

WE MEET @ DIGITAL DAYS



SUSTAINABLE FOOD PRODUCTION WITH HORTICULTURE LEDS

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Business Development Manager

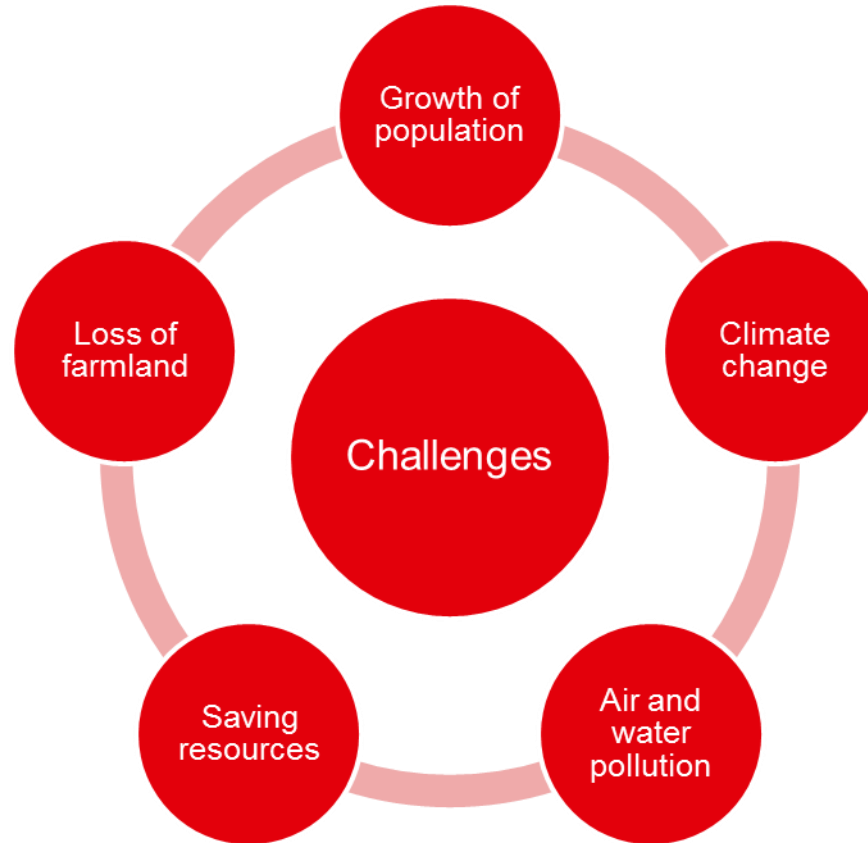
WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

AGENDA

- Challenges of humanity
- Controlled Environmental Agriculture – Vertical Farming
- Why Horticulture LEDs? Characteristics and Benefits
- Why Würth Elektronik - More than you expect
- Q&A



CHALLENGES OF HUMANITY



Higher world population in combination with less usable farmland under unpredictable weather conditions
How can we secure food supply?



All these impacts and challenges needs solutions
Horticulture LEDs can contribute to be a part of the solution

CONTROLLED ENVIRONMENTAL AGRICULTURE (CEA)

