e-GRO Alert

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Volume 12 Number 11 March 2023

The Pros and Cons of Indoor Plant Production Facilities

The most compelling reason for growing in an indoor plant production facility is the complete control of the growth environment.

Within the last five years, there has been an increasing number of indoor growing facilities – those completely enclosed and without sunlight – in the United States (Figure 1). Many of these controlled-environment facilities are growing leafy greens or culinary herbs and seek to reduce the number of food-miles that these products travel, often from California, where most of the lettuce production is in the US. In addition, in the last decade, some greenhouses have shifted from seasonal floriculture crops to food crops to move away from the tumultuous, condensed spring season and move towards a year-around business with more steady revenue. Regardless of the crops grown, growers and entrepreneurs should consider the benefits and challenges of both greenhouse and indoor production systems prior to starting any new venture.

Figure 1. Growers can control all environmental conditions in an indoor plant production facility including light quantity and quality.

Benefits of Indoor Growing Facilities

Complete control of the growth environment

There are numerous advantages of growing in a completely controlled environment, which for vegetable production is often referred to as indoor farming or a plant factory. The most compelling reason for growing in a plant factory is complete control of the growth environment; there is no variability in sunlight or temperature as there is inside a greenhouse. For example, in the northern US (including western Michigan), there are some locations that receive as little as 5 to 10 moles of light per square meter per day ($mol \cdot m^{-2} \cdot d^{-1}$) outdoors in January (Figure 2). Greenhouses glazed with polyethylene film receive approximately half of that outdoor total. What does that mean? Crops grown in greenhouses in these locations need supplemental lighting to reach the rule-of-thumb minimum of 10 $mol \cdot m^{-2} \cdot d^{-1}$ during the winter months. Some vegetable crops, including butterhead lettuce, has a recommended DLI of 17 $mol \cdot m^{-2} \cdot d^{-1}$. By growing in an enclosed environment, sole-source lighting can provide specific lighting conditions for plants year around.

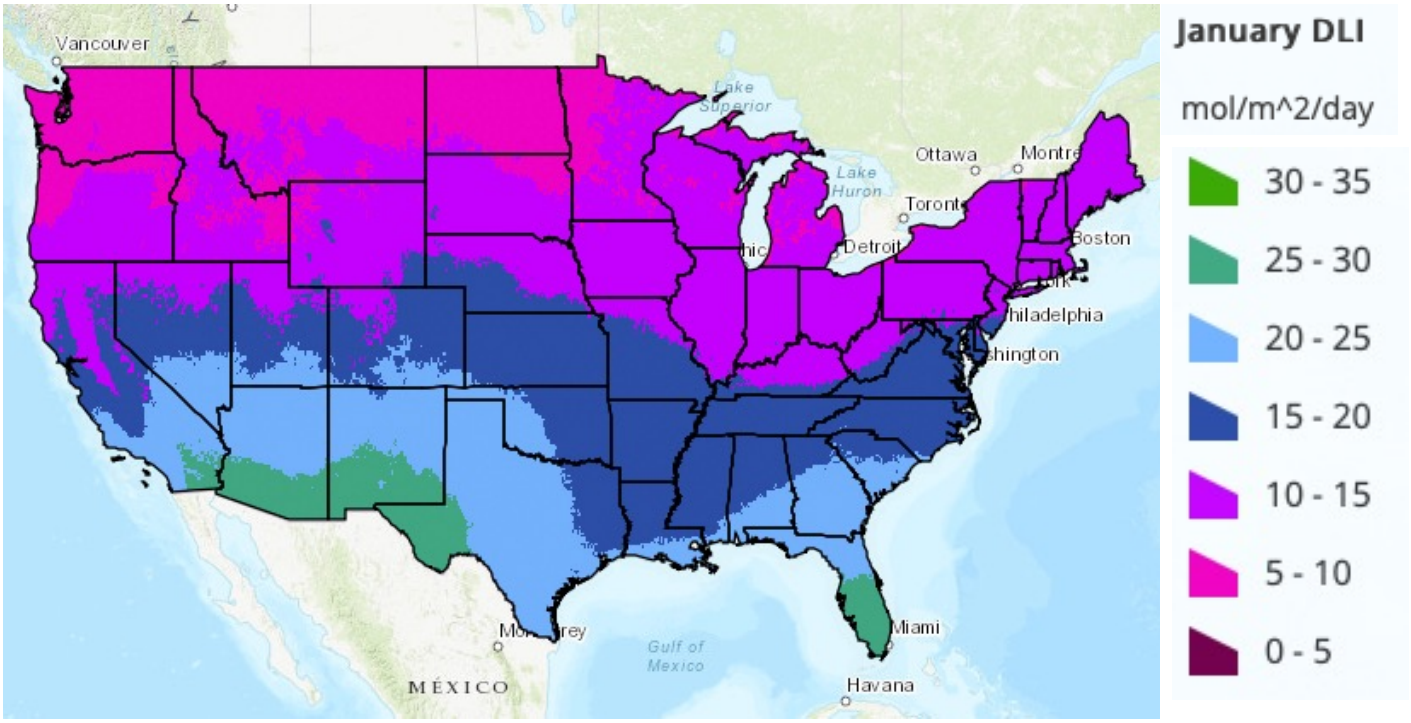

Figure 2. Daily light integral (DLI) outdoors in the lower 48 states in January in $mol \cdot m^{-2} \cdot d^{-1}$ (Courtesy of American Floral Endowment https://endowment.org/dlimaps).

