Ten aspects of lighting spring crops that can help your bottom line

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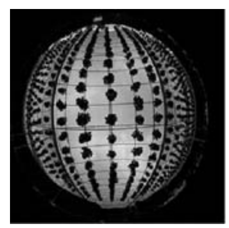
Light is key to producing quality crops and early flowering of long-day plants. But specifically how can you turn greenhouse lighting of spring crops into profit? The following pointers can help.

1. Before investing in supplemental lighting, maximize the amount of light already available to you. You should aim for at least 50% light transmission in the winter (i.e., half the light outdoors reaches crops inside a greenhouse). Determine your greenhouse light transmission by using a light meter outside then inside a greenhouse and calculate what percentage of light is transmitted. Two common ways that light is excessively reduced are:
   - Polyethylene covering is dirty or old. It is false economy to keep poly covering beyond the recommended product life: 10% less light equals roughly 10% less plant growth. Consider anti-condensation materials for the inside and clean off dirt from the outside of greenhouses.
   - Too many hanging baskets above your crop, which can sap the flower power from your bench crop. Research by James Faust of Clemson University found that 2 hanging baskets per square yard above a crop can reduce light transmission to the bench below by 40%. When producing hanging baskets, grow crops that are less light-sensitive on the bench below (for example impatiens or spikes rather than geraniums or petunias).



Fish-eye image showing the view upward into a canopy of hanging baskets. One hanging basket every 32 x 32 inches, as shown here, intercepted 27% of light. Photo by James Faust, Clemson Univ. (point 1)

2. Know how much light is reaching your crops. In general, at least 10 moles per square meter per day (moles/day) at plant level will produce bedding and potted crops of acceptable quality. Moles/day is a measure of the accumulated photosynthetic light over a 24-hour period, and is referred to as the daily light integral (or DLI). In contrast, footcandles and lux are instantaneous light level units.

   In December and January, most locations in the northern half of the United States receive 10-15 moles/day of sunlight outdoors, and only 5-8 moles/day inside the greenhouse. James Faust developed “light maps” that estimate DLI during each month across the U.S. (http://virtual.clemson.edu/groups/hort/faculty/faust/maps.htm).

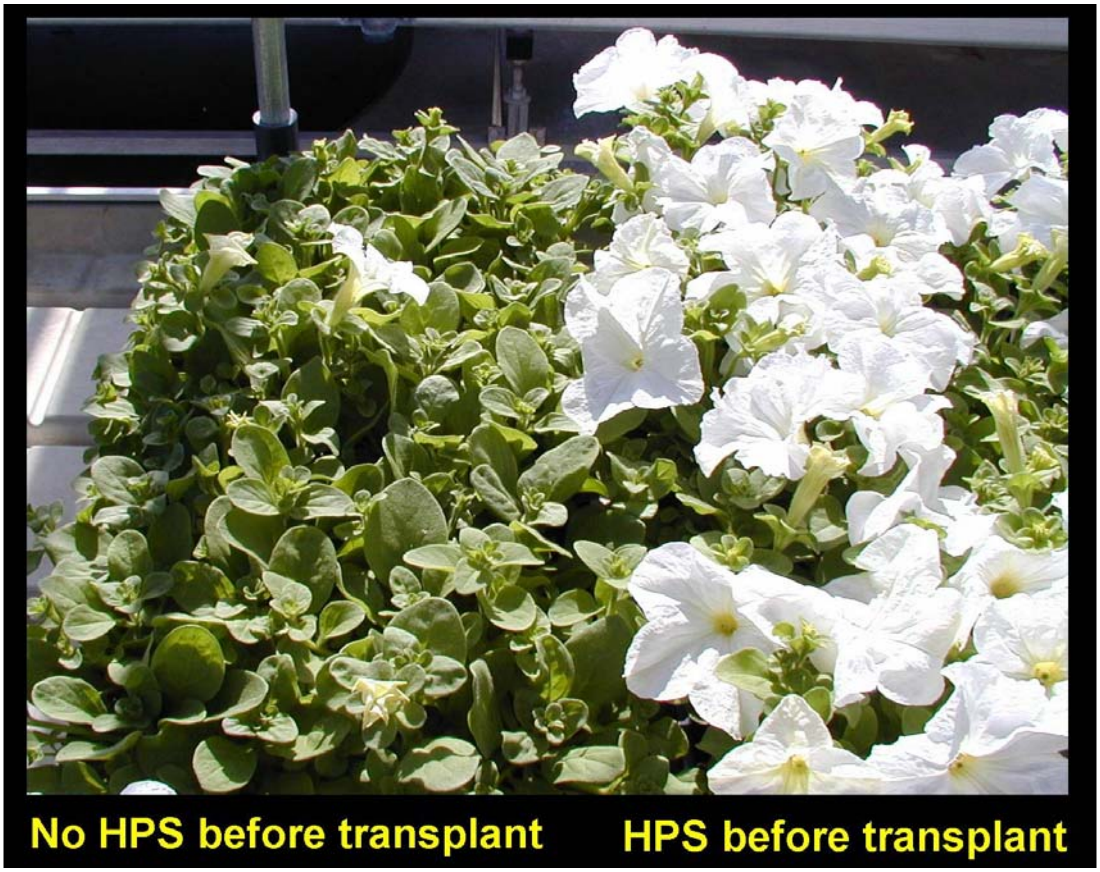
There are very affordable ($150-$350) light meters that measure instantaneous light levels or the DLI (for example www.specmeters.com and www.apogee-inst.com). Make sure the sensor is calibrated to sunlight and reads up to 10,000 footcandles, 108 kLux, or 2,000 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Instantaneous light meters are helpful for fine-tuning light management such as checking transmission through glazing or uniformity of light distribution from lamps.