Indoor Farming



Vertical Farming

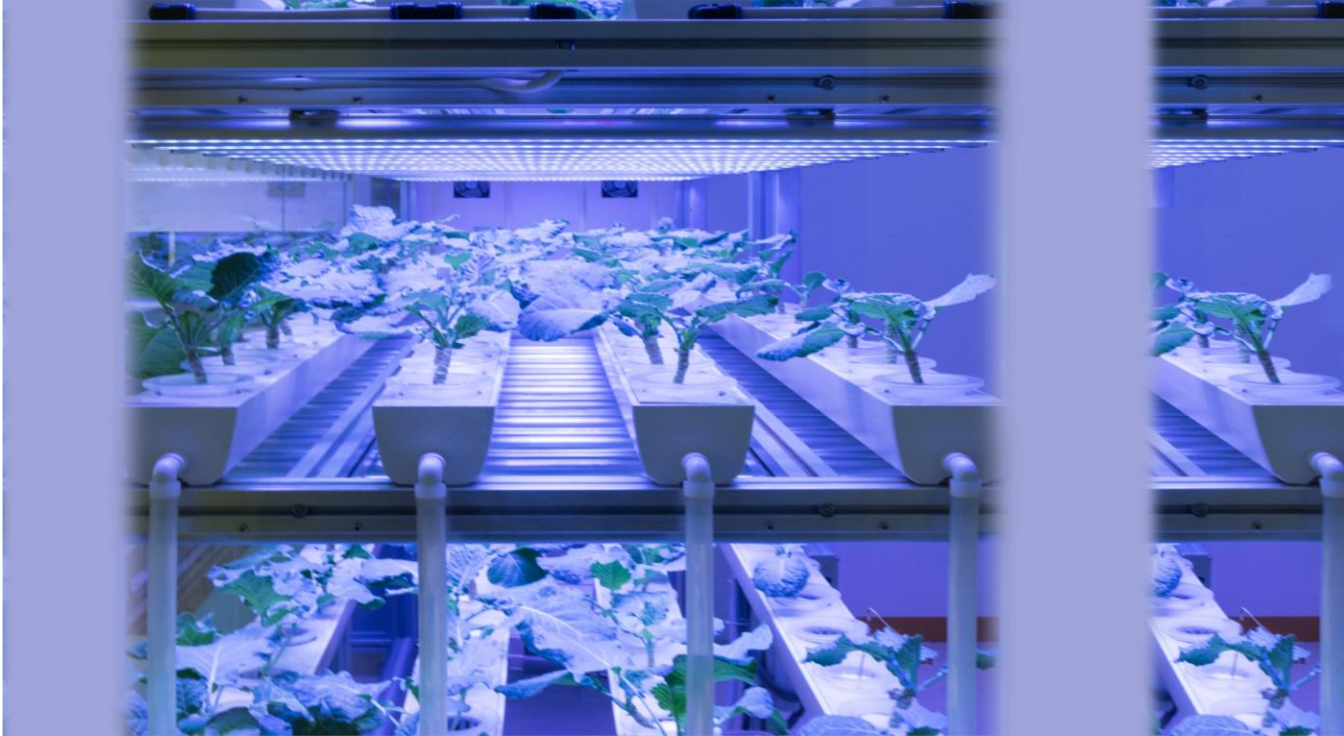


Greenhouse



- Cultivation of plants under optimal growing conditions
- CEA is a chance, not a competitor to traditional farming

VERTICAL FARMING



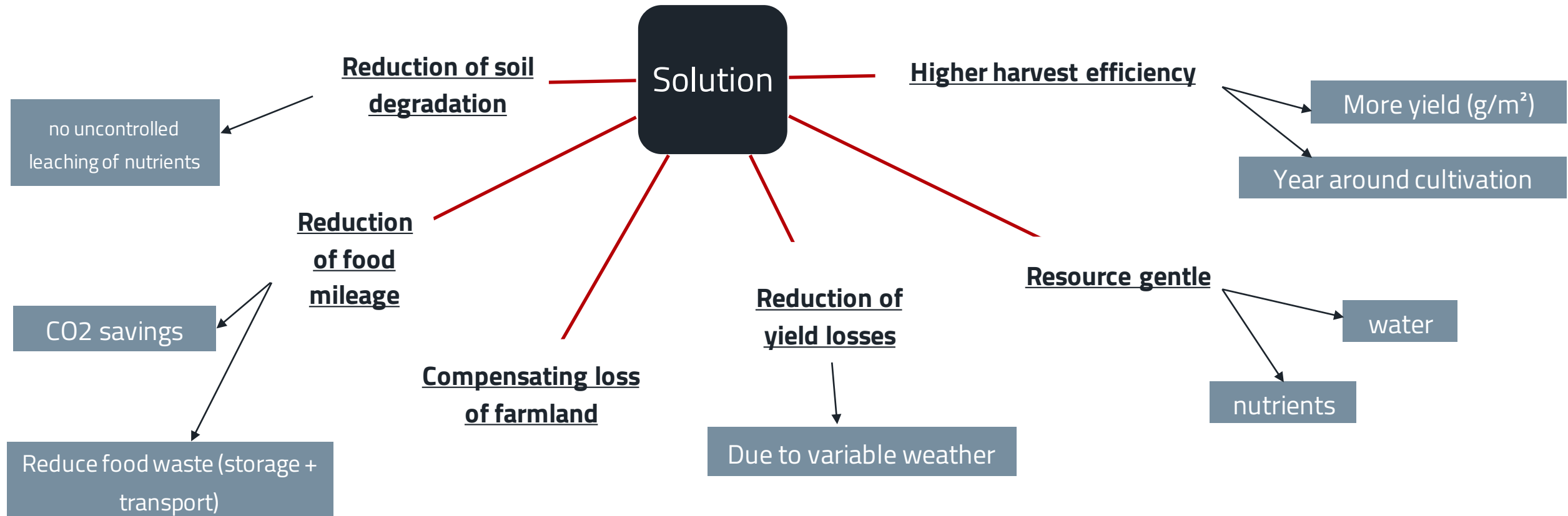
The farm of tomorrow: agriculture in the middle of the city, close to the customer

- Use of a multilayer cultivation system – minimum growing area
- Use of hydroponics (closed water and nutrient cycle)
- No long transportation of food
- Optimization of growth conditions – app control/AI
- Consistency of products – same quality
- Growing all over the world is possible – challenging places
- Harvest on demand – 100% local, higher nutritional value

