> .....	10
<b>Reach-In FytoScope FS-RI-1600</b> .....	11
<b>Small Footprint FytoScopes</b> .....	12
<b>Research Greenhouses</b> .....	13
<b>Incubated Shakers / AlgaeTrons</b> .....	14

# LED Light Technology

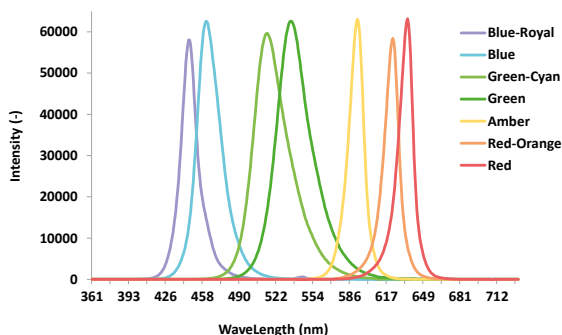
Control of light intensity and spectral quality is essential for optimal plant growth and biomass production. PSI uses mainly LED light technology to optimize light conditions.



## ■ LEDs Provide Unique and Precise Light Quality Control

- Sun light simulation
- Cloudy sky imitation
- Dawn and dusk imitation
- Specific pigment excitation
- Stimulation of individual phytochromes
- Simulation of red and far-red ratio as is in the canopy

Multi-Color LED



## ■ Key Features of LED Light Sources

- Precise light flux and waveband control
- Rapid activation enabling microsecond light pulses
- Precise ramping of light intensities
- Uniform homogeneity of irradiance
- Focused to maintain light intensity at different distances
- High incident irradiance, PPFD up to  $5,000 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Ability to lighting the side of the canopy
- Incremental control from 0 to 100% of maximum
- Minimal heat load on plants
- Durable, low power requirement
- Long life span of 6–7 years



# Comparison of *Arabidopsis* Growth under Different Light Sources

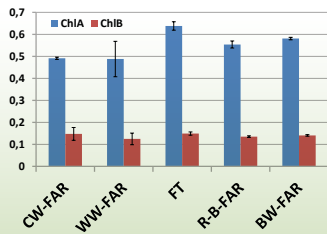
## ■ Experimental Setup

- 24 day old *Arabidopsis*
- 12/12h light regime 22/20 °C, 55% humidity
- Light intensity (PPFD) 150  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Mean and standard deviation presented (n=10)

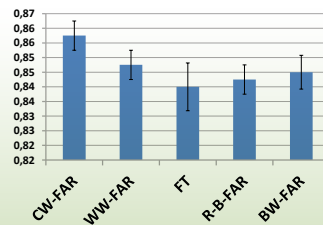
## ■ Abbreviations

- CW-FAR cool white LED with far-red
- WW-FAR warm white LED with far-red
- FT fluorescent tube
- R-B-FAR red and blue LEDs with far-red
- BW-FAR brightness cool white LED with far-red

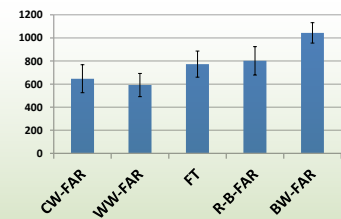
Total chlorophyll content ( $\mu\text{g}/\text{ml}$ )



NDVI values



Rosette area ( $\text{mm}^2$ )



White LEDs with far-red



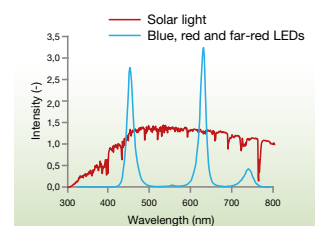
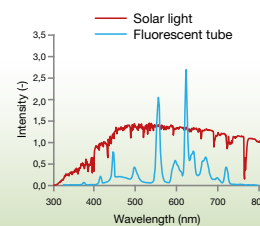
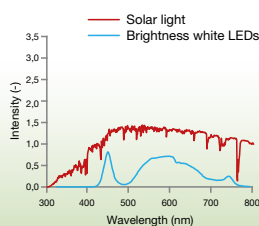
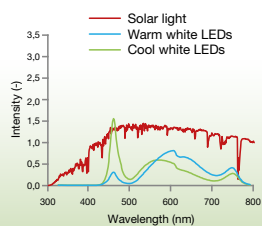
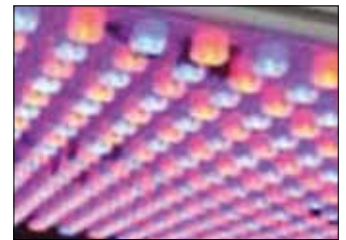
Brightness white LED with far-red

