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# Don't be Dim! Watch out for Low Light on Leafy Green Seedlings

*Are your leafy green and herb seedlings looking excessively tall and spindly? The problem may very well be lack of adequate light. This is a common problem in greenhouse production during the dark, winter months. The problem is also found for those starting seedlings in indoor locations (i.e. sole source light) when there is insufficient lighting capacity installed. This alert will cover symptoms of low light and strategies to grow stronger leafy green seedlings.*

## Seedling basics

Hydroponic leafy greens and herbs are often propagated in substrates such as rockwool, oasis, or jiffy pots prior to transplanting in the hydroponic production system. For head lettuce and herbs, seedlings are typically transplanted when they have 3-4 true leaves and a sufficient amount of root growth (Figs. 1, 5). The exact size of seedlings will depend on the cell-size and individual grower needs.

Fig. 1. A high quality lettuce seedling with about 5-6 true leaves. The plant is compact with well developed leaf and root surface area.



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Fig. 2. Poor quality lettuce seedlings grown under insufficient light exhibit excessive stem length and poor leaf and shoot development.

During seed germination, seeds may be germinated in chambers with humid, low-light conditions. As soon as germination has occurred (seed coat cracks and radicle emerges) it is important to move seedlings to higher light condition. Otherwise rapid, unwanted elongation of the seedling can occur.

For head lettuce, our Cornell CEA group has found we can produce robust seedlings with 3-4 true leaves in as little as 11 days if light and other conditions are optimized (Fig. 4). During germination (sowing until radicle emergence, which takes place in 24 hours for lettuce) we keep substrate temperatures at 68 °F (20 °C). A low light intensity  $<50 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  can be used during this stage, but one must be sure to move seedlings to higher light as soon as the radicle emerges. We target a light intensity of  $50 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  during the first 24 hours (daily light integral of  $4.3 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ ) which is enough to prevent excessive stretching of the seedlings while minimizing the tendency of supplemental lighting to dry out the surface of the medium. Following the seedling



Fig. 3. Poor quality lettuce seedlings grown under insufficient light exhibit excessive stem length and poor leaf development. In this case the problem with low light is exacerbated by sowing multiple seeds per cell.

stage (days 1-11) we maintain DLI at  $22 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  to push growth of seedlings. (Note that seedlings are not sensitive to leaf tip burn, a calcium disorder of more mature head lettuce, for more information see: [http://www.e-gro.org/pdf/2015\\_431.pdf](http://www.e-gro.org/pdf/2015_431.pdf)). The DLI target can be met by lighting at  $250 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  with a 24 hour photoperiod. Shorter photoperiods are acceptable if the light intensity is increased to provide the same total DLI target. Seedlings are ready to transplant into the hydroponic system when they have 3-4 true leaves. During days 1 to transplant we maintain day/night temperatures are maintained at 75/66 °F (24/19 °C). This seedling production strategy has worked well for other leafy greens and herbs, with the exception that most other

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species take longer than lettuce for the initial germination stage (for example, about 2-3 days for arugula and kale and 3 days for spinach).

### Symptoms of low light

Symptoms of low light include tall seedlings with excessive stem elongation, leaves may appear thin and strap like (Figs. 2, 6). Root mass will be smaller than well-lit seedlings. In general, the seedling production stage will take much longer for plants to form sufficient leaf and root mass as compared with well-lit plants. Seedlings will be more fragile and may show stress upon transplanting and acclimating to higher light conditions. Symptoms are exacerbated when seed is sown at a high density or when multiple seeds are sown in the same cell due to plant competition for light and shading of neighbors (Fig. 3).

### Strategies for success

Regarding light, the key points to produce compact and stocky seedlings are 1) move seedlings to adequate light as soon the radicle has emerged from the seed and 2) ensure that an adequate daily light integral (DLI) is provided to seedlings. Note that if domes are used to cover seeds during germination, these should also be removed as soon as the radicle emerges, otherwise young seedlings will stretch under the high humidity conditions. Also, we find best success when we begin fertilizer seedlings from day 0 (we provide 100 to 150 ppm N from a complete hydroponic fertilizer).

What is the minimum DLI for growth of quality leafy green seedlings? This topic has not been well researched but anecdotally we find poor quality seedlings (fragile seedlings with excessive height with poor root and leaf development) when DLI is less than about  $6 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ , fair quality seedlings (a bit of excessive height and slower development of

sufficient leaf and root biomass) when DLI is  $6\text{-}10 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ , good quality seedlings when DLI is  $10\text{-}15 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ , and excellent quality when DLI is between  $15\text{-}22 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ . The above DLI suggestions should be taken only as rough guidelines and also depend upon the seedling or cultivar used. And again note, that besides poor seedling quality at low light levels, it will take longer for seedlings to be ready to transplant. This is typically a linear response, so if seedlings take 11 days at  $22 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  they will take double this, 22 days, at  $11 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  and 44 days at  $5.5 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ .

At the seedling stage supplemental or sole source light can be used 24 hours a day, if needed, to supply a sufficient DLI. For example, consider seedlings growing under  $100 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ . If the lights are on for 12 hours, then  $4.32 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  is provided by the light:  $([100 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1} \times 3,600 \text{ seconds/hour} \times 12 \text{ hours/day}] / 1,000,000 \mu\text{mol/mol} = 4.32 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1})$ . If this is the only light source, seedling quality will be poor. If the same lights were operated 24 hours a day, they would provide  $8.64 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  resulting in fair seedling quality.



Fig. 4. Lettuce seedlings with 3-4 true leaves just after transplanting into rafts for deep water culture (pond) hydroponics.



Fig. 5. (Above) High quality lettuce seedlings about 1 week after transplanting into nutrient film technique (NFT) channels.



Fig. 6. (Right). Older lettuce plants grown under insufficient sole source light in an indoor location. Notice strap like leaves with poor leaf surface area and very pronounced internode elongation.