Vertical Farming was made possible by LEDs

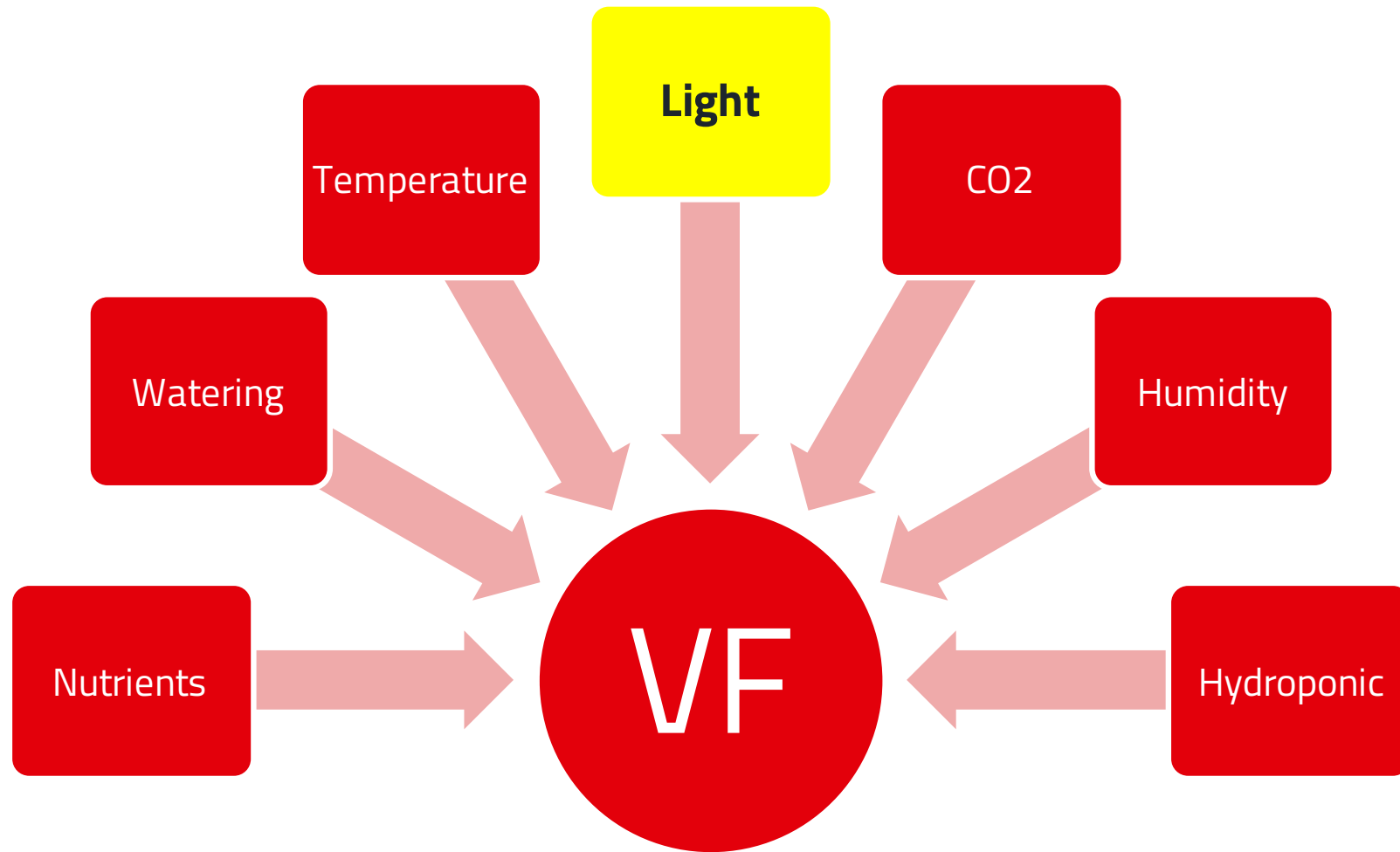
SOLUTION:

Vertical Farming is one part, which has the potential to contribute to help against the challenges of humanity:



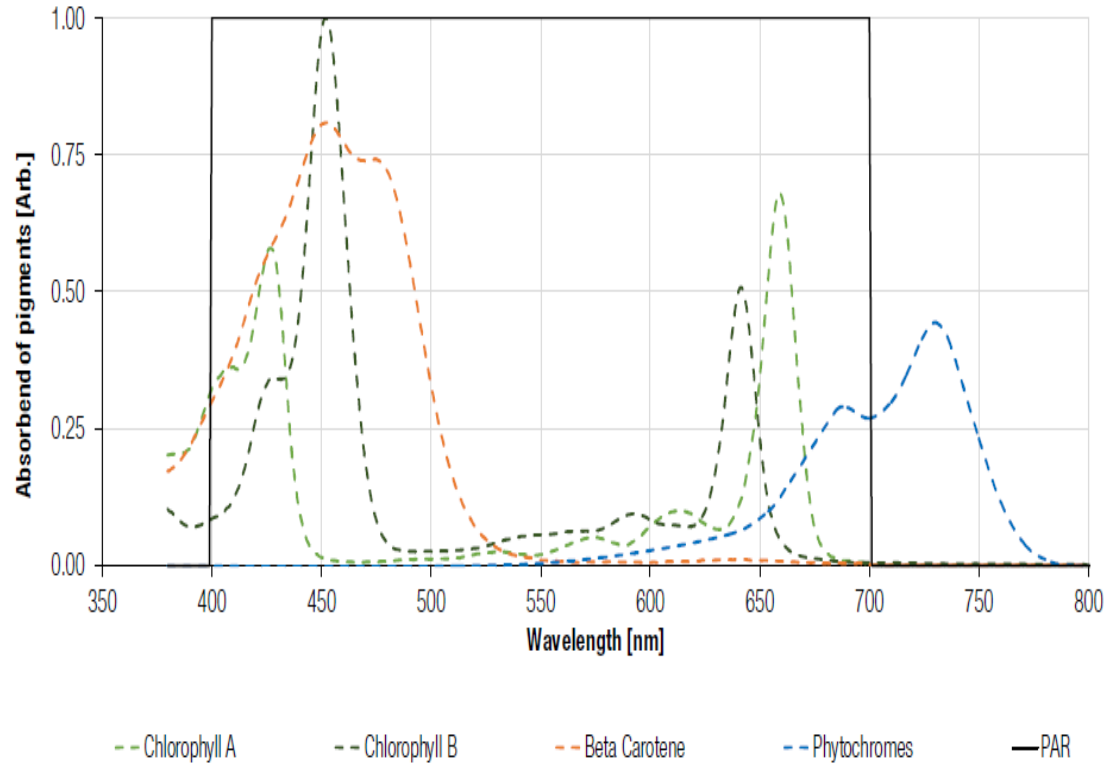
→ Vertical Farming can be used to improve food security and ensure nutrient rich food, while reducing carbon footprint and food miles.

