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Horticultural Lighting in Nurseries from the Ground UP

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Summary

This paper describes how supplemental lighting can extend the growing season increase yields and promote healthy plant growth. It includes descriptions of light's properties and how to measure those properties.

INTRODUCTION

Light is an electromagnetic wave. Humans see light between 380 nm and 750 nm (Fig. 1). Plants use light wavelengths between 400 nm to 700 nm (Fig. 1).

Plants use light wavelengths in the photosynthetic active radiation region (PAR) to produce fit itself and grow.

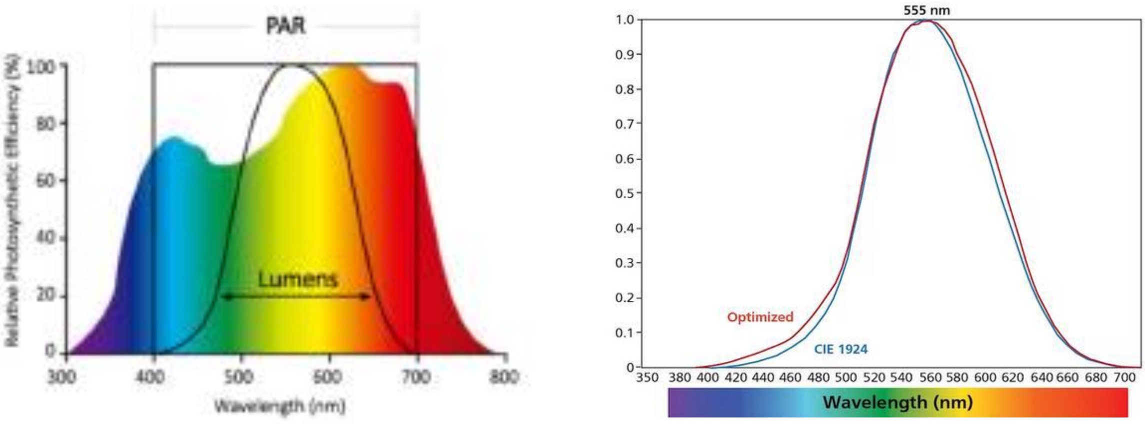
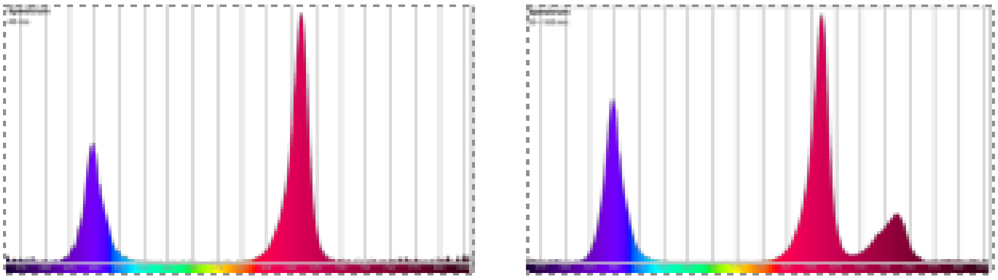


Figure 1. Light wavelength sensitivity and use by humans and plants.

Supplemental horticultural sources may deliver monochromatic or full spectrum light (**Fig. 2**). Monochromatic is an energy efficient supplemental light option but it can be more costly compared to full spectrum sources. Full spectrum lighting is more similar to sunlight and may be used as a supplemental light source or as the sole lighting source for indoor growth systems.

Monochromatic



Full spectrum

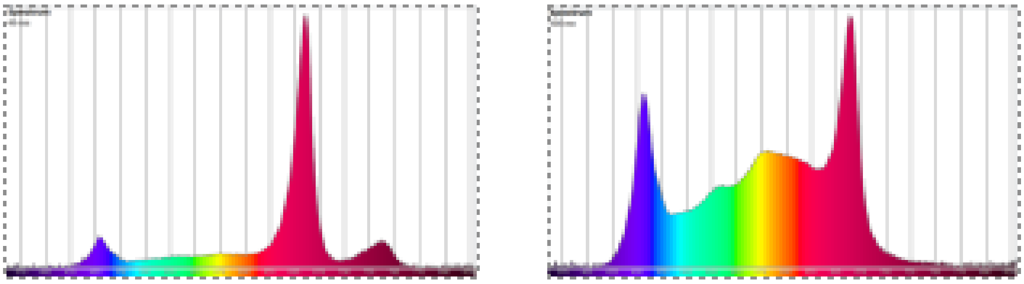


Figure 2. Monochromatic and full spectrum light wavelengths.