In addition to lighting, indoor growing facilities can regulate temperature and humidity to a greater extent than a greenhouse, even when greenhouses have energy-efficient environmental control systems (heat curtains, venting, foggers, etc.). With such precise control of the growing environment, production time of crops is often shorter than in a greenhouse, and there is less shrinkage. This can be an especially desirable facet of indoor production when weaning tissue-cultured plants (Figure 3).

Plants propagated by tissue culture are often expensive to purchase and benefit from the high-humidity and consistent environmental conditions after transplant. Providing a week in a highly controlled propagation chamber can reduce plant loss prior to moving them to the more variable greenhouse environment.

Figure 3. A floriculture grower developed a plant growth chamber in order to acclimate tissue culture-propagated plants prior to moving them into the greenhouse. The chamber has reduced their losses of some hard-to-root species, such as echinacea, by at least 50%.

Control light quality throughout stages of production

There's been an abundance of research examining how plants grow indoors and respond to light quality (light spectrum) throughout production. For example, Michigan State University's Floriculture and Greenhouse Crop Production Website has dozens on articles on "Light Management in Controlled Environments." For instance, plants grown under higher percentages of blue light, especially in low-light environments (<10 $mol \cdot m^{-2} \cdot d^{-1}$) are more compact than those with less blue light, which can reduce the need for plant growth retardants in floriculture crops and vegetable transplants. In addition to compactness, elevated blue light levels can amplify the production of plant pigments such as anthocyanins in some species, such as purple fountain grass, ornamental cabbage, and red-leaf lettuce. Under sole-source, indoor lighting, growers can customize the light spectrum to regulate flowering, promote or inhibit elongation, and/or induce the production of plant pigments.

Comfortable work environments

Even with whitewash and heat curtains, greenhouses can be very hot and uncomfortable for employees during the summer with high temperatures and strong sun. Plant factories have consistent year-round temperatures, humidities, and light levels, which can create a more pleasant working environment.

Pest exclusion

Indoor growing environments have a greater ability to exclude insect and disease pests compared with greenhouse production. Especially in crops propagated by seed, such as lettuce and many annual bedding plants, there is a reduced likelihood of insect hitchhikers or disease outbreaks. The heating, ventilation, and air conditioning (HVAC) systems inside plant factories filter the air and prevent pests from coming into the facility.

Limitations of Plant Factories

Crop types

Only the most high-value crops, and usually those with short stature, are suitable for commercial indoor farming. Plant factories often use their vertical space – hence the name 'vertical farms' – to increase plant production per square foot of land. Propagules of floriculture crops and short-statured edibles such as microgreens (Figure 4), herbs, and leafy greens with very short production times are the most viable for this cropping system.

High startup costs

Vertical farms might not be economically feasible in all areas or with all crops and require a large initial capital investment. Plant factories require lighting, HVAC systems, (semi-) automated irrigation, and usually automated systems to move plants within the production area. The initial start-up costs are even greater in high throughput-facilities that utilize state-of-the-art technology.

Operating costs

In addition to the high start-up costs, the viability of a plant factory depends on utility costs such as electricity to power the lighting fixtures and HVAC system. Utility costs vary by location, season, and sometimes time of day. Unless a facility is highly automated, labor costs for indoor farms can also be high.

Figure 4. Microgreens are a prime example of a crop that are the most economically viable in an indoor growth system.

Sufficient expertise and staffing

Everything in a vertical farm – except the plants – requires technology and sufficient expertise to run the systems. While greenhouse growers are no strangers to repairing plumbing, heaters, and injectors, vertical farms often have additional layers of technology or automation. Fixing highly specialized automated systems (Figure 5) requires specialized expertise, parts (Figure 6), and a back-up plan when the system is not working. While these automated systems may reduce the number of employees handling individual plants on an everyday basis, they require even greater maintenance and oversight than most greenhouse systems (Figure 7).

Sufficient HVAC systems

HVAC systems need to be properly engineered for vertical farms to not only air condition (and sometimes heat) the facility, but also to dehumidify the air. If the HVAC is inadequate and the humidity levels in the facility are very high, there can be insufficient uptake of water and decreased photosynthesis, which inhibit plant growth and can cause physiological disorders. Environments with high humidity also are conducive to disease development, which could render a crop unsellable very quickly.

All photos: Heidi Lindberg

Figure 5. Vertical farms often have highly automated electrical, HVAC, and irrigation systems.

Figure 6. Indoor plant production facilities have highly specialized irrigation systems.

Figure 7. While automated systems decrease everyday plant handling, the high level of automation requires a specialized expertise to maintain the systems and ensure quality crops.

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