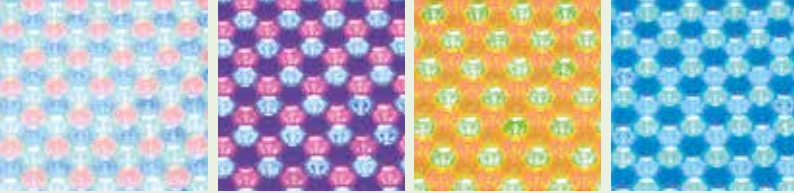


Fluorescent tubes



Blue, red and far-red LEDs





# LED Light Sources

## LED LIGHT SOURCE SL 3500

SL 3500 self-standing high-performance LED panels can operate in multiple regimes: flash, continuous, modulated light, or with user-defined modes of action. They can also complement other PSI instruments such as FluorCams, Photobioreactors, FytoScopes.

### ■ Technical Specifications

- Light intensity (PPFD) up to 3,000  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Uniformly homogenous illumination
- Manual or software control
- Multicolor LED spectra from UVA to far-red
- Single, bi- and tri-color versions available
- Precise control of light intensity and quality
- Microsecond pulses enabled

### ■ Available Panels

- 130 × 130 mm; 200 × 200 mm; 300 × 200 mm

### ■ Applications

- Plant research and biomedicine
- Light signaling studies
- Plant handling under dim green light

## LED FYTO-PANELS

LED Fyto-Panels were developed for illumination of large areas in growth chambers with a uniform light source. Panels are delivered with a control unit for regulation of timing, light intensity and spectral quality.



### ■ Technical Specifications

- PPFD 200–1,500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  (at 100 cm)
- Uniformly homogenous illumination
- Standard version: Cool white LEDs with far-red
- Optional multicolor LED spectra available
- LED panels are cooled
- Precise control of light intensity and quality
- Independent control of each LED channel/color
- Light modes enable ramping/cloudy sky simulation etc.

### ■ Available Sizes

- 270 × 810 mm; 270 × 410 mm
- Combination of available sizes

### ■ Applications

- Controlled uniform irradiance
- Plant research and biomedicine
- Agricultural and biotechnology research



# LED Light Sources

## LED LIGHT BARS

Individual LED light bars are designed for mounting in greenhouses and growth chambers for supplementary illumination to enhance plant growth. LED light bars may also be used as alternative lighting options to current sources.



### ■ Technical Specifications

- PPFD up to  $500 \mu\text{mol.m}^{-2}.\text{s}^{-1}$  (at 100 cm)
- White LEDs
- White LEDs enriched by far-red

### ■ Available Sizes

- Maximal bar length 4 m
- Minimal bar length 20 cm
- Customized formats

## CULTIVATION SHELVES

Cultivation Shelves provide modular cultivation spaces within growth rooms to maximise growth space usage. Each shelf is irradiated by LED panels that are directly incorporated into the base of the shelf above. Each modular system is delivered with PSI's Light Controller for user-friendly programming of timing, light intensity and spectral quality.

### ■ Technical Specifications

- PPFD up to  $250 \mu\text{mol.m}^{-2}.\text{s}^{-1}$  (at 30 cm)
- Uniformly homogenous illumination
- White LED illumination with far-red LEDs
- Precise control of light intensity and quality
- Independent control of each LED channel
- Light modes enabling ramping/ cloudy sky simulation etc.

### ■ Shelves

- Maximum capacity of 8 shelves per unit
  - Height adjustable up to 25 mm
  - Easily removable
  - Available configurations\*
    - CS 250/300\_5\_3
    - CS 250/300\_5\_2.4
    - CS 250/200\_7\_4.2
    - CS 250/200\_7\_3.4
- \*) PPFD/at distance (mm)\_number of shelves\_cultivation area ( $\text{m}^2$ )

### ■ Applications

- Maximizing space for cultivation in growth rooms
- Large scale experiments



# Growth Rooms



PSI provides customized growth rooms designs.

