e-GRO Edible Alert

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Slow basil growth

Is your basil taking longer than expected to reach a harvestable size? From fall through winter and early spring, basil can take longer than you'd like to reach a harvestable size, reducing crop turns and potentially increasing energy consumption. This e-GRO Edible Alert will focus on those factors that can influence the growth of development of basil and reduce your crop time.

Basil is the most popular culinary herb that is grown in hydroponic systems. For many hydroponic herb growers, basil is the backbone of their program. Growers are usually commenting on how they are able to sell all the basil they produce and can't grow enough! However, another comment I hear frequently is how their basil just doesn't grow in the late fall, winter, and early spring. This is when growers are experiencing longer crop times and delayed harvests. Although growth is slower during these "off-seasons", there are steps that can be taken to increase growth and keep production on track.

When producing cut basil, yield is based on the weight of harvested shoots. Therefore, in order to increase the amount harvested or reduce time until a crop reaches a harvestable size we want new leaves to appear and mature as quickly as possible. The two factors that are going to have the greatest impact on leaf unfolding and growth are light and temperature. In this Alert we are going to cover how you can manage light and temperature to enhance the growth and development of basil, as well as how other factors can affect

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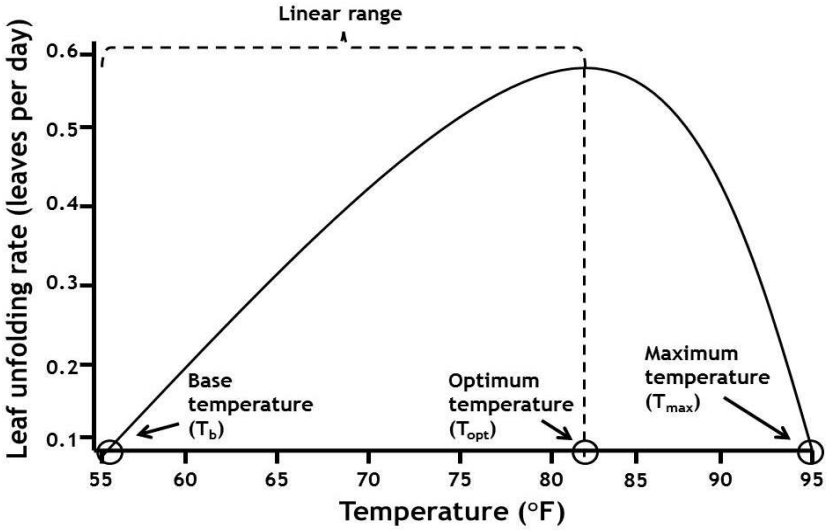

Figure 1. A typical and generic temperature response curve for plants including the base, optimum, and maximum temperatures, as well as the linear range.

the yield of fresh-cut basil.

Temperature

Temperature can affect plants in several different ways. Extremely low or high temperatures can cause damage, reducing yields and/or making shoots unmarketable. Increasing or decreasing the difference between day and night air temperatures ("DIF") can increase or decrease stem and internode elongation. As previously mentioned, increasing the rate that new leaves are formed can help increase yield. The rate that

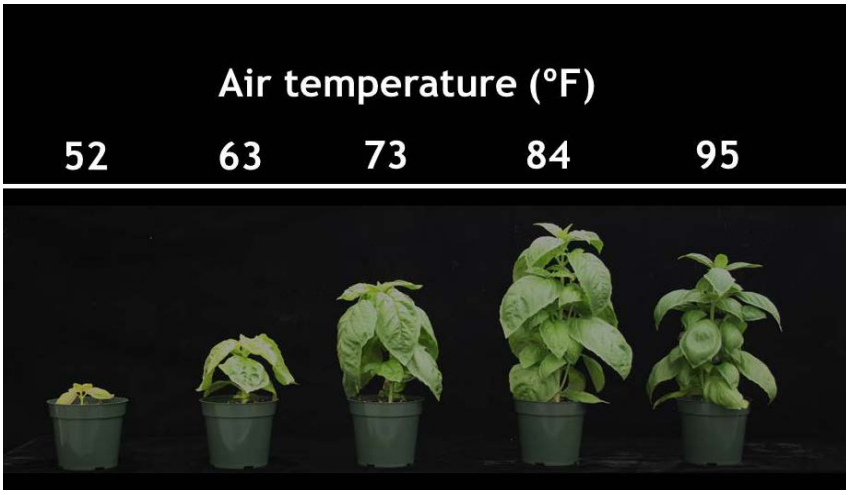

Figure 2. Sweet basil grown under a range of average daily air temperatures. Photo taken 3 weeks after placing seedlings into temperature treatments.

new leaves are formed is strongly influenced by the average daily temperature. There are three temperatures that help us understand the effect of average daily temperature on plant development: 1) the base temperature (T_{base}), the temperature below which plant development stops; 2) the optimal temperature (T_{opt}), the air temperature at which plant development is maximal; and 3) the maximum temperature (T_{max}), the temperature above which plant development stops (Fig. 1). Between the T_{base} and T_{opt}, plant development has a linear response to average daily temperature and this range of air temperatures is called the linear range. Within the linear range, plant development increases as the temperature increases and decreases as the temperature decreases.

