Top Misconceptions About CEA

Thinking about getting into hydroponic growing or expanding your current business? You need to read this first.

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Controlled environment agriculture (CEA) uses advanced horticultural and engineering techniques to optimize crop production, quality and production efficiency. A controlled environment allows crop production year-round in regions where they would otherwise be impossible. With today's consumers increasingly demanding a diet that includes fresh, high-quality vegetables, CEA production systems have seen increased attention by both traditional growers and entrepreneurs alike. While CEA greenhouses can supply a tremendous quantity of produce, they also require high capital investment and operating costs. Furthermore, their successful operation demands sound knowledge of a wide range of horticulture, engineering and business skills.

The Cornell University CEA research group has more than 25 years of research experience in CEA greenhouse hydroponic vegetable production. In 1999, the Cornell CEA Program constructed a small commercial scale greenhouse (8,064 sq. ft.) for hydroponic lettuce production in Ithaca, New York. The facility has a production capacity of 1,245 heads of high-quality lettuce per day (see Figure 1).

Below, we provide food for thought in the form of a selection of common CEA misconceptions. Many of the misconceptions noted are based on experience operating the facility as a commercial enterprise. We hope these thoughts will help you to make well-informed decisions when considering beginning or expanding your own CEA operation.

"Anything that can go wrong, will go wrong."
MURPHY'S LAW

"Murphy was an optimist."
BASIC LAW OF CEA

Production misconceptions

We will have full production from the start. Business models look great when you assume full yields from the beginning. In practice, it typically takes a year or two to work out the kinks and ramp up to full-scale production. We think it takes at least an entire year to gain experience as a grower even if you're only producing a single crop. There are problems associated with each season involving excess/lack of light, heat and humidity, occurrence of diseases and insects, and equipment failures.

We recommend growers start small, solve problems, broaden the market for their produce and then scale-up. Our rule of thumb for safety is to be capitalized sufficiently, so that you'll survive with no sales in Year 1 and half sales in Year 2. This is a pessimistic viewpoint, but provides insurance.

We avoid insect or disease problems. We hear this a lot, especially from folks interested in warehouse/factory growing. Despite your best intentions to exclude insects and disease, there will always be insect and disease problems. Some will be persistent and some new issues will show up every year.

Some of the more common problems we've noticed include Pythium root rot, powdery mildew, aphids and thrips. A talented grower will always be on the lookout. Assume there can be a problem at any time. Continually scout. Have specific control plans in place to control each pest.

Failure to understand the importance and cost of providing adequate light. Light is the driving force for photosynthesis and thus yield of hydroponic crops. Humans are very bad at determining how much photosynthetically active radiation (PAR) is available because we perceive light differently than plants. It's important to install multiple quantum sensors in the greenhouse to log PAR. The daily light integral (the total quantity of photosynthetic light plants receive in a day) varies greatly season-to-season and even day-to-day.

In our CEA head lettuce system, we use movable shading and supplemental lighting to provide a DLI of 17 moles of PAR per square meter every day to ensure consistent year-round production. When DLI is supplied at this level, we can produce a 5-oz. head of lettuce in 35 days from seed. Shading is important because lettuce plants develop leaf tip burn when DLI is higher than 17 moles. (Assuming vertical airflow fans [VAF] are operated. Without VAF, the limit is 12 moles. See Figure 2.)

At lower DLI, plants take longer to reach harvestable yield. In Ithaca (one of the cloudiest places in the contiguous 48-states), we provide 30% of the plant's light needs from supplemental light when averaged across the year. Our lighting cost is expensive—about $12 per sq. ft./year. But if we didn't supply it, yields would be markedly lower. In the winter, the DLI in Ithaca is low (averaging 5 moles per square meter per day in the greenhouse). It takes more than 100 days to produce a 5-oz. head of lettuce with no supplemental light. For other crops, such as spinach, low DLI leads to unacceptable crop quality.