## CULTIVATION SYSTEMS

- Cultivation Banks (page 8)
- Walk-In Fytoscope (page 9)
- Cultivation Shelves (page 6)



### ■ Key Features

- Relative humidity between 40% to 90%
- Temperature range -5 °C to +40 °C
- Gas-tight rooms
- Gas mixing for CO<sub>2</sub> regulation and exchange
- Online computer control

### ■ Control & Setting

- User friendly GUI
- 10.5" LCD color touch screen
- Up to 100 user defined protocols
- Program changes in 1 min steps
- Parameters changes in gradual steps
- Real time data visualization
- Graphical/table data view
- Remote control
- Ramping modes – cloudy sky simulation etc.
- Warning messages via SMS
- USB port



### ■ Precise Control of Irradiance

- Cool, warm or neutral white LEDs with added deep-red and/or far-red LEDs for optimal plant growth
- Collimated LEDs for uniform illumination
- Incremental changes in irradiance from 0 to 100%
- Ramping modes, cloud simulation etc.
- Natural light simulation



# Growth Rooms

## Cultivation Banks

- More than 12 different temperatures and light settings in one cultivation chamber
- Each Cultivation Bank is independently controlled
- Suitable for multiple or parallel experiments
- Uniform homogeneity of set parameters
- Sophisticated air ventilation system
- LED light technology for optimal plant growth
- Easy programming & remote control

### ■ Sophisticated Air Ventilation System

- Extremely low air flow up to 0.25 m/s
- Minimal heat load in chamber
- Zero water condensation
- Light-independent regulation of temperature
- Uniformly homogenous environment

### ■ Customizable Cultivation Banks

- CO<sub>2</sub> regulation
- Different light sources available (LEDs with different wavelengths or fluorescent tubes)
- Light radiation monitoring
- Chlorophyll fluorescence module
- Variable number of Cultivation Banks

### ■ Wide Range of Applications

#### *In vitro* and soil cultivation of plants

- Suspension culture cultivation
- Multiple simultaneous physiological studies
- Phenotypical analysis (*Arabidopsis*)
- Vernalization (*Brassica*, *Hordeum*)
- Dusk and dawn response simulation

### ■ Key Features

- Individual control of multiple experiments
- Temperature range +2 °C to +45 °C
- PPFD up to 1,500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  (at 30 cm)
- Sophisticated and user friendly software





# Growth Rooms

## Walk-In Fytoscope

### Walk-In FytoScope Provides

- Unique system of temperature control
- Prevention of water condensation
- Uniform homogeneity of set parameters
- Specially assembled LED light technology
- Customizable to user-specifications
- Remote control

#### ■ Wide Range of Applications

- Large scale experiments *In vitro* / soil cultivation
- High humidity cultivation (*Oryza*)
- Vernalization (*Brassica*, *Hordeum*)
- Homogeneity of growth (phenotypical analysis)

#### ■ PSI Innovative Solution

Our temperature exchanger enables:

- Precise temperature regulation not affected by light cycle regulation
- Uniform homogeneity of temperature and humidity
- Prevention of water condensation

#### ■ Customize Your Fytoscope

- Chamber size according to your needs
- Multiple shelves to meet your application
- Shelving may be fixed or motorized
- Various light sources available (LEDs with different wavelengths, UV, fluorescent tubes)



#### ■ Innovative Technology Allows

- Temperature extremes of  $-5\text{ }^{\circ}\text{C}$  to  $+45\text{ }^{\circ}\text{C}$  during full light exposure!
- Light intensity (PPFD) up to  $3,000\text{ }\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Humidity control from 40–90 % (guaranteed from  $+5\text{ }^{\circ}\text{C}$ )

# Growth Chambers

## Step-In FytoScope

### Step-In FytoScope Provides

- Unique system of temperature control
- Prevention of water condensation
- Uniform homogeneity of set parameters
- Specially assembled LED light technology
- Customizable to user-specifications
- Remote control

### ■ Example Applications

- *In vitro*/soil cultivation
- Cultivating large plants and trees (0.9 m<sup>2</sup> × 1.9 m)
- Extreme humidity cultivation (*Oryza*)
- Vernalization (*Brassica*, *Hordeum*)
- Climate studies
- Stress responses
- Light dependent experiments  
(Study of light signaling pathways, shade avoidance responses etc.)

### ■ Customize Your FytoScope

- Gas mixing system for CO<sub>2</sub> control
- Multiple adjustable shelves
- Chlorophyll fluorescence measurement module
- Online monitoring of photosynthetic performance
- Different light sources (LEDs with different wavelengths/UV/fluorescent tubes)

Basic technical parameters (i.e., temperature, humidity, illumination, software control) are the same as described in Growth Rooms Introduction (see page 7).



