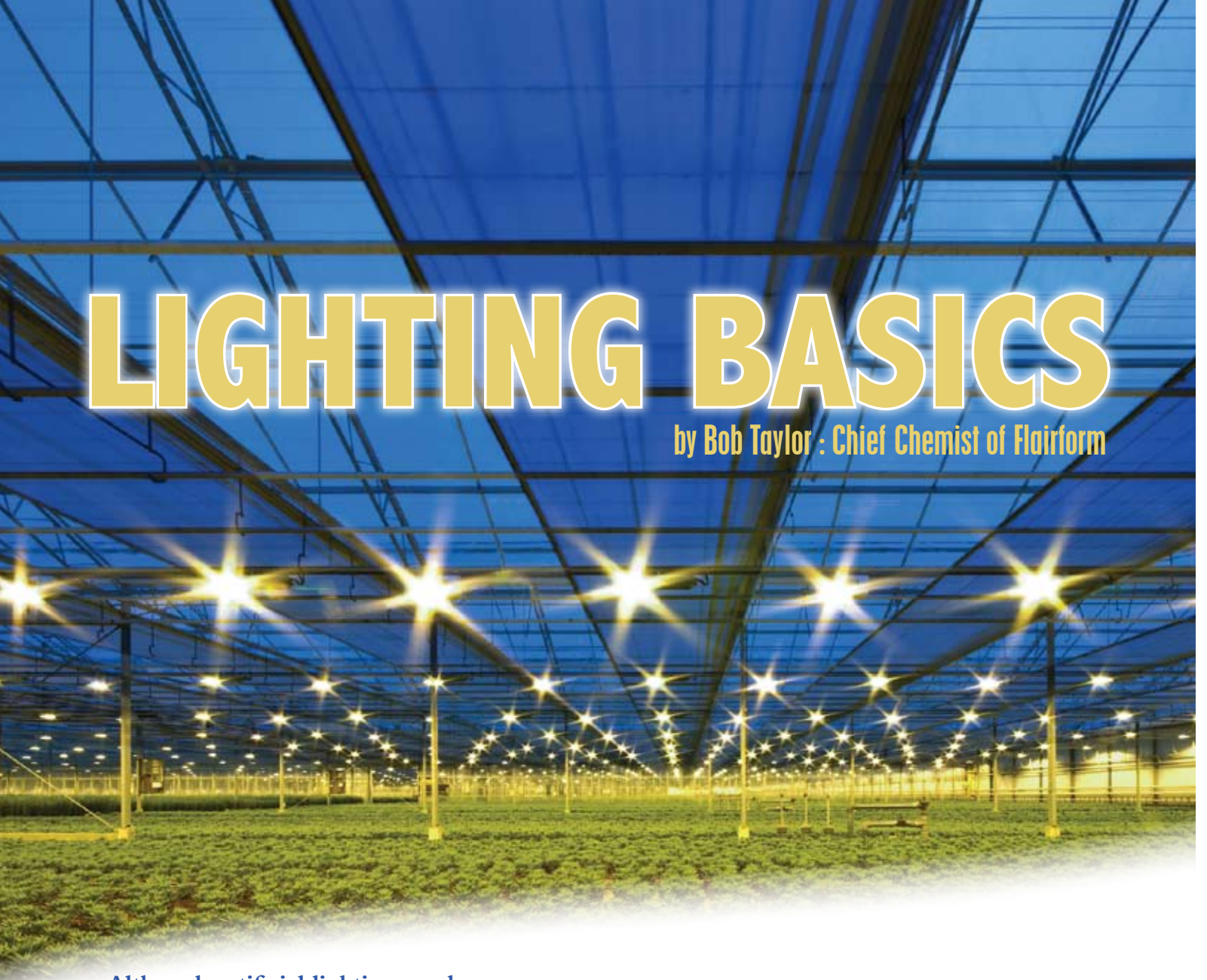
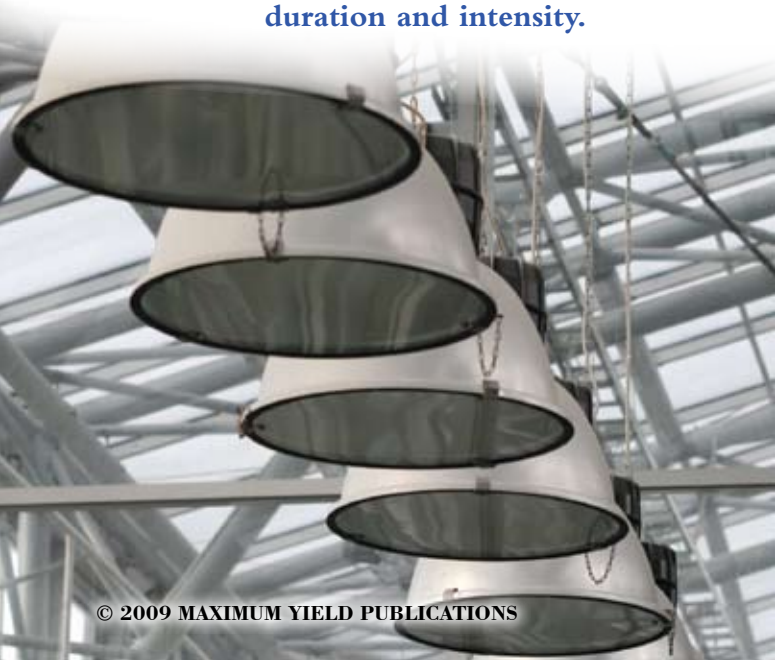


