Increasing Yields of Baby Leaf Vegetables

Researchers at Cornell University are studying how light quantity impacts baby leaf vegetable production. Read on to learn the results of their latest study.

By Charles Gagne and Neil Mattson

It only takes a few minutes walking through the produce section of your local grocery store to notice the growing popularity of baby leaf vegetables. New baby leaf salad mix products are popping up in droves on produce aisles all across the U.S. These products often contain a mix of six to eight baby leaf vegetables that are selected for their flavor, nutrition, and aesthetic qualities.

While the definition of baby leaf vegetables varies, these crops are best defined as vegetables harvested after the development of true leaves, but before the eight true-leaf stage. Harvesting the crops at this stage is gaining popularity due to good leaf size, color and texture, as well as thicker leaves which allows for a longer shelf life.

The rise of baby leaf salad mixes has been closely linked with the increased production of baby leaf vegetables indoors in greenhouses and plant factories using hydroponic, aquaponic and aeroponic technologies. Light, water, plant nutrition, air and root temperatures, humidity and carbon dioxide can all be controlled in indoor production to optimize growth and allow growers to produce year-round

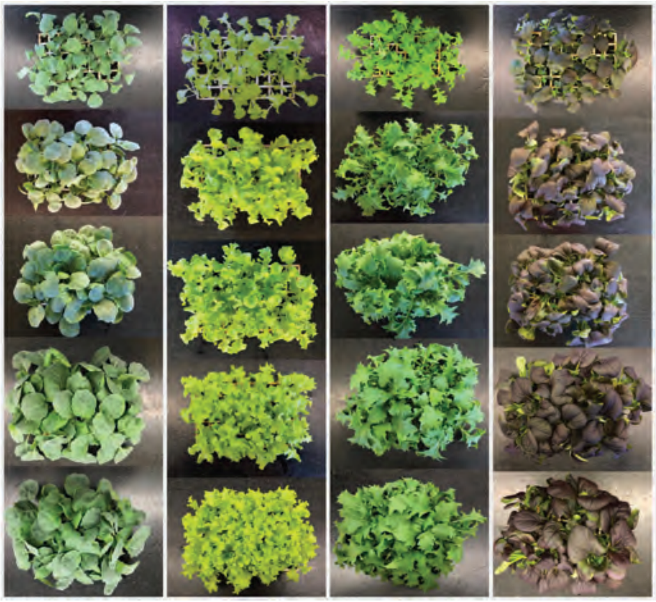

Figure 1. From left to right, baby leaf collards, lettuce, mizuna and pac choi 12 days after germination under daily light integral of 6, 12, 18, 24 and 30 mol·m^{-2}d^{-1} (from top to bottom).

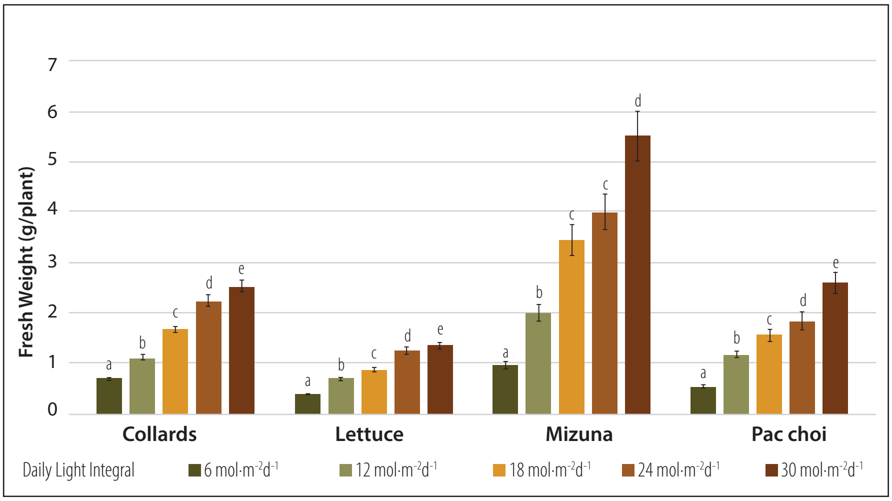

Figure 2. Images of vegetable species utilized in this experiment where A, B, C and D represent collards, lettuce, mizuna and pac choi.