### ■ Innovative Technology Allows

- Temperature extremes -5 °C / +45 °C with ensured full light exposure!
- Light intensity (PPFD) up to 3,000 μmol.m<sup>-2</sup>.s<sup>-1</sup>
- Dynamic multispectral irradiance
- Large plants and trees cultivation



# Growth Chambers

## Reach-In FytoScope

### FS-RI-1600

#### Reach-In FytoScope Provides

- Unique system of temperature control
- Prevention of water condensation
- Uniform homogeneity of set parameters
- Online monitoring and control of set parameters
- LED light technology
- Easy programming & remote control

#### ■ Suitable Applications

- Small scale experiments *In vitro*/soil cultivation
- Phenotypical analysis
- High humidity cultivation (*Oryza*)
- Vernalization (*Brassica*, *Hordeum*)
- Large plants (*Zea*, *Solanum*), trees cultivation

#### ■ Construction Adjustments

- Easily adjustable shelves
- One large or 2–3 smaller cultivation areas
- Extremely large inner space:  
97 × 65 × 122 cm (D × W × H)
- Equipped with wheels for easy manipulation
- Optionally: connection and communication with other PSI devices (chlorophyll fluorescence measurement)

Basic technical parameters (i.e., temperature, humidity, illumination, software control) are the same as described in *Growth Rooms Introduction* (see page 7).

#### ■ Innovative Technology Allows

- Temperature extremes -5 °C / +40 °C with ensured full light exposure!
- Prevention of water condensation
- Light intensity (PPFD) up to 2,000  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Relative humidity from 40% to 90%
- White LEDs with supplementary far-red LEDs (Optionally multicolor LEDs can be mounted)
- Large plants and trees cultivation
- Cultivation of small model plants



# Growth Chambers

## Small Footprint

## FytoScopes

Growth chambers for cultivation of higher plants and suspension cultures in limited space.

### ■ Technical Features

- Small footprint ideal for limited space
- Temperature control 15–40 °C
- Uniform LED lighting for optimal plant growth
- Two light color versions:
  - (a) white + far-red
  - (b) red + green + blue + far-red
- Control of light intensity and spectral quality
- Air exchange

### ■ Customizable Features

- CO<sub>2</sub> regulation
- Temperature upgrade +7 to 55 °C
- Light intensity (PPFD) upgrade up to 1,500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Additional humidifying
- Integrated devices: Orbital shaker
- Chlorophyll fluorescence module
- Precise PC software control of protocols, additional functions such as ramping modes, cloudy sky simulation etc.

### ■ Applications

- Suitable for small scale experiments
- Plant growth in soil and *In vitro*
- Cultivation of suspension cultures
- Space for dark adaptation and canopy simulation

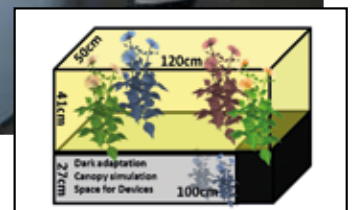
### ■ Control and Settings

- Digital display
- Sensor for temperature and optionally for RH
- Real time data collection and visualization
- Intuitive programming for: timing, temperature, light intensity and light quality
- Diurnal cycling
- Incremental light intensity control 0–100 %



### FYTOSCOPE CHAMBER FS 130

- Space saving solution for the lab
- Easily adjustable shelf
- Inner space: 40 × 42 × 69 cm (D × W × H)
- Internal volume: 124 Liters
- Light intensity (PPFD): up to 1,500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Space for light independent sample incubation
- Temperature Range:
  - +7 °C to +55 °C (lights OFF)
  - +10 °C to +55 °C (lights ON)



### FYTOSCOPE CHAMBER FS 360

- Cultivation chamber accessible from the top
- One large or 2 smaller cultivation areas
- Internal volume: 290 Liters
- Light intensity (PPFD) up to 300  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  upgradable to 600  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Temperature range +15 °C to +40 °C

# Research Greenhouses



## ■ Key Features

- Customized designs
- Online control and monitoring of environment
- Regulation of:
  - CO<sub>2</sub> level
  - Relative humidity
  - Temperature
  - Lighting
- Central and remote control
- Individual greenhouse sectors may be controlled separately
- Automatic watering and light/dark control of tables
- Conventional and/or adiabatic cooling
- High-performance air-conditioning (air circulation, air exchange, humidity level control)
- Special regime for inner air recirculation (minimum fresh air required)
- Double or triple layer glass for maximum energy efficiency
- Software-regulated external shading system for heat/light control