With respect to basil, we start to see growth slow down in the fall, winter, and spring because the average daily temperature is getting lower in the greenhouse and the rate of new leaf appearance is decreasing. With the slower leaf unfolding rates, it takes longer for basil shoots to form enough leaves to become harvestable. While your greenhouse air temperature set points for heating and cooling may not have not changed throughout the year, average daily temperatures may decrease for several reasons. First, with lower light intensities there is less radiant energy entering the greenhouse and increasing the air temperature. Additionally, plants will lose heat to the greenhouse superstructure and to clear night skies, which can result in plant temperatures below air temperatures.

Basil is sensitive to cold temperatures and has a T_{base} of 47 °F for leaf unfolding based on our research at Iowa State University. Alternatively, it grows very well at warm temperatures, and our research shown leaf unfolding of sweet basil increaseses with air temperature up to 84 °F (Fig. 2). Therefore, one of the ways you can hasten growth and reduce the time to harvest is to increase your

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average daily temperature. Though you may be concerned about the cost of increasing air temperatures (and rightly so!), there are a few things to take into consideration. First, unlike ornamental plants we are not as worried about increased internode elongation from a positive DIF. Therefore, you can start by increasing your daytime air temperatures. Secondly, while raising your air temperature may increase heating costs, how much are missed crop turns from longer production cycles costing you?

Light

Temperature primarily influences the rate of development, while light primarily influences growth- an irreversible increase in weight or mass. Light drives photosynthesis, which produces carbohydrates that have a variety of fates, from becoming cell walls to stored starch. As the intensity of light increases, more carbohydrates are formed and wieght increases; alternatively, photosynthesis decreased under lower light. As such, reduced