WHAT ARE INFLUENCING FACTORS IN A VERTICAL FARM (VF)



CHARACTERISTICS OF HORTICULTURE LIGHTING

Biological Basics



What does a plant need?

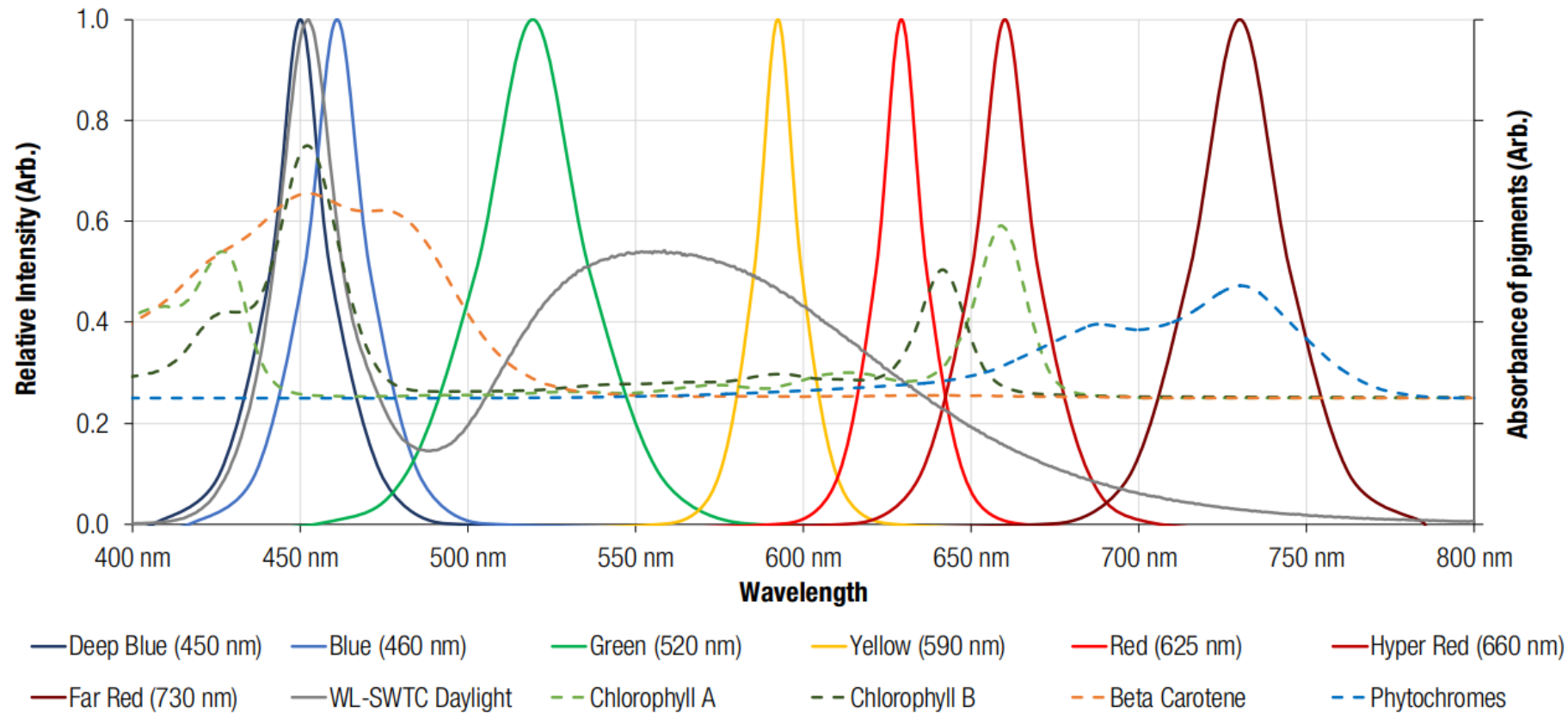
→ light is essential for plant growth

- **PAR (Photosynthetic Active Radiation)**
region from 400nm to 700nm in which the plants are able to use photosynthesis
- **PBAR (Plant Biological Active Radiation)**
region from 280nm to 800nm in which the plants recognize light

→ light can control: photosynthesis, morphology, flowering secondary metabolites, flavor, etc...