LIGHTING BASICS

by Bob Taylor : Chief Chemist of Flairform

Although artificial lighting produces an imperfect spectrum compared to the sun, it does allow control of variables such as duration and intensity.



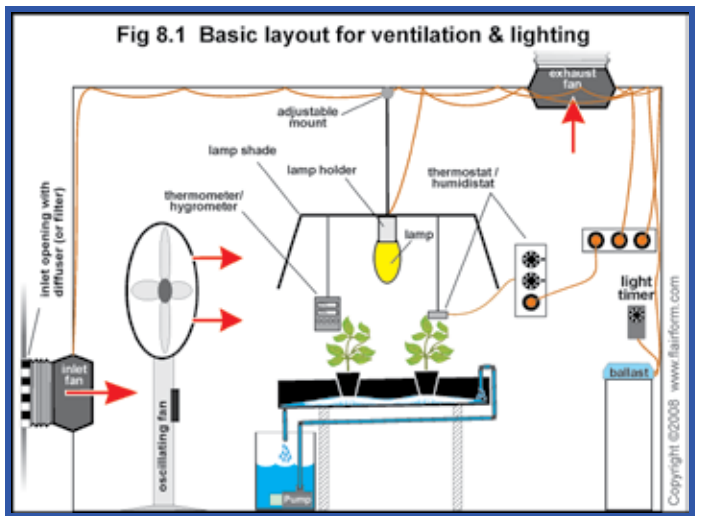


Figure 10.2: Lamp selection (from left to right) 'High pressure sodium' (HPS), 'metal halide' (MH), 'strip fluorescents' (SL), 'compact fluerescent' (CFL).

Equipment Overview

Artificial lighting requires the use of a ballast (used to ignite then regulate current to the lamp), a shade or reflector (directs light towards the plants and usually incorporates the lamp holder/socket), a timer (controls when the lights turn on and off) and the lamp itself (figure 8.1).

Lamp Selection (Optimizing Color Spectrum)

Photosynthesis occurs mainly within the visible light spectrum (wavelength range 400 to 700 nanometers). Within this range, 445 nanometers (blue) and 650 nanometers (red) are needed most.

HID: High Intensity Discharge lamps (HID) are generally used for the vegetative and flowering/fruiting phases due to their high lumens per watt rating. (HIDs produce five times as many lumens per watt than incandescent lamps – figure 10.2). The following types of HID are commonly used:

- **Metal Halide (MH):** Produces light predominantly blue in color. This is ideal for strong vegetative growth (e.g. larger leaves, thicker stems) and a shorter, dense plant (i.e. shorter internodal spacing), which will utilize light more efficiently.
- **High Pressure Sodium (HPS):** Produces more red light. This promotes flower onset and production and is, therefore, more suited to the flowering/fruiting phase.