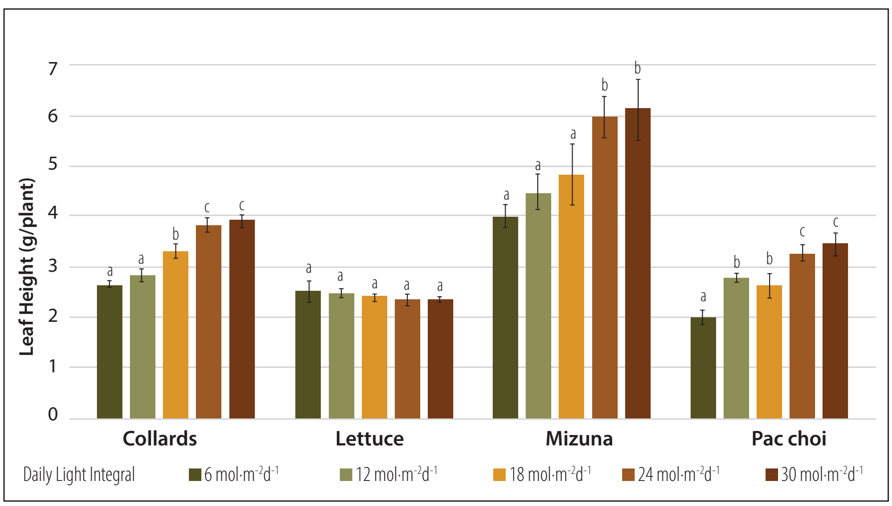

Figure 3. Average fresh weight per plant at Day 12 of collards, lettuce, mizuna and pac choi under five DLI treatments of 6, 12, 18, 24 and 30 mol·m^{-2}·d^{-1}.

with high, predictable yields and short growth cycles.

As the popularity of baby leaf vegetables grows, so does the need for research into their growth and development in controlled environments. Decades of research has gone into developing detailed strategies for the optimal production of mature lettuce and other leafy greens; however far less research has gone into developing these optimization standards for plants grown specifically as baby leaf vegetables.

THE IMPACT OF DLI

The intention of this article is to share some thoughts on using daily light integral (DLI) to improve the growth and development of baby leaf vegetables. Ultimately, this could help growers to make supplemental lighting decisions to increase yields, shorten growth cycles and enhance the ability to produce year-round.

Our study aimed to look at the effects of increasing light quantity, an important lighting characteristic, on the growth and development of hydroponically grown baby leaf vegetables. Light quantity is a product of instantaneous light intensity, or the number of photons of photosynthetically active radiation (PAR) delivered to the plant surface at any given moment, and photoperiod which is the number of hours of light provided to the plants in each 24-hour period.

Daily light integral (DLI), measured in mol·m^{-2}·d^{-1}, is the metric most commonly used to measure light quantity. The optimal DLI varies by species, for example, for head lettuce up to 17 mol·m^{-2}·d^{-1} is used and for tomatoes a minimum of 20 and ideally 30+ mol·m^{-2}·d^{-1} is common. In general, within bounds, increasing DLI usually leads to an increase in photosynthesis and crop biomass, but this has not been well studied for baby leaf vegetables.

STUDY PARAMETERS

In this study, four leafy vegetable species; collards (*Brassica oleracea L.* 'Flash'), lettuce (*Lactuca sativa L.* 'Sulu'), mizuna (*Brassica rapa L.* var. japonica) and pac choi (*Brassica rapa L. var. chinensis* 'Red Pac') were studied (Figure 1). These species were chosen for their presence in baby leaf salad mixes, similarity in germination rate and hours to germination (as determined in a preliminary experiment), and for their diversity in color, texture and leaf shape.

Plants were grown in a growth chamber under T5 fluorescent lamps and the photoperiod was fixed at 20 hours. The experiment was conducted over time, with the growth chamber set to one of five DLI treatments for each of the crop cycles. The DLI treatments were 6, 12, 18, 24 and 30 mol·m^{-2}·d^{-1} at plant level. Plants of each species were randomly assigned different mini hydroponic ponds within the chamber.

