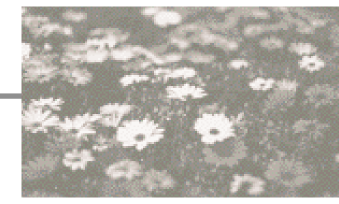


How Much Light Do Bedding Plants Really Need?

Producing the best quality plants at the best possible price requires a basic understanding of light requirements — and how to compensate for less than perfect light quality.

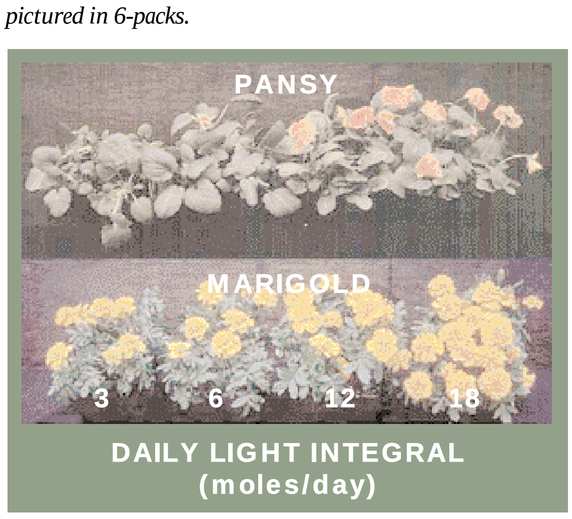
By Veronda B. Holcombe, Kelly Lewis and James E. Faust

Over the past couple of years, Clemson University has been conducting experiments to better understand how to manage light in the greenhouse environment. We presented contour maps that describe how much light is delivered to different regions of the United States during each month (GPN, October 2000). Then, we demonstrated how much light is intercepted by hanging baskets (GPN, February 2001).

This article addresses how much light bedding plants need. In other words,, "what light quantity is required to produce a quality plant?"

Figure 1. The effect of daily light integral (moles/day) on begonia growth and flowering. Plants are pictured in 6-packs.

Figure 2: The effect of daily light integral (moles/day) on pansy and marigold growth and flowering. Plants are pictured in 6-packs.



Light quantity refers to the total amount of light delivered to a plant over the course of one day, also known as the daily light integral. Daily light integral (DLI) can be likened to rainfall. If you want to know how much rain fell yesterday, you would place a bucket outside and catch all the rain. Similarly, if you want to know how much light was delivered yesterday, you would place a sensor in the greenhouse and record light measurements all day.

Table 1 provides typical DLIs delivered to different locations for each month of the year. These light levels are based on the assumption that 50 percent of the light outside the greenhouse is transmitted to greenhouse crops. Actual light transmission typically varies from 35-70 percent based on the number of hanging baskets overhead, greenhouse infrastructure, shade cloth and cleanliness of the glazing material.

In order to determine the DLI requirements for different bedding plant crops, we grew plants under different shade cloths ranging from 25-90 percent light interception. Light sensors placed above the crops recorded the daily light integral for each day. These values were averaged over the life of the crop to provide the average daily light integral that each crop received during each experiment.

SPRING EXPERIMENT

Our first experiment was conducted inside a greenhouse during March and April. Fibrous begonias, pansies, marigolds, angelonia, petunias and impatiens were grown in 606 flats. The average DLI for each of the light treatments was 18 mol/day for 0 percent shade; 12 mol/day for 25 percent shade; 6 mol/day for 50 percent shade; and 3 mol/day for 75 percent shade. Occasionally, the plugs, received from commercial plug growers, had visible flower buds prior to the start of the experiment. In these cases, the flower buds were removed at the time of transplant.

Begonia. Fibrous begonias were more compact and well-branched, and the flower number increased as the DLI increased. Begonia leaves were more intensely colored and thicker at higher light levels, while leaves grown under the lower light levels were thin and pliable. In our opinion, begonia quality was commercially acceptable at 6 moles/day; however, 12 and 18 moles/day provided the highest quality plants.

Pansy. Pansies have a higher light requirement than many other bedding plants. Twelve moles/day were required for a commercially acceptable crop; however, the best quality occurred at 18 moles/day. Pansies grown at 3 moles/day were exceptionally floppy, while those grown at 6 moles/day produced few flowers. One method to overcome the poor growth associated with low light levels is to grow pansies at cool temperatures (50-60º F). At cooler temperatures, growth is considerably slower, so less stretching occurs. However, higher light levels are still needed to produce abundant flowering.