## ■ Smart Lighting Solutions

- Software control of light intensity and cycles
- Precise irradiance in gradual steps
- LEDs controlled from 0 % to 100 % output
- Homogeneous irradiance by high-intensity LEDs
- Height-adjustable LED light bars
- Cost-effective and energy efficient light sources
- Sodium/ Metal-Halide lamps controlled from 30 % to 100 %



# Incubated Shakers

## AlgaeTrons

AlgaeTrons are floor standing incubators with small footprint size developed for optimizing cyanobacteria and algae cultivation.

### ■ Technical Features

- Small size suitable for every lab space
- Temperature control 15–50 °C
- LED illumination (cool or warm white)
- Control of light intensity and spectral quality
- Air exchange

### ■ Control and Settings

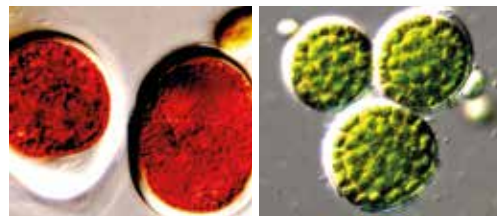
- Digital display of settings and parameters
- Real time data collection and visualization
- Intuitive programming for timing, temperature, light intensity and spectral quality
- Light intensity range 0–100 %

### ■ Applications

- Precise cyanobacterial and algal cultivation
- Incubation of *In vitro* cultures in flasks/dishes
- Suitable for small scale experiments

### ■ Customizable Features

- Integrated orbital shaker
- Optional CO<sub>2</sub> regulation
- Relative humidity control
- Temperature upgrade +7 °C to +55 °C
- Light intensity (PPFD) upgrade up to 1,500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
- Multicolor LED combination (red + green + blue + far-red)
- Precise control of protocols and functions such as ramping modes, cloudy sky simulation etc.



## ALGAETRON AG 130-ECO

- Most economical space-friendly cultivation
- Easily adjustable shelf
- Inner space: 40 × 42 × 69 cm (D × W × H)
- Internal volume: 124 Liters
- Space for light-independent sample incubation
- Light intensity (PPFD):
  - up to 1,000  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  (cool white)
  - up to 500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  (warm white)



## ALGAETRON AG 230

- Three independently illuminated shelves
- Inner space: 40 × 50 × 130 cm (D × W × H)
- Internal volume: 265 Liters
- Space for light-independent sample incubation
- 1 to 3 orbital shakers
- Light intensity (PPFD):
  - top shelf up to 500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$
  - lower shelves up to 100  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$



# 2<sup>nd</sup> Integrated Plant and Algal Phenomics Meeting 2016

New Approaches in the Lab and Field  
Prague, Czech Republic  
September 4<sup>th</sup> – 7<sup>th</sup>

We are very proud to invite you to the 2nd Integrated Plant and Algal Phenomics Meeting (IPAP), to be held this year in the beautiful and historic city of Prague between September 4<sup>th</sup> and 7<sup>th</sup>.

The conference will focus on the rapidly expanding field of high throughput plant and algal phenotyping, and will feature an excellent program with speakers presenting data from laboratory and field studies derived using a variety of phenotyping platforms and techniques.

For further information see: [www.psi.cz/ipap2016](http://www.psi.cz/ipap2016)

## *Did You ever hear about... Czech Republic?*

'PILSNER' (type of beer) / 1842



Word 'ROBOT'  
Karel Čapek / 1920



POLAROGRAPHIC  
METHOD  
Jaroslav  
Heyrovský / 1922



SUGAR CUBES  
Jacob Christoph Rad / 1841



SHIP SCREW PROPELLER  
Joseph Ressel / 1827



SOFT CONTACT LENSES  
Otto Wichterle / 1961



LIGHTNING ROD  
Prokop Diviš / 1754



BLOOD GROUP SYSTEM  
Jan Janský / 1907



MENDELIAN INHERITANCE  
Gregor Johann Mendel / 1866



Berlin



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**[www.led-growing-lights.com](http://www.led-growing-lights.com)**

**[www.plantphenotyping.com](http://www.plantphenotyping.com)**

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