Supplemental light influences plant growth depending on the light spectra. Light sources rich in blue light promotes seedling root and vegetative leaf growth as well as shorter internodes (**Fig. 3**).

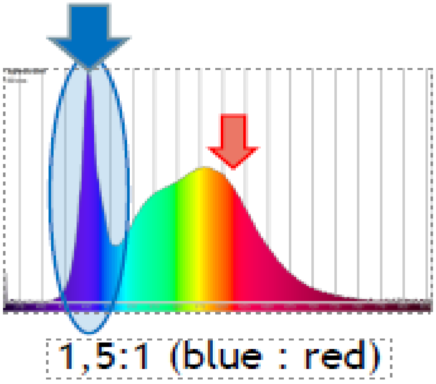


Figure 3. Light spectra enriched for blue light.

Supplemental light with more red wavelengths tends to promote stem growth, flowering and fruit production. This is accompanied by increased photosynthesis, leaf counts and subsequent yield (**Fig. 4**).

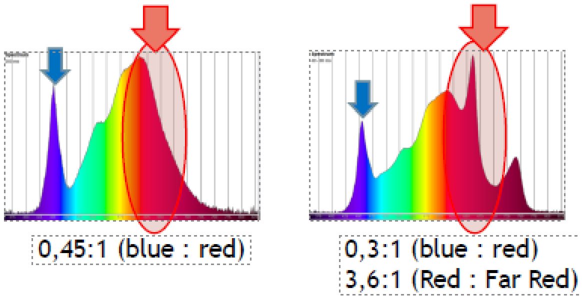


Figure 4. Light spectra enriched for red light.

When trying to identify which light spectra to specify for your plant needs, it is often related to red, blue and far-red ratios. In general, consider more blue light for propagation and vegetative growth and red/far red for flowering and fruit development (**Fig. 5**).

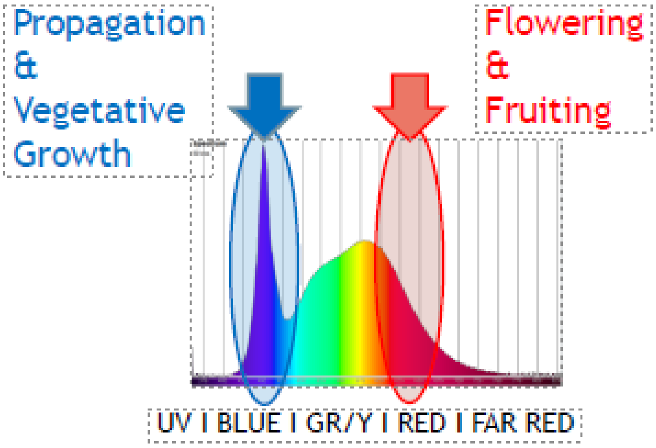
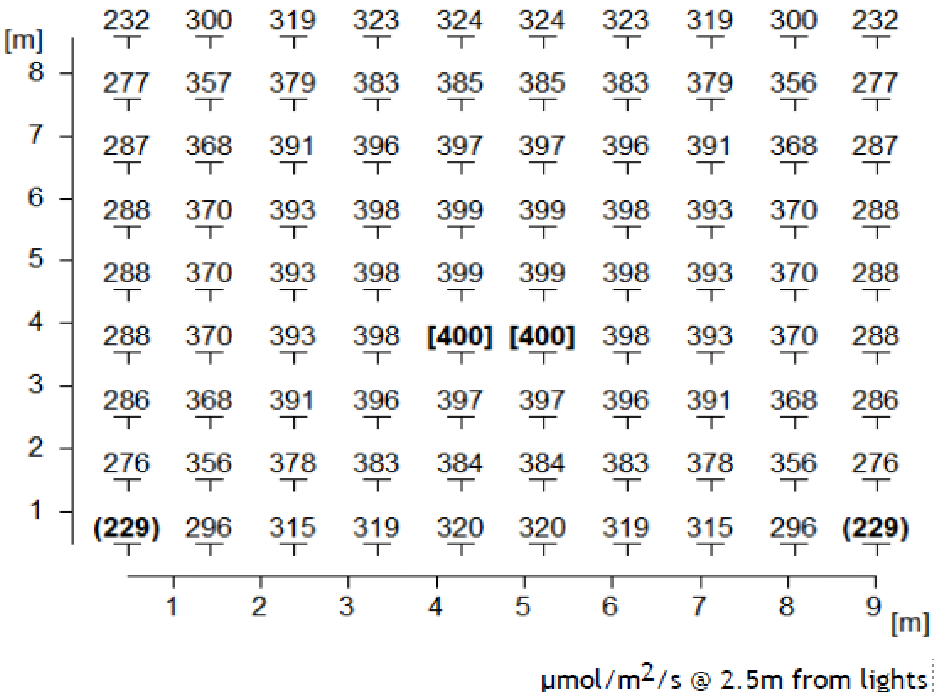