Marigold. Surprisingly, marigolds flowered reasonably well at 3 moles/day; however, the plants were still relatively poor quality, lacking "substance." In other words, leaf area, branching, flower size and number improved as light levels increased, and 6 moles/day were required for a commercially acceptable crop.

Angelonia. Angelonia displayed a dramatic improvement as DLI increased. At 6 moles/day or less, very little flowering occurred and lateral branches were weak and floppy. Plants flowered at 12 moles/day, but 18 moles/day were required to produce a plant with many flowers.

Petunia. The petunias grown in this study did not flower, since long days were not provided; however, shoot length and leaf size decreased as DLI increased.

Impatiens. Impatiens are shade-tolerant plants. Thus, they flowered and produced commercial quality plants at the lowest light levels (3 moles/day). Light quantities from 6-12 moles/day produced the highest quality plants. Impatiens can be grown at DLIs greater than 12 mole/day; however, some leaf yellowing may occur. Plant height decreased as DLI increased.

SUMMER EXPERIMENT

A second experiment was conducted outdoors during June and July. Ageratum, vinca and zinnia were grown in 4-inch pots under four light levels. Plants grown in full sun received 38 moles / day. Plants grown under 50 percent shade cloth received 15 moles / day. Plants grown under 70 percent shade received 7 moles / day, while plants grown under 90 percent shade received 3 moles / day.

Ageratum. Ageratum quality improved dramatically as DLI increased. Fifteen moles / day were required to produce a commercially acceptable crop. Plants grown at 3 and 7 moles / day flowered poorly, if at all, and were spindly. The higher light levels produced very compact and well-branched plants that had many flowers.

Vinca. As with marigold, vinca flowered at very low light levels (3 moles / day); however, the plant quality was poor and flower color was faded. Seven moles / day were required for "normal" flower size and color. Branching increased as the DLI increased. At low light levels, plants had only one stem while the highest light treatments had more stems than we could count.

Zinnia. Zinnia quality — indicated by lateral branching, flower size and flower color — increased as DLI increased. The 38 moles / day treatment produced the most lateral branches, the most intense flower color and the largest flowers; however, flowers developed even at 3 moles / day.

FALL EXPERIMENT

A third experiment was conducted outdoors during August and September. Geraniums and melampodiums received 30 moles / day in full sunlight, 13 moles / day under 50 percent shade, 8 moles / day under 70 percent shade and 3 moles / day under 90 percent shade.

Geranium. Geranium quality increased as DLI increased. The highest quality plants were grown at 30 moles / day; however, the quality was commercially acceptable at 13 moles / day. Interestingly, the coloration of the zonal pattern on the leaf was much more accentuated in the plants grown under higher light.

Melampodium. Melampodium also performed best at the highest light level (30 moles / day), but the plants grown at 8 moles / day were commercially acceptable. The high-light plants were more highly branched, had a greater number of flowers and flowered earlier. Plants grown at 3 moles / day consisted of only a single stem, although the plants did flower.

PLANT APPEARANCE

It is interesting to note the plant characteristics that are primarily affected by DLI. Shoots, roots and flowers were all affected by light, but in our opinion, lateral branching was the most consistent marker of plant quality that improved as DLI increased. The more light the plant receives, the more lateral shoots the plant can support. Thus, higher light levels produce "fuller" plants, and lateral shoots often translate into flowers.

Most horticulturists assume that lower light levels result in tall, stretched plants; however, plant height is not always affected by light level. Petunia and impatiens were taller at lower light levels, but for most species, low light levels actually resulted in shorter plants. We think that low light levels result in plants that "appear" to be stretched, because the plants lack lateral branching. Thus, the plant has an "open" appearance. Low light does reduce plant quality but, in most cases, does not promote stem elongation.

Flower size, flower number and time to flower were all impacted to varying degrees by the daily light integral. Surprisingly, several crops produced flowers at very low light levels (3 moles / day). However, the quality was usually quite poor since these plants typically only had one stem and relatively small flowers. In most cases, once the plants had greater than 5 moles / day, flower size and color were unaffected by light levels. The exception was zinnia, which produced its largest flowers and brightest-colored flowers at the highest light levels.