3. When constructing a new greenhouse, consider its orientation and structure carefully.
   - A north-south oriented greenhouse has less light transmission but is often recommended for ornamental crops because light is more uniform (shadows move during the day, resulting in even drying and flowering). An east-west greenhouse transmits more light but is less uniform within the greenhouse.
   - Build with high sidewalls so that you can install retractable shade and electrical lamps. Fewer, more powerful and efficient lamps can be installed in greenhouses with high sidewalls compared with low Quonset-style houses.
   - Consider polycarbonate (82% twin-wall), acrylic (85% twin-wall), or glass (90%) coverings rather than double-poly (80%). These light transmission levels do not account for reflection, aging, and shadows from the structure. Open roof and wide glazing panes obviously help.

4. Install retractable shading to maximize light. Retractable shade curtains enable growers to maximize light and growth on cloudy days and during the morning and afternoon, and shade for temperature control at midday on sunny days. When nights are cold, curtains can be closed at night to reduce heat loss. In the winter, don't shade most finish crops during the day unless less light is needed for humidity or temperature control.

5. Provide artificial long days during early spring when growing plugs that are long-day plants. Long-day plants flower when the day is long and the night is short. Starting with lighted plugs can therefore reduce finish crop time. For example, research by the University of New Hampshire, Rutgers University, and Kube-Pak in New Jersey found that 'Ultra White' petunia seedling plugs that received supplemental lighting in the plug tray and were finished under natural day lengths flowered 10 days earlier in March than plugs that did not receive supplemental lighting.

   Some seedling varieties have a juvenile period, where plants are unresponsive to day length until they are of a certain size or maturity. For example, John Erwin at the University of Minnesota found that flowering of 'Purple Wave' petunia is not responsive to long-day lighting until 2-3 weeks after sowing. Cuttings/liners generally do not have a juvenile phase, and lighting can be beneficial once cuttings are rooted.



Consider purchasing plugs that received supplemental lighting and long days to to reduce finish crop timing. Both groups of petunias in this picture were grown under natural days after transplanting from plugs in March. The plants on the left came from plugs grown under natural days, whereas the plants on the right came from plugs that received long days with supplemental lighting. Photo by Brandon Smith, UNH. (point 5)

6. Increasing the DLI can accelerate flowering of many spring crops. Researchers at the University of Minnesota have categorized many bedding plants based on how plants respond to the average DLI. Some high-light plants such as petunia or geranium flower earlier and with more blooms when the DLI (moles/day) is increased, which is independent of the photoperiod response. In other words, adding supplemental light (400-600 footcandles) in winter can reduce finish crop timing for many high-light plants.

   You can use published information from Univ. of Minnesota and other sources, or run your own trials, to identify which varieties are more responsive to light level and photoperiod to control flowering. For example, long-day, high-light plants such as petunia have a strong flowering response to both photoperiodic and supplemental lighting.

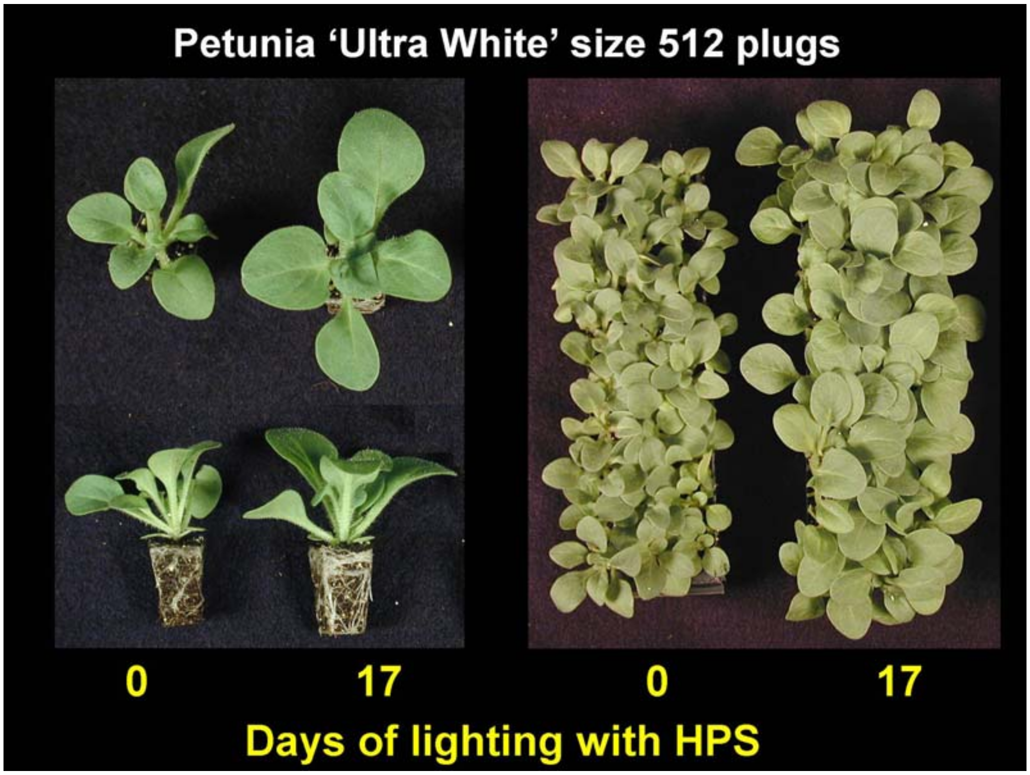
7. Similarly, research by Michigan State University has categorized the flowering responses to light for a wide range of perennials to help you program flowering. Similar to bedding plants, perennials flower in response to photoperiod and DLI. For example, *Aquilegia flabellata* 'Cameo' is day neutral and requires a cold treatment