Marketing misconceptions

Everything that's grown will be sold. Marketing produce at a price the grower can bear is among the most difficult challenges in CEA production. It takes time to cultivate relationships with customers. Often, you'll need to begin by showing potential buyers examples of the product you can produce. For this reason, it often makes sense to start with a small-scale prototype facility at first then expand as you increase your market. Selling everything you grow requires a complex marketing plan with many contingencies.

Figure 1. Inside the small, commercial scale hydroponic greenhouse developed by Cornell CEA.

Figure 2. Leaf tip burn on head lettuce resulting from a high daily light integral.

Customers will be loyal. Produce managers will promise to take everything you can grow … until they find a better price elsewhere. Restaurants may be more loyal, but outside forces such as seasonal demand may affect their willingness to consistently buy your product. CSAs are a good way to get "loyal" customers, but they pre-pay, so they take what they've already pre-purchased. Contingencies must be set up in case you produce less or more than expected.

Customers will understand if a crop fails. You MUST have a backup plan to deal with crop failures. It may be to purchase someone else's product and stick your label on it. Not having produce that a manager is counting on is a sure way to lose customers.

System misconceptions

Nothing will be broken. Something will almost always be broken. An important part of your job will be learning to fix things on a daily basis—remember the basic law of CEA!

Growing plants is mainly about following fixed recipes and relying on computer control. Greenhouse production is the combination of dozens of interacting systems that must work together to produce a crop (seed, substrate, water, fertilizer, environmental control, pest and disease control, labor). Your conditions are likely very different from those given in the textbook recipe. Systems will need to be >>>

adjusted over the growing season and as conditions change.

For example, perhaps your preferred seed variety is no longer available. Your new variety will require tweaks to all of the above systems. While computerized environmental control is important, don't blindly trust the computer. Never rely on just a single sensor—one sensor can easily lose calibration, become covered with dust, etc. Even in a small greenhouse, two (or better, three) is safer.

Aeroponics saves water compared to other hydroponic systems. This is not true. The main driving forces for water uptake are plant transpiration (evaporation from the leaf surface) and growth. The process of plants taking in carbon dioxide for photosynthesis requires the loss of water by the plant. These processes occur whether the plant is grown in soil or hydroponically. Closed irrigation systems do save water because water is captured and reused, but high-quality water is necessary to use these systems.

LED fixtures make CEA lighting cheap. The operating costs of lights should be considered in terms of wall plug efficacy—light output per kWh of total electricity consumed (including electricity for the power supply, ballast and cooling). In terms of wall plug efficacy, LED overhead greenhouse supplementary lighting systems aren't currently better, or only marginally so, than high-wattage greenhouse high intensity discharge (HID) lighting.

A recent comparison of greenhouse lighting fixtures reported that the best LED lamps had a similar efficacy to the best high-pressure sodium (HPS) fixtures (Nelson and Bugbee, *PLOS ONE*, June 2014.). The same paper reported that the capital cost of LED fixtures was five to ten times more than HPS fixtures when calculated per unit of light delivered. Due to the high capital costs, the five-year electricity plus fixture cost was 2.3 times higher for LED fixtures. Over time, LED fixtures will become more economically viable as capital costs decrease and efficacy further increases.

LED fixtures don't give off heat. Because LED efficacy is similar to HPS efficacy (see above), by definition both lamp types convert about the same amount of electricity to light. The rest of the electricity must (necessarily) be converted to heat. The most notable difference is that HID lighting radiates a significant amount in infrared wavelengths, in addition to longer wave radiation from the hot unit, which heats the crop canopy. Part of the LED heat loss is from the back end of the fixture (through the heat sink/fan).

Magical light spectra combinations exist for greatly improved growth under LEDs. This hasn't been proven in scientific experiments. While specific red and blue wavelengths provide adequately for photosynthesis, plants are relatively good at using all light between 400 and 700 nanometers. Moreover, for greenhouse plant growth, sunlight will still be the major source of light and will provide the full spectrum.