CHARACTERISTICS OF HORTICULTURE LIGHTING

Optical Basics

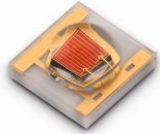


We developed our LEDs for customized light solutions for different Qualityparameter of the plants.
Suitable for all Horticulture Lighting Applications

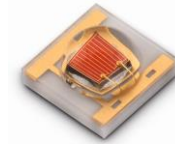
WÜRTH ELEKTRONIK HORTICULTURE LEDS

High Power Products

Horticulture

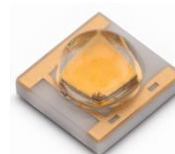
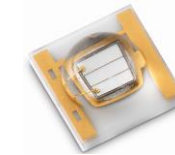


Order Code	Color	λ_p
150353DS74500	Deep Blue	450 nm
150353HS74500	Hyper Red	660 nm
150353FS74500	Far Red	730 nm



Advantages

- adjustable spectrum
- plant adapted spectrum
- full spectrum
- low thermal resistance
- high efficacy



more Information on www.we-online.com/leditgrow

Order Code	Color	λ_p
150353RS74500	Red	635 nm
150353YS74500	Yellow	593 nm
150353GS74500	Green	520 nm
150353BS74500	Blue	460 nm

Visible

WL-SMDC

Order Code	Color	λ_p
15335338AA350	Ultraviolet	385 nm
15335339AA350	Ultraviolet	395 nm
15035340AA350	Ultraviolet	405 nm

UV

WL-SUMW

Order Code	Color	CCT
158353027	Sunrise	2700
158353030	Warm White	3000
158353040	Moonlight	4000
158353050	Daylight	5000
158353060	Cool White	6000

White

WL-SWTC

WÜRTH ELEKTRONIK HORTICULTURE LEDS

Mid Power Products

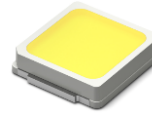
WL-SMTW

Horticulture



ERWEITERT

Order Code	Color	λ_p
150283DS73103	Deep Blue	450 nm
150283HS73103	Hyper Red	660 nm
150283FS73103	Far Red	730 nm



Visible



ERWEITERT

Order Code	Color	λ_p
150283RS73103	Red	635 nm
150283YS73103	Yellow	593 nm
150283GS73103	Green	520 nm
150283BS73103	Blue	460 nm

White

Order Code	Color	CCT
158303227A	Sunrise	2700
158303230A	Warm White	3000
158303240A	Moonlight	4000
158303250A	Daylight	5000
158303260A	Cool White	6000

WL-SWTP 3030

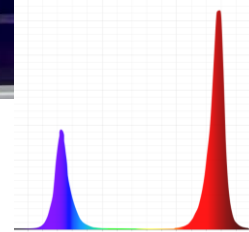
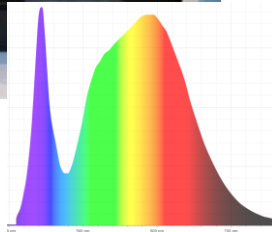
Advantages

- low power Solution
- adjustable spectrum
- plant adapted spectrum
- low thermal resistance
- no need for expensive cooling solution
- full spectrum & homogeneous illumination
- size 2835 for color and 3030 for white LEDs
- very high efficacy

more Information on www.we-online.com/leditgrow

CHARACTERISTICS OF HORTICULTURE LIGHTING

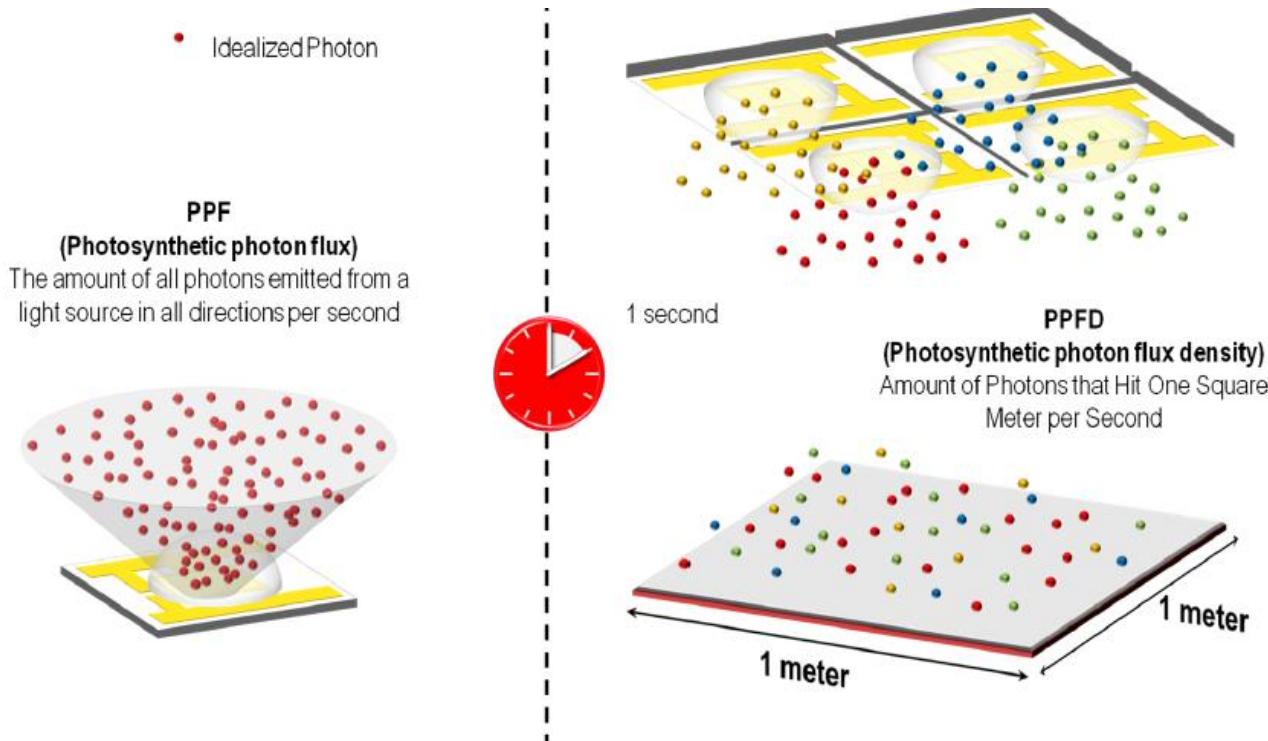
Optical Basics



adjustable spectrum → effective light recipes to obtain optimal plant growth, development and quality
dynamic Lighting → e.g. vegetation stadium