for flowering; *Coreopsis grandiflora* 'Sunray' requires both a cold period and long days; *Campanula carpatica* Blue Clips' requires long days only; and asters and *Helianthus* 'Low Down' are short-day plants.

Many long-day plants flower earlier and more vigorously when provided both more hours of light and also more total light energy from supplemental lighting. The long-day perennial Campanula punctata 'Cherry Bells' was grown under 9-hour short days (left) or 16-hour long days provided with either incandescent (center) or HPS lamps (right). The average daily light integral was 12 moles/day under short days or incandescent lamps and 14 moles/day under HPS lamps. Photo courtesy of Cathy Whitman, MSU. (points 6 and 7)

8. Supplemental lighting with high-pressure sodium (HPS) lamps is usually more cost effective for plugs and liners than finished plants because young plants take up less space and time. University of New Hampshire cost analysis found that typical lighting costs for supplemental lighting (375-575 footcandles) are around $3 to $6 per square foot ($ft^2$) including installation, and 3 to 6 cents/ft^2/week for electrical operating costs. A 1020 tray takes up 1.4 square feet, and plugs are typically lit for 2 to 4 weeks. An example of the cost to light a plug tray is: 4 weeks H 1.4 square feet H 6 cents electrical cost/ft^2/week = 34 cents/plug tray. Dividing this cost into a 105- or 512-count tray is minimal on a per-plant basis.

   In contrast, the cost of lighting a poinsettia at 1 ft^2 spacing for 8 weeks (48 cents) would be hard to recoup in increased crop price. Supplemental lighting can be cost-effective if you have increased yield (e.g., more cut flowers), better quality and price (e.g., early season perennials), or reduced crop timing. In addition, supplemental lighting is especially beneficial during dark periods. Typical supplemental light programs for ornamental crops can add 1.5-4.5 moles/day, which is roughly 50% more light than sunlight alone in northern climates in the winter.



Supplemental lighting can be very cost effective for plugs and liners. These petunia plugs received either sunlight only or sunlight and 6 hours of HPS lighting at 450 footcandles. Photo by Brandon Smith, UNH. (point 8)

9. Photoperiodic lighting (10-20 footcandles) is relatively inexpensive, usually less than 50 cents/ft^2 for installation, and less than 0.5 cents/ft^2/week to operate. Photoperiodic lighting is used to control flowering of daylength-sensitive crops but does little to influence the DLI. A 4-hour night break (from 10 p.m. to 2 a.m.) will keep short day plants vegetative and induce flowering in long day plants. For photoperiod control, night-break light does not usually need to be continuous. There are several ways to provide intermittent light, for example cyclical incandescent lighting, mounting high-intensity discharge lamps on a traveling boom, or high-pressure sodium lamps with a rotating reflector.

High-pressure sodium lamps mounted on a boom for photoperiod control of perennials. Photo by Paul Fisher, UNH. (point 9).

10. If investing in supplemental lighting, consider light's two invisible partners: carbon dioxide and heat. As light level increases, carbon dioxide can become limiting for photosynthesis. In winter, dense crops in tight greenhouses can reduce carbon dioxide to around 200 ppm, nearly half the ambient level of 350 ppm. Carbon dioxide supplementation is a low-cost investment that increases growth. Calculations by A.J. Both from Rutgers University found that cost is typically below 1 cent/ ft^2/week to maintain 1000 ppm CO_2 during daylight hours in winter. In addition, heat emitted from supplemental lamps can raise plant temperature, which can hasten plant development and reduce crop timing.

For detailed information on this and other research, we recommend the book "Lighting Up Profits" from the "Online Store" at www.meisterpro.com or Ball Bookshelf (www.ballpublishing.com). Photographs are reprinted with permission from Meister Publishing.