Flower number is closely linked with shoot number, so more well-branched plants produce more flowers. Thus, flower number increases as the daily light integral increases.

If plants had sufficient light to develop flowers, there was usually not a great effect of daily light integral on the time to flower. However, if there was not enough light to support flowering, the lowest light treatment was very slow to flower or did not produce any flowers.

Leaf size tended to decline as DLI increased. Leaves are usually larger under low light levels, since under those conditions it is beneficial for plants to intercept more light.

Root growth often parallels shoot growth, so the low light treatments (3 moles / day) always produced the poorest root systems, while higher light conditions produced well-rooted plants.

IN GENERAL

There are some general guidelines about plant performance and light levels that growers can extract from these experiments.

Less than 5 moles/day. DLIs less than 5 moles / day usually produce poor quality plants.

5-10 moles/day. Plant quality increases rapidly between 5 and 10 moles / day for most bedding plants. Most crops grown at these DLIs are commercially acceptable; however, high light-requiring crops will branch and flower poorly at this range. Five to 10 moles / day produces very good quality plants for shade-adapted species.

10-20 moles/day. Plant quality continues to improve as DLI increases from 10 to 20 moles / day for most species. Exceptional quality crops can be produced at these light levels.

More than 20 moles/day. High light species benefit from light levels above 20 moles / day; however, most species do not require these levels to produce high-quality crops.

Figure 3: The effect of daily light integral (moles/day) on angelonia, petunia and impatiens growth and flowering. Angelonia are pictured in 6-inch pots.

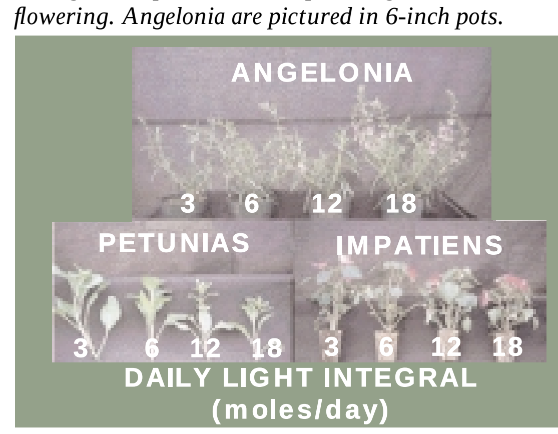


Figure 4: The effect of daily light integral (moles/day) on Ageratum 'Hawaii White' growth and flowering. Plants are pictured in 4-inch pots.

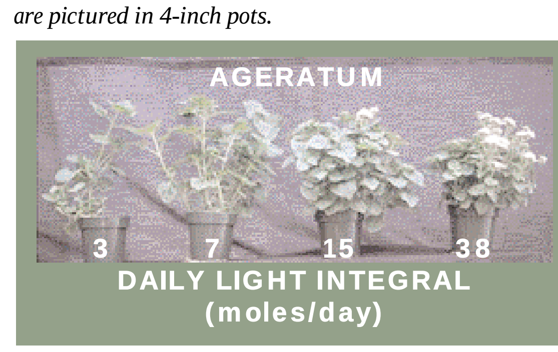


Figure 5: The effect of daily light integral (moles/day) on vinca 'Pacifica Lilac' growth and flowering. Plants are pictured in 4-inch pots.

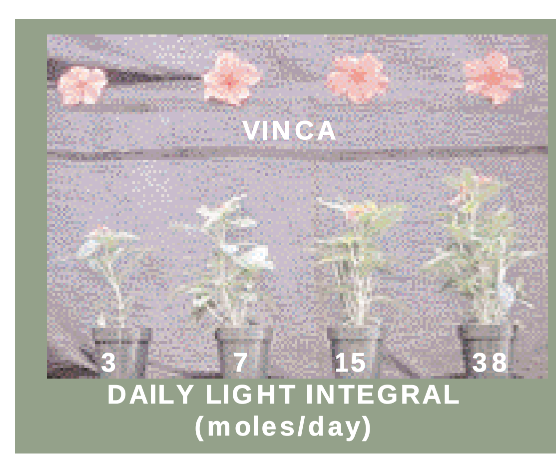
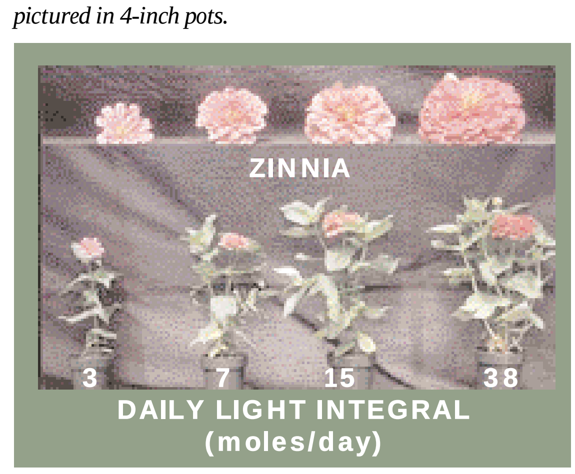