Unfortunately, MH and HPS lamps each require a different ballast and lamp holder. Therefore, it is common practice to use a HPS lamp for both vegetative and flowering – especially if plants have a very short vegetative phase. However, using HPS throughout can promote tall and spindly growth in many species.

Blended light lamps: To save needing a separate lamp kit (lamp, ballast and lamp holder) for both vegetative (MH) and flowering (HPS), "blended light" lamps are available. These produce a more balanced spectrum of red and blue light.

Fluorescent: Fluorescent lamps produce less lumens per watt compared to HID lamps, hence their use is limited to plants needing low to medium light intensities, such as seedlings, clones, herbs, orchids and lettuce. They are simpler to use than HID lamps because they generate less heat.

These are broadly categorized as either 'strip' fluorescents (SL) or 'compact' fluorescents (CFL) and are available in different wattages and color temperatures (figure 10.2). Those of high color temperature (known as "cool white") are more blue in color and more suited to vegetative growth and development of seedlings/clones. Lower color temperatures ("warm white"), are redder in color and, therefore, better for flowering. CFLs are generally available in higher wattages than SLs and thus, are suitable for species needing higher light intensities.

Table 10.1 Is ALL your foliage getting enough light?

	250W HPS	400W HPS	600W HPS	1000W HPS
Initial lumen output (lm)	30,000	50,000	90,000	140,000
Intensity at 1ft* (lm/sq.ft)	30,000	50,000	90,000	140,000
Intensity at 2ft	7,500	12,500	22,500	35,000
Intensity at 3ft	3,333	5,555	10,000	15,555
Area of coverage**	0.6x0.6m (2x2ft)	0.9x0.9m (3x3ft)	1.0x1.0m (3.3x3.3ft)	1.2x1.2m (4x4ft)
Minimum gap between lights & foliage***	~15cm (6in)	~25cm (10in)	~35cm (1.1ft)	~45cm (1.5ft)

* The inverse square law defines the relationship between light emitted from a point source and distance (i.e. Intensity = light output / distance squared). **Assumes lights are mounted vertically. ***Assumes lights or shades are not cooled. Gap can be reduced by using cooled shades/ lights.

Optimizing Light Intensity

Insufficient light will produce sparse foliage, spindly branches and poor flowering. This can occur because lamp size (and type) is inadequate; lighting duration is inadequate; foliage is too far away from the lamp; or foliage is being shaded by other plants.

Lamp size: A lamp's size is measured in watts (W). The size of the growing area will partly determine the required wattage - see table 10.1 and figure 10.3.

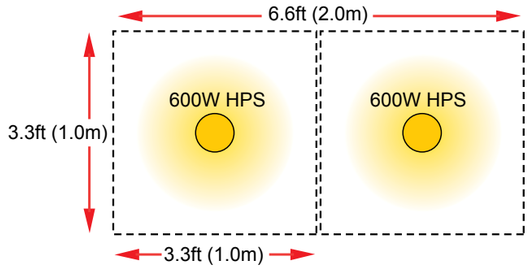


Figure 10.3: From Table 10.1, we can estimate that 2 x 600W HPS lamps would be suitable for lighting an area 3.3 x 6.6ft (2.0m x 1.0m).

Plant height: A plant's height must be considered when determining lamp size because light intensity diminishes rapidly as distance from the lamp increases. (Table 10.1 shows the drop in intensity from one to three feet). For example, imagine your plants covered an area of three by three feet. You may be tempted to use a 400 watt lamp instead of a 600 watt HPS (i.e. power costs are 50 per cent less, and it generates less heat). However, if a significant proportion of the foliage is three feet from the lamp, the intensity is only 5,555 lumens per square foot. This intensity may be insufficient for the species being grown. By choosing a 600 watt HPS, the intensity would be roughly double (assuming equal gap between lamp and foliage).

HINT: It is also preferable to keep plants as short (and therefore wide) as possible. This can be achieved by removing the 'growing tip' and also restraining upwards growth (and training sideways growth) by erecting netting at an appropriate height.