CHARACTERISTICS OF HORTICULTURE LIGHTING

Electrical Basics



Source: Würth Elektronik eiSos

- **PPF (Photosynthetic Photon Flux)**
amount of all photons emitted from lightsource in all directions per second
– Unit: $\frac{\mu mol}{s}$
- **PPFD (Photosynthetic Photon Flux Density)**
amount of Photons that hit one square meter per second
– Unit: $\frac{\mu mol}{m^2 s}$
- **Photon Efficacy**
refers to how efficient a lighting system is at converting electrical energy into photons of PAR
Unit: $\frac{\mu mol}{J}$

BENEFITS OF HORTICULTURE LEDS

Biological Advantages

- year around cultivation
- weather independent
- increase of plant quality parameter
- high harvest efficiency

Electrical Advantages

- high lifetime of LEDs
- high efficacy of LEDs
- lower maintenance costs
- lower operating costs

Environmental Advantages

- resource gentle
- space savings
- harvest on demand



more yield

+



less energy costs



**fast return of investment and
more profit for the grower**

the green revolution already started- vertical farming grows 24% every year

WHY WÜRTH ELEKTRONIK?

- Our LEDs have a very high PPF Output
- We deliver the whole necessary spectrum, for all Horticulture Lighting application
- We help you to find the right LEDs (Mid Power/ High Power, Fullcolor/ Monocolor) for your unique application and target plant "qualityparameter"



- Beside our already existing excellent service, we provide many more special Horticulture application support:



MORE THAN YOU EXPECT – WÜRTH ELEKTRONIK HORTICULTURE LEDS

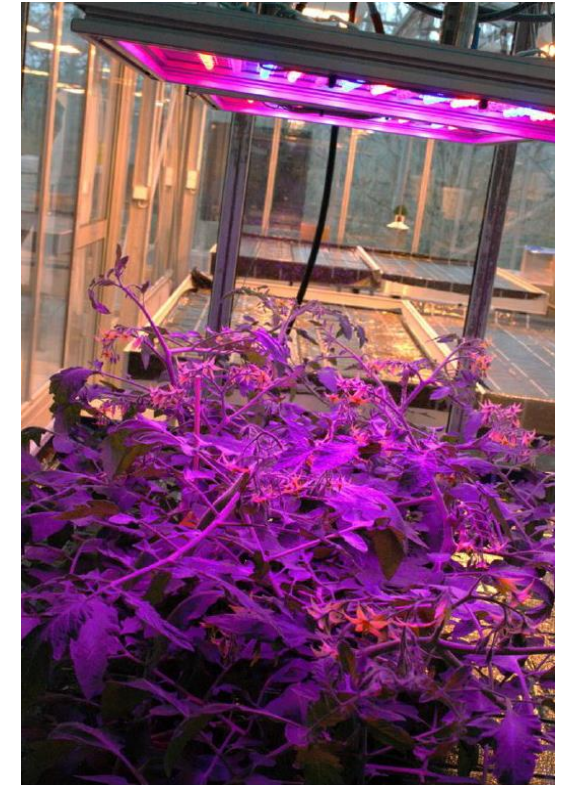
- own plant scientists in team
- cooperation with universities
- know-how through own biological tests