Figure 5. Light spectra related to plant growth.

Photons of light can be expressed in a number of different terms including lumens, lux and moles. All can be useful, but expression in moles can best describe light in the photosynthetic range for plants as photosynthetic photon flux density (PPFD). Instantaneous light intensity (flux density) is measured as the micromoles of light per meter squared per second (μmol/m^2/sec). The accumulated light over a specific day is expressed as a daily light integral (DLI) expressed as moles per day. The daily light integral can be increased by using supplemental lighting including extending the day length.

PPFD is an intensity value required to make up a particular DLI over the photoperiod. PPFD maps (often referred to as PAR maps) show the range of μmol/m^2/sec (light intensity) over a particular plant grow space – easily generated through simulation software **(Fig. 6**).



232	300	319	323	324	324	323	319	300	232
277	357	379	383	385	385	383	379	356	277
287	368	391	396	397	397	396	391	368	287
288	370	393	398	399	399	398	393	370	288
288	370	393	398	399	399	398	393	370	288
288	370	393	398	**[400]**	**[400]**	398	393	370	288
286	368	391	396	397	397	396	391	368	286
276	356	378	383	384	384	383	378	356	276
(229)	296	315	319	320	320	319	315	296	**(229)**

Figure 6. This PPFD the map shows intensity values over the grow space at a particular distance away from the light source/sec.

Plant daily light integral (DLI) should reflect the optimal amount of light per day for a given plant growth cycle. It can be calculated as:

DLI = PPFD (intensity) x light hours per day (photoperiod) x (3600/1000000)

Photoperiod is the number of light hours a plant receives in one day. Put simply, this is the number of hours the plant is “awake” to feed and grow.

The optimal photoperiod is given per plant, per growth cycle/ stage. So, you may find propagation and vegetative growth cycles photoperiods are similar and the flowering photoperiod something else. Often simulating seasons that induce /stress the plants into different growth cycles/ stages. Remember that under the sun’s capabilities, the photoperiod will have dawn and dusk times that do not reach the optimal light intensity.

Research your crop/s on the internet to find DLI’s and/ or photoperiods for the stages of growth you are concerned with. After some simple calculations you can produce the “magic numbers” for an intensity for a particular number of hours. There is a lot of information on the internet on how to do trials to find out optimal DLI, intensity and photoperiod – lead your field!

Now that you know what your crop can optimally handle, it's time to understand what you are giving it at the moment, and then throughout the year? Today in Port Edward we have just under 13 hours of daylight with fewer hours at any optimum intensity value, the first of January had just over 14 hours daylight and 21 June bottoming out at just over 10 hours daylight. Let's just assume, for low intensity requirements, that the first and last hour of each day equate to 1 full hour at optimal intensity – best case as I see it –so that’s 13 optimal intensity hours on 1 January and 9 hours mid-Winter. What if your seedlings/ transplants could handle that intensity for 18 hours? 28% more time at optimum growth conditions mid-Summer and 100% more time at optimum growth conditions mid-Winter.

An advantage can be key to success in a competitive market. Knowledge is power that allows you to create your own advantage. You need to be able to measure environmental variables like light. These can include installed and personal device sensors that are readily available in the market. Personal devices can measure intensity at a moment and installed devices can measure DLI over a day.

Run trials, record data… Agriculture 4.0, it has been given a name.