At experiment initiation, seeds were single seeded by hand into individual cells of the 40 cell polystyrene flats filled with a commercial peat-lite germination mix (LM-1, Lambert Peat Moss) resulting in a density of 144 plants per square foot. Flats were individually wrapped in one-gallon plastic bags to maintain moisture during germination and then placed on benches inside of the growth chamber and covered by light restrictive flats.

Preliminary experiments were conducted to determine hours to germination for each species which yielded germination times of 47 hours for mizuna and pac choi and 54 hours

FRESH WEIGHT (LBS PER FT^2)					
Daily Light Integral ($mol·m^{-2}$ d^{-1})					
Species	6	12	18	24	30
Collards	0.22ᵃ	0.35ᵇ	0.53ᶜ	0.71ᵈ	0.80ᵉ
Lettuce	0.12ᵃ	0.22ᵇ	0.28ᶜ	0.39ᵈ	0.43ᵉ
Mizuna	0.31ᵃ	0.64ᵇ	1.09ᶜ	1.27ᶜ	1.75ᵈ
Pac choi	0.17ᵃ	0.37ᵇ	0.49ᶜ	0.58ᵈ	0.82ᵉ
*Yield calculations assume 100% germination which is not representative for commercial production.					

Table 1. Fresh weight at Day 12 in pounds per square foot of collards, lettuce, mizuna and pac choi under five DLI treatments of 6, 12, 18, 24 and 30 $mol·m^{-2}·d^{-1}$. Assuming a plant spacing of 144 plants per square foot (one plant per square inch).

DAYS TO 4-INCH LEAF HEIGHT					
Daily Light Integral ($mol·m^{-2}$ d^{-1})					
Species	6	12	18	24	30
Collards	14.8ᵃ	14.2ᵃ	13.0ᵇ	12.2ᶜ	12.0ᶜ
Lettuce	15.6ᵃ	15.1ᵃ	15.9ᵃ	15.8ᵃ	15.6ᵃ
Mizuna	11.9ᵃ	11.2ᵃ	10.4ᵃ	9.7ᵇ	9.6ᵇ
Red Pac	19.0ᵃ	14.8ᵇ	16.0ᵇ	13.3ᶜ	13.0ᶜ

Table 2. Days to 4-inch tallest leaf height for collards, lettuce, mizuna and pac choi under five DLI treatments of 6, 12, 18, 24 and 30 $mol·^{-2}d^{-1}$.

for lettuce and collards. For each experiment, all flats were seeded at the same time and then the mizuna and pac choi flats were floated 47 hours after seeding, whereas the lettuce and collard flats were floated after an additional seven hours (54 hours after seeding). The day that the plants were floated was considered Day 0.

Flats were then floated on mini hydroponic ponds each filled with 28 L of reverse osmosis water and 0.28 L each of 1:100 concentration Jack's Hydroponic 5-12-26 (JR Peters Inc.) and calcium nitrate resulting in 150 mg L^{-1} nitrogen. The ponds were topped off with nutrient solution to maintain this volume throughout the experiment.

During each of the three harvests, one randomly assigned float from each pond was removed from the nutrient solution and the non-germinated cells were noted. The plants around the edges were removed to account for edge-effects. Plants from the inner 18 cells were then individually cut and weighed. Five representative plants from the inner cells were randomly selected and measured for tallest leaf height, widest leaf width, total leaf number, and total leaf area.

RESULTS

This experiment showed that incremental increases in DLI between 6 and 30 $mol·m^{-2}·d^{-1}$ resulted in significant increases in fresh weight and dry weight in each of the four species of baby leaf vegetables studied.

Figure 3 shows the average fresh weight per plant at Day 12 for each of the four species at each of the five DLI levels. It is also very easy to see in Figure 3 that there are large differences in yields between the four species. This variation in average yields is an important takeaway as it highlights the importance of species and cultivar selection for optimizing baby leaf vegetable yields.