basil under different light conditions



more than twice amount of flavonols after 8 days

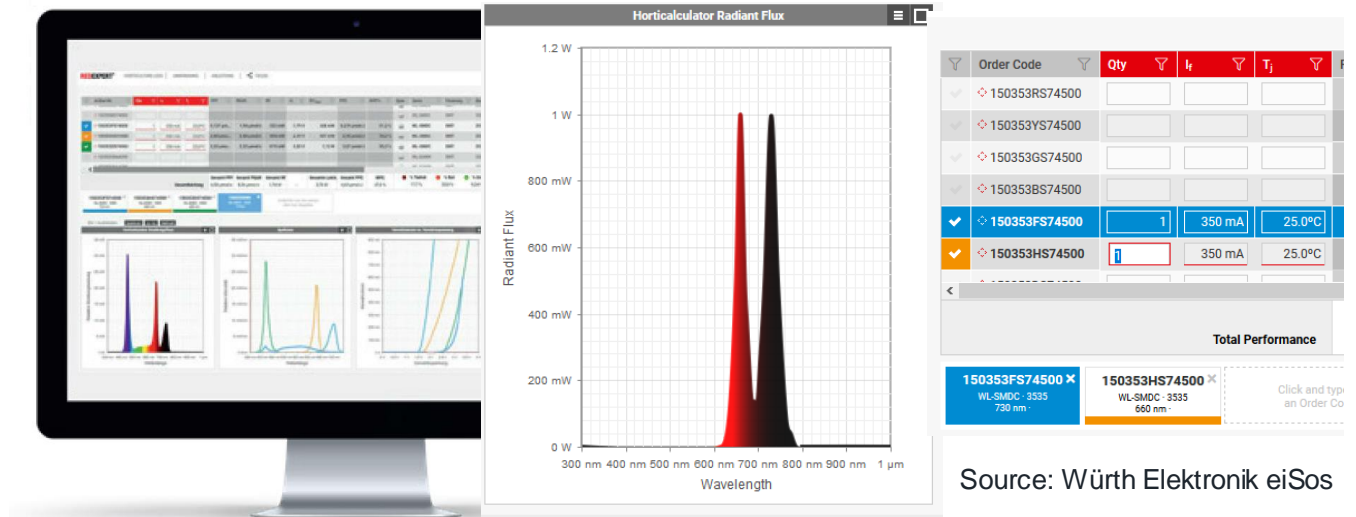


induction of flowering in the winter/14% more flowers compared to other light sources

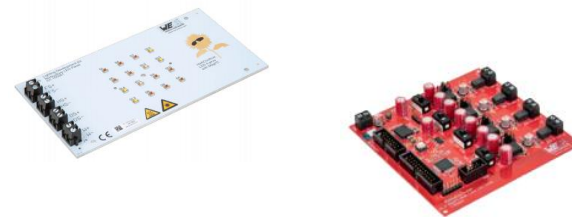
we do research to find optimum light recipe for different quality parameter of the plant

MORE THAN YOU EXPECT – WÜRTH ELEKTRONIK HORTICULTURE LEDS

- Spectrum Design Tool Horticultor
- Horticulture Application Notes
- Lighting Development Kit



Source: Würth Elektronik eiSos



Order Code 150001

Source: Würth Elektronik eiSos



WEilluminat App

APPLICATION NOTES

■ Three different Application Notes

ANO002 LEDs- The Future of Horticultural Lighting

ANO003 Advantages of LED Lighting in Horticultural Applications

ANO004 The Phytochrome System Why use far-red?

www.we-online.com/leditgrow

more than you expect

APPLICATION NOTE

LEDs – The Future of Horticultural Lighting

ANO002 BY DR. RICHARD BLAUKE

1. Introduction

Greenhouse farms may not be a new technology but with an every growing world population and the move towards sustainability, intensive yet highly efficient and standardized food production will increasingly become the norm in future years opening a potentially huge new agricultural sector that incorporates the latest technologies from the bio science and engineering fields. But how can researchers and personnel from these separate fields understand the mutually dependent requirements of indoor greenhouses?

Greenhouses have a long history, purportedly from the roman era but were not used for viable intensive cultivation until the 20th century. Nowadays, there are millions of controlled protected plant enclosures all over the world, most of which use natural light. However, advancements in lighting, heating, watering and control systems have allowed the construction of vast, artificially lit, indoor greenhouses (Figure 1). These installations can produce significantly larger yields, than conventional agriculture and low-tech greenhouses.



Figure 1: Example of indoor greenhouse plant bed with LED light source

There are also several other advantages. The different stages and cycles of plant development can be controlled by providing different wavelengths of light to gain greater yields or reduce growing times. Water usage is greatly reduced due to reduced evaporation and the control of humidity and temperature in the installation. The control or elimination of insect, fungal or bacterial pests is also more effective because of the closed system. In addition, the carbon footprint of food production and supply can also be significantly reduced by building the installations close to population centers, reducing transport requirements.

One of the most significant future advancements in the viability of indoor greenhouses has been the maturation of LED technology. Originally, LEDs were expensive and extremely limited in the wavelengths of light they could generate. However, as advancements in their fabrication have progressed, LEDs have become the preferred solution for indoor cultivation. LEDs can now be made to emit very specific bandwidths of light while being extremely rugged and relatively small when compared to other lighting technologies. In addition, LEDs have a long life, have low voltage requirements and do not generate as much excessive heat making them exceptionally efficient. This will greatly reduce the operating costs of indoor greenhouses.

ANO002A // 2018-01-02 // RWB

Page 1 of 7

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Application Note

Advantages of LED Lighting in Horticultural Applications

ANO003 // DR. RICHARD BLAUKE

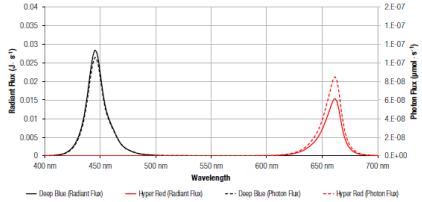
1. Introduction

High intensity discharge (HID) lamps are the current industry standard used by the artificial lighting greenhouse industry because of their economic viability and providing a consistent, adequate spectrum for plant growth (1). Light emitting diodes (LED) provide a multitude of advantages as horticultural lighting sources but early difficulties, primarily cost and intensity, limited their implementation in horticultural applications. However, rapid advances in LED design and manufacture have closed the gap to traditional discharge based lighting technologies and are now becoming an economically viable alternative to HID sources, especially for high-value crops (2), which some have called "a monumental shift" (3). The following Application Note compares the advantages of LEDs with traditional HID light sources for horticultural applications. Although the properties have been addressed in different sections, they are highly interrelated. Gaps in one performance characteristic will compromise others. For an introduction to the use of LEDs in horticultural applications, please refer to ANO002 LEDs – The Future of Horticultural Lighting.