Figure 6: The effect of daily light integral (moles/day) on zinnia 'Dreamland Rose' growth and flowering. Plants are pictured in 4-inch pots.



COMPENSATING FOR LOW LIGHT

Nothing can replace the value of sunlight for producing high quality plants; however, temperature, plant growth regulators and supplemental lighting can be used, to some degree, to compensate for poor growth during periods of low light.

Lower temperatures help improve plant quality when ambient light levels are low. Under warm conditions, leaves and flowers develop rapidly. If light levels are low, plants have very little energy to pack into the plant tissues, thus the resulting growth is thin and lacks substance. In contrast, cool conditions allow the plants to grow slowly, thus the light energy absorbed by the plant is distributed to fewer leaves and shorter internodes.

Similarly, growth regulators can help to "tone" growth, so that the light energy is packed into more compact internodes. Also, growth regulators can slow primary shoot growth and allow lateral shoots to "fill-in" the plant canopy.

Finally, supplementing sunlight with artificial light can improve plant growth, but growers should be aware that typical high-pressure sodium lighting for 12 hours per day provides approximately 2 moles/day. If the ambient daily light integral is below 10 moles/day, then supplemental lighting can significantly improve plant growth. For most crops, supplemental lighting is not cost-effective if the ambient light level is greater than 10 moles/day. GPN

Figure 7: The effect of daily light integral (moles/day) on geranium 'Glamour Salmon' and melampodium 'Derby' growth and flowering. Plants are pictured in 4-inch pots.

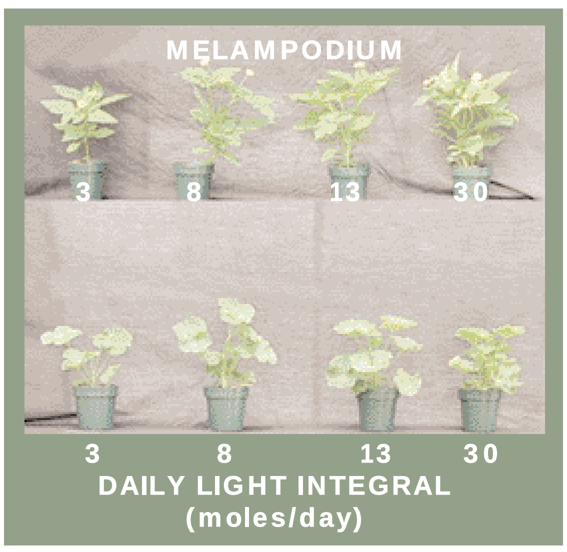


Table 1: Mean daily light integrals inside greenhouses each month of the year at eight locations across the U.S. (Note: greenhouse light transmission assumed to be 50 percent, although actual values vary from 35-70 percent, depending on numerous factors.)

Month	Daily Light Integral (moles/day)							
	Los Angeles, CA	Seattle, WA	Denver, CO	Dallas, TX	St. Louis, MO	Atlanta, GA	Grand Rapids, MI	Boston, MA
January	12	4	12	12	8	12	6	8
February	16	6	14	16	12	14	12	12
March	20	12	20	20	16	20	16	16
April	26	12	14	22	22	24	20	20
May	30	22	26	24	24	26	24	24
June	30	22	28	24	24	24	24	22
July	32	24	30	28	26	24	26	24
August	30	22	26	26	24	24	22	22
September	24	16	22	22	18	20	16	16
October	20	10	20	20	14	16	12	12
November	14	6	12	14	8	12	6	10
December	12	4	10	12	6	12	6	6

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