Plant density/shading: Shading becomes an issue when plants are positioned too close to one another. Hence, it is generally more productive to plant less than more.

Lamp height: To best utilize lamp output, position the lamp as close as possible to the top of plants without causing photo-respiration or burning of foliage (see table 10.1 for "minimum gap" guidelines). Air cooled shades should be used because they enable lamps to be positioned much closer to foliage - particularly beneficial for 1,000 watt lamps (figure 10.4).

Lamp shades: These help maximize the amount of light directed towards the plants (figure 10.5). Shades need to be hung so that their height can be easily adjusted as plants grow. For safety, ensure mounts are securely fastened to the ceiling.

Light cycles: Plants generally require 18 hours of light per day during the seedling and vegetative phase. During flowering/ fruiting however, the duration can be reduced to 12 hours. Growth can suffer if lighting intervals are irregular. Therefore, employ a timer to help ensure consistency. Note also, vital processes occur during the night (lights off) period, therefore, avoid interrupting it by turning lights on.

Reflective material: The use of reflective material on walls (etc.) helps ensure that light is not wasted through absorption.

Hints for Set-up and Maintenance

Light meter: Useful for determining whether light levels are adequate throughout the garden, and for routinely checking if

Figure 10.4: The heat generated by HD lamps is the biggest problem facing indoors growers, especially in summer. An effective way of removing this heat by directly ducting heat away through air cooled shades. These simplify ventilation requirements by minimizing hot spots and enable lights to be positioned closer to foliage.

Figure 10.5: Lamp shades help maximize lamp reflection. They are either painted white or plated with a highly reflected material.

lights are operating to specification (figure 10.6).

Compatibility: Ensure the ballast and lamp suit one another. For example, lamps of different type (e.g. MH or HPS) or different sizes (wattages) may require a specific ballast. Also, if using an electronic ballast, ensure the lamp is compatible, otherwise premature lamp failure and blackening may occur.

Handling HID lamps: Lamps can explode if they are cold when lit or have fingerprints on glass. Always wrap in clean paper or towel before handling. To clean the lamp glass use window cleaner (or rubbing alcohol) and allow to dry thoroughly before use. Lamps should not be restarted immediately after being switched off (MH lamps should generally be left off for at least 20 minutes; HPS for at least three minutes).

Effective working life: A lamp's intensity will diminish with use, and may also use more power. Note that MH lamps have a shorter effective working life than HPS. Also note that the capacitor in magnetic ballasts will deteriorate with use and consequently the light intensity will diminish. Ask the manufacturer for the useful working life of these items.

Figure 10.6: Light meters are essential for verifying that all foliage is receiving sufficient light.

Lamp orientation: Lamp directions will specify whether a lamp can be orientated vertically, horizontally, etc. Failure to comply can cause poor lumen or color output, and shorten the lamp's life span.

Safety: Consider safety at the design stage:

- Keep power devices and junctions away and/or above any potential water spillages/ floods.
- Determine whether the electrical lines can handle the current draw.
- Where multiple lamps are being lit ensure to stagger start up times. HID lamps draw large amounts of electricity, therefore, safety must be a priority.
- As an overall safety measure, install a miniature circuit breaker (MCD) and residual current device (RCD). If there is a faulty circuit these will cut the power supply (figure 6.23).

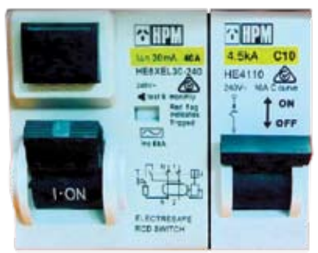


Figure 6.23: A miniature circuit breaker (MCD) and residual current device (RCD) are indispensable when water and electricity are in close proximity.

Calculating electricity costs:
Cost of power per day = Cost of power per kilowatt* x Total kilowatts x daily duration.**
e.g. If the cost of power is $0.10 per kW and there are two 600 watt lamps (1.2kW) alight for 12 hours per day, the daily cost of electricity is $1.44 (i.e. $0.10 x 1.2kW x 12hrs)
***Refer to your last power bill. ****1,000 watt = one kilowatt (kW)**

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