2. Output Intensity

Initially, the intensity of LEDs was too low to be of practical use in horticulture, being more suited to indicator lights and control panel backlighting. The intensity of light that can now be generated by LEDs means photosynthetic photon flux (PPF) output is comparable to that of HID sources when used in clusters. The output intensity of lighting is usually expressed in lumens, as humans perceive light, which is biased towards the sensitivity of the eye. However, photosynthesis and plant growth is driven by photons and so is quantified as PPF. This is especially important when comparing LEDs that can generate specific wavelengths of light. As radiant energy is inversely proportional to wavelength, "red photons" have a lower radiant energy content resulting in more photons being generated per watt of input energy. This means that although blue LEDs have higher radiant flux than red LEDs, the difference in PPF is much closer (Figure 1). It is difficult to compare the output intensity of LED and HID sources in a useful way due to a number of factors including, the number of LEDs, the inherent radiation pattern of the devices (LEDs are unidirectional while HID lamps have an omnidirectional broad emission pattern), and the use of reflectors and lenses. The aim is to maximize the transfer of the emitted light from the light source to the plant leaves. It may be therefore, more interesting to consider how light is delivered to the plants. There is no perfect emission distribution pattern but there are some that are more suitable for certain greenhouse configurations. Precision overhead luminaires and lenses can be used to control the emission pattern of HID devices and focus light to the plant growth areas. This is necessary in small greenhouses with widely separated cultivation areas. Canopy photon capture efficiency of above 90% can be achieved in this manner, regardless of the light source. But capture rates near to 100% can be achieved using LED intracanopy lighting (4). The heat generated by HID fixtures makes intracanopy lighting infeasible.

Figure 1: Comparison of PPF and radiant flux of the WL-SMDC Deep Blue (150 353 D57 4000) and Hyper Red (150 353 H57 4000)



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1

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Application Note

The Phytochrome System – Why Use Far-Red?

ANO004 // JOHANN WALDHERR // DR. RICHARD BLAUKE

1. Introduction

The light requirement of plants is now known to be far more complex than originally thought leading to the development of numerous LED technologies that produce a variety of different light spectra, both monochromatic and polychromatic. The worthwhile inclusion of some wavelengths in light recipes are as yet unexplored, but one area of the spectrum that cannot be ignored is the far-red region. Far red encompasses wavelengths 700 - 800 nm, a region of light that is on the edge of visibility in humans. However, these wavelengths have been proven to result in faster growth, increased biomass and better sensory characteristics (e.g. smell, taste, texture, color). But why are wavelengths that aren't used in photosynthesis so influential on plant development? Unlike people and animals, plants are unable to move. Their sessile existence means that without any outside influence, plants will grow and live in the same place for all of their existence. This may seem like a simple observation but the consequence for plants is that they must be able to tolerate and survive when their immediate surroundings change to less favorable conditions. Responses to limited resources such as water, nutrients and light, in addition to circadian and circannual cycles are essential for plant survival. These responses can be manipulated to achieve favorable growth characteristics. This application note describes why these survival techniques evolved and why far-red wavelengths are essential for plant luminaires. For an introduction to the use of LEDs in horticultural applications, please refer to ANO002 LEDs – The Future of Horticultural Lighting.

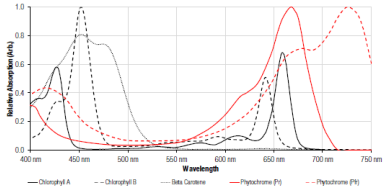
2. Photoreceptors and the Phytochrome System

Light is primarily needed for photosynthesis, the main energy conversion mechanism of a plant and the main development factor that is mainly driven by red and blue light via chlorophyll in photosystems II and I. Three factors are important here:

- Light intensity – which is the amount of photons that the plant can use.
- Photoperiodism – which reflects the duration of the exposure.
- Light quality – which corresponds to the wavelengths of light plants are exposed.

Blue light also influences a number of other plant processes. Each process can be linked to a photoreceptor that reacts to a specific range of wavelengths. Cryptochromes sense blue/UV light and are responsible for phototropism and photomorphogenesis, whereas photoreceptors called phytochromes detect far-red light (Figure 1). Phytochromes are unlike cryptochromes blue light receptors, as the phytochrome system is intrinsically reliant on the interplay between near wavelengths. The system consists of two forms of phytochromes that differ in their absorption wavelengths (1). P_r (Phytochrome red) has an absorption maximum at 660 nm and P_{fr} (Phytochrome far-red) has an absorption maximum at 730 nm. However, interestingly P_r and P_{fr} can reversibly interconvert their molecular structure depending on the ratio of red and far-red wavelengths (Figure 2).

Figure 1: Typical absorbance spectra of the principle pigments of plants



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1

Source: Würth Elektronik eiSos

19

SUSTAINABLE FOOD PRODUCTION WITH HORTICULTURE LEDS
JOHANN WALDHERR | 24.02.2022

SUMMARY

- We are faced with more and more challenges. climate change, growing world population, loss of farmland and the need for a better use of resources - to solve these challenges, Würth Elektronik is actively accelerating the green revolution by supporting the development of the farm of tomorrow to ensure sustainable food production.