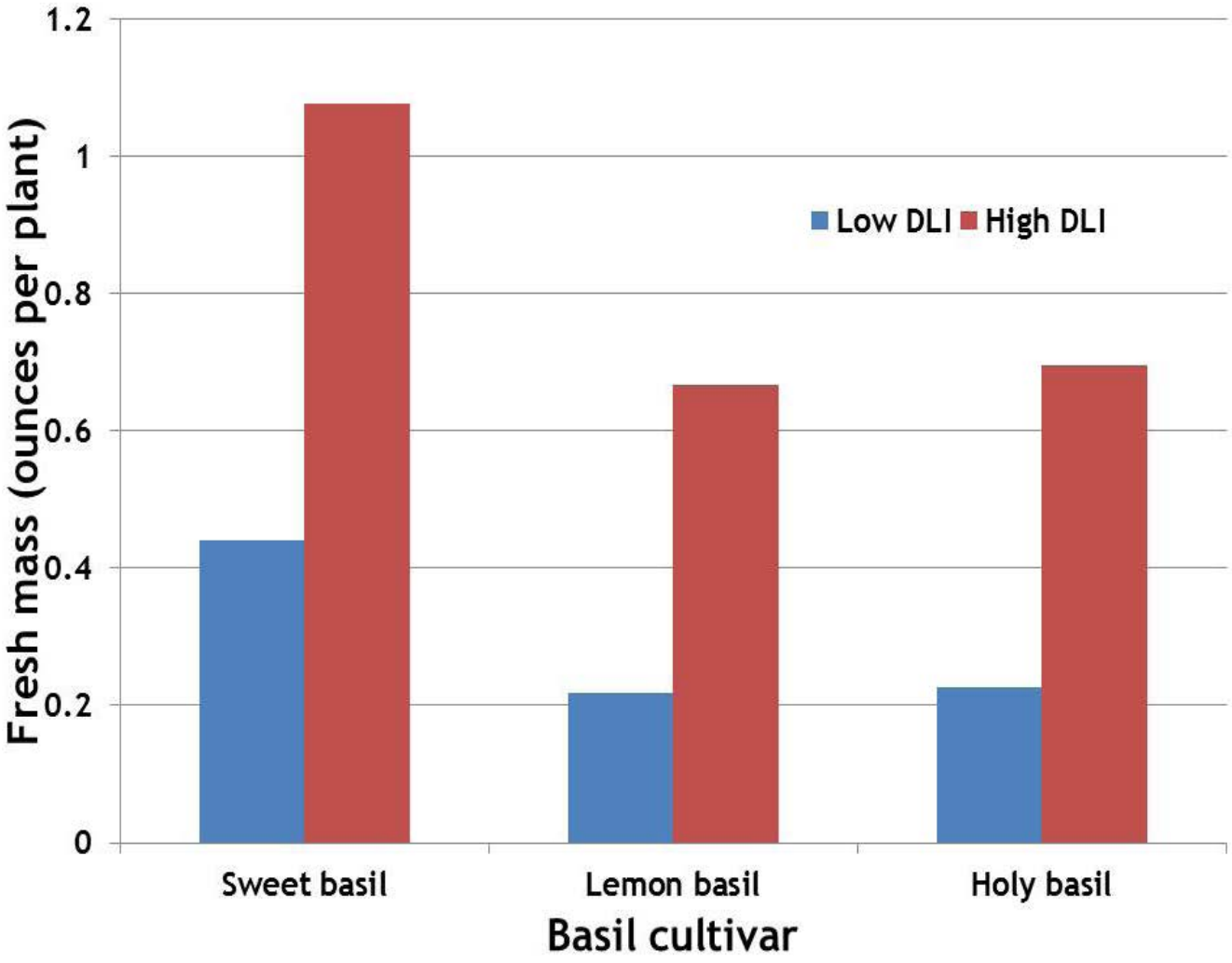

Figure 3. Shoot fresh mass, or yield, of sweet, lemon, and holy basil grown in nutrient-film technique hydroponic systems under a low (~7 mol·m^{-2}·d^{-1}) or high (~15 mol·m^{-2}·d^{-1}) daily light integral (DLI). Data were collected 3 weeks after transplanting seedlings into hydroponic systems.