In Table 1, these fresh weight yield results were translated into terms of pounds per square foot to estimate potential commercial yields of larger crop stands. Both Figure 3 and Table 1 show that for each of the four species there continued to be an increase in yield up to the $mol·m^{-2}·d^{-1}$ treatment, however, for lettuce and collards a relatively small yield increase was noted between the 24 and 30 $mol·m^{-2}·d^{-1}$ treatments, suggesting there may not be an economic benefit of lighting beyond 24 $mol·m^{-2}·d^{-1}$ for these species.

This experiment also revealed that incremental increases in DLI have some significant impacts on leaf height, as well as leaf width, leaf area, and leaf number. Leaf height in particular is often used to characterize baby leaf vegetables — along with number of true leaves and days to maturity — with the typical harvestable leaf height usually being described as ~4 inches (or ~10 cm). Figure 4 shows the tallest leaf height per plant at Day 12 for each of the four species under each DLI treatment; it can be seen from this graph that leaf height response to DLI varies greatly by species — with almost no impact being shown for lettuce.

Additionally, the leaf height growth curves between Day 0 and Day 12 were used to create Table 2 to show the days to reach 4 inches in leaf height for each of the four species under the different DLI treatments. Table 2 indicates that for some species, increasing the DLI could shorten the days to reach harvestable height, thus allowing for more harvests per year.

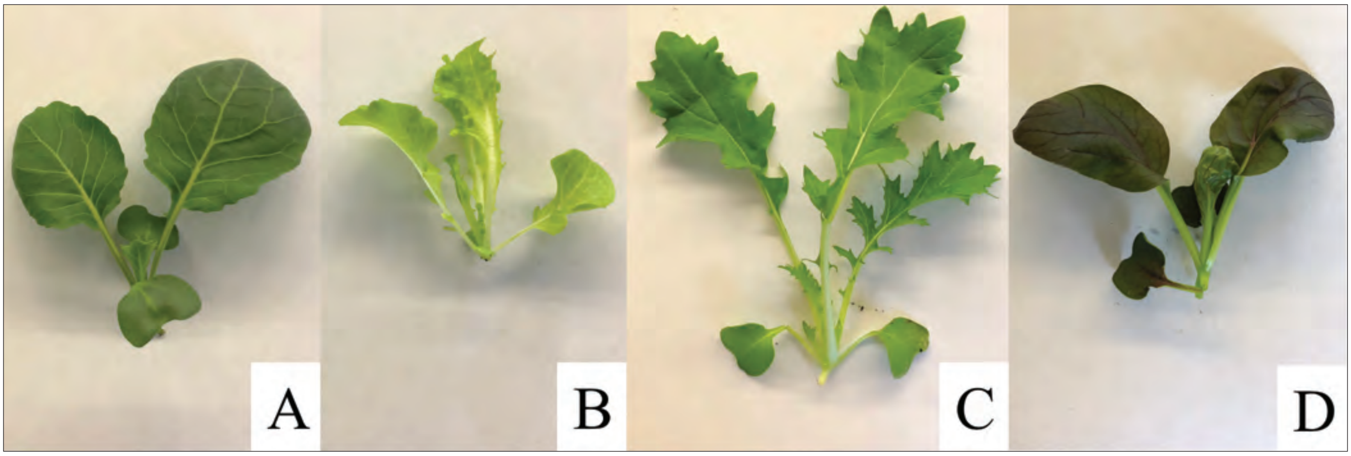

Figure 4. Tallest leaf height per plant at Day 12 of collards, lettuce, mizuna and pac choi under five DLI treatments of 6, 12, 18, 24 and 30 mol·m^{-2}·d^{-1}.

In conclusion, the results of this experiment could be valuable to baby leaf vegetable growers for a number of reasons. First, it was shown that for each of the four species increasing DLI continued to have a significant positive impact on yield up to the 30 mol·m^{-2}·d^{-1} treatment.

Additionally, it was indicated that for certain species it is possible to use DLI to decrease days to harvestable height thus allowing for more harvests per year. These results also showed very large differences in yield between the four species, which is an important consideration in species and cultivar selection for baby leaf salad mixes. However, it should be noted that it is always important to weigh the potential impacts to yield and days to harvest against the increased electrical demand and potential need for additional lighting fixtures that comes with increasing DLI. Overall, we recommend conducting your own in-house trials with lighting under your own growing conditions. ❖

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