Growth Sphere for Optical Measurements in Plants

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Abstract

A precise measurement in plants is necessary to know in detail the functions and processes of these living beings, which are a fundamental part for the development of life on the planet. The optimal growth conditions for any plant generated in a controlled atmosphere are very helpful to make measurements of the variable that may be the highest hierarchy: light. This paper describes the design of a growth sphere for optical measurements in plants (GSOMP), which fulfills two primary functions; generate the optimal conditions for the growth of the plant during its whole life cycle and perform incident light absorption measurements taking advantage of the geometric shape (spherical) and the coating of the device surface, so it is possible to obtain the light absorption spectrum in each phenological stage of any plant. Due to the aforementioned, this device is unique and represents a very useful option for research and experimentation in vegetables.
Key words: plant, growth sphere, life cycle, absorption spectrum, controlled atmosphere, light.

1. Introduction

The development of equipment for growing plants in a reproducible controlled environment is widely recognized as an extremely important contribution to plant science research [1]. Different types of chambers and/or growth rooms in a controlled environment have been implemented for this purpose, increasing in this way the knowledge in the internal processes of the plant and providing tools to obtain improvements in quality and productivity at large scale. Example of this type of device can be found in [2], [3] and [4]. It is in great way thanks to experimentation in controlled environments, that today the optimal conditions for the growth of plants such as lettuce [5] and tomato [6] can be known. Controlled environment chambers are essential to understand the responses of plants to a variety of climates [7] and recipes for lighting using artificial light. There are also results of this, in terms of intensity and photoperiod [8], as well as wavelength (color) [9] resulting in effects on transpiration, photosynthesis rate, stomal conductance, efficient use of water and in the same way; efficient use of light and photochemical reflectance index.

The main factors, which can be generated in a controlled environment, and which affect plant growth are: light, air speed, temperature, relative air humidity and the concentration of CO_2. Light is a crucial parameter since it is considered the main source of energy required for photosynthesis and other physiological processes [5]. In fact, apart from boosting photosynthesis, light also regulates the morphology, physiology and phytochemical content of the plant [10]. The process of photosynthesis carried out by plants and algae, exploits the same region of the electromagnetic spectrum that a person with normal vision can detect; the 400-700 nm region. For this reason, this region of the electromagnetic spectrum is known as visible light. The radiation in this band is also called photosynthetically active radiation (PAR) or irradiance and its most used unit of measurement is $\mu\text{mol}/\text{m}^2\cdot\text{seg}$. These units are also known as photosynthetic photon flux units [11].

It is convenient to emphasize the differences between the photoresponse that the human eye and the plant have towards incident light. While the physiology of the eye is less sensitive towards the extreme bands in the range from 400 to 700 nm, the plant has high sensitivity to them, and with the middle band in this range (from 520 to 580 nm) the opposite is true (see figure 1). In other words, plant absorbs blue and red colored photons better than green colored photons. It is for this reason that the detectors to measure the absorption in plants must be quantum, that is to say; they must have a sensitivity more similar to the photo response of the plant in units of molar mass on surface units per time units ($\mu\text{mol}/\text{m}^2\cdot\text{seg}$). Units such as lux or can-

2573-3001/20/$31.00 ©2020 IEEE
DOI 10.1109/ICMEAE51770.2020.00030