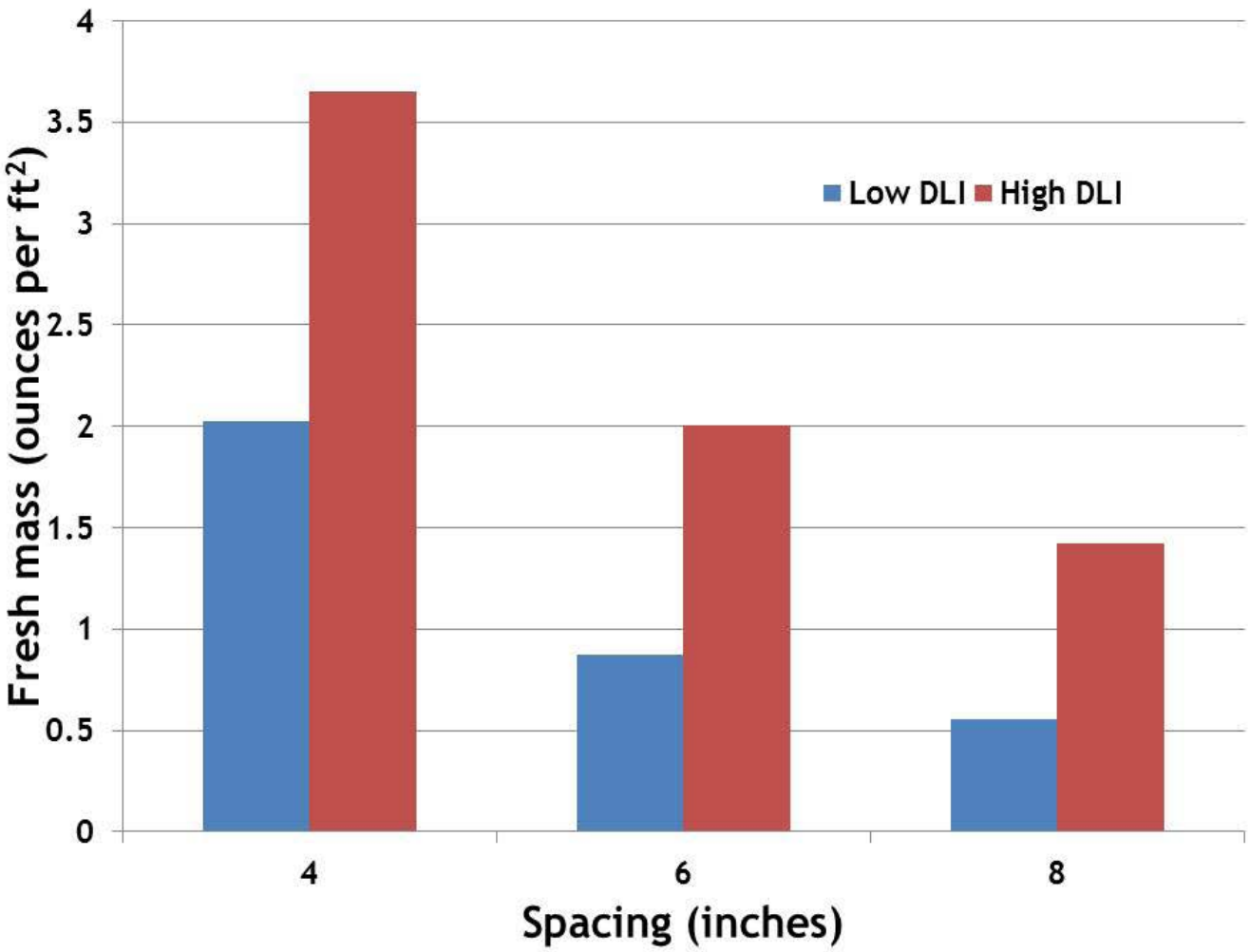

Figure 4. Shoot fresh mass, or yield, of sweet basil grown in deep-flow technique (DFT) hydroponic systems under a low (~7 mol·m^{-2}·d^{-1}) or high (~15 mol·m^{-2}·d^{-1}) daily light integral (DLI) on 4-, 6-, or 8-inch centers. Data were collected 3 weeks after transplanting seedlings into hydroponic systems.

photosynthesis from low light levels are another factor contributing factor to the dimished growth of basil in the late fall, winter, and early spring. Research at Iowa State University has shown that the optimal light intensity for production of fresh mass in sweet basil is 500 µmol·m^{-2}·s^{-1} and light intensities are often much less than this from fall through spring. Additional research we have performed has shown that increasing the daily light integral (DLI) from 7 mol·m^{-2}·d^{-1} to 15 mol·m^{-2}·d^{-1} increases the fresh mass of sweet, lemon, and holy basil by 144, 207%, and 208%, respectively (Fig. 3).

To maximize transmission of light into the greenhouse, make sure your glazing material is clean and your superstructure over the plants is minimal. However, when ambient light levels are low, there is really only one way to appreciably increase your light intensity or DLI inside the greenhouse, and that is with the use of supplemental lighting. High-pressure sodium (HPS) lamps are the most widely used light source for increasing light intensity and DLI in greenhouses. Many types of light-emitting diodes (LEDs) have been introduced into the marketplace recently and, while this is a new technology that may be less familiar to growers, there is promise as a supplemental light source. Whether HPS lamps or LEDs, a

good starting supplemental light intensity is from 70 to 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The number of lamps that you will need will depend entirely on the output of the fixtures, distribution of the light, and distance from the plants they are placed. Lighting companies can help provide support when trying to determine your needs and can assist you in putting together a lighting plan.

Planting density

If you are unable or choose not to increase the air temperature or utilize supplemental lighting, there is another way to increase basil yield in the greenhouse. Fresh-cut basil is not harvested and sold on a per-unit basis; rather, it is sold on a weight basis- most commonly in 0.75-ounce packages. One method to increase the yield per square foot or square meter in the greenhouse is to increase your planting density in the greenhouse. Our research has shown that sweet basil can be grown on spacing as close as 4-inch centers, which increased yields under both low and high DLIs. On an 8-inch spacing, there are 2.25 plants per ft^2, whereas plant density increases up to 9 plants per ft^2 on 4-inch centers. While reducing spacing and increasing plant densities will not enhance the growth of individual basil plants, it will increase the yield per ft^2 and greenhouse space will reach harvestable yields more quickly.

Mineral nutrition

Properly managing the nutrient solution for hydroponic basil production is important for producing high-quality basil. Basil with visible nutrient deficiencies is not marketable, so foliage must be healthy and free of unappealing symptoms. However, though correct nutrient solution management results in appealing plants, increasing the amount of nutrients does not increase the weight of crops. Our research on the effect of electrical conductivity (EC) has shown that increasing the nutrient solution from 0.5 to 4.0 $mS \cdot cm^{-1}$ does not increase the growth or fresh weight of basil. Using nutrients to “push” growth is not effective in hydroponic basil production.

Bringing it all together

Basil is an important crop for any culinary herb production program. It can be a challenging crop because basil grows best with warm temperatures and high light; these are not the conditions we have, during the late fall, winter, and early spring, when greenhouses and controled-environments provide their greatest advantage for production. There are opportunities for improving growth with proper management of air temperature and light, and increasing planting density offers another opportunity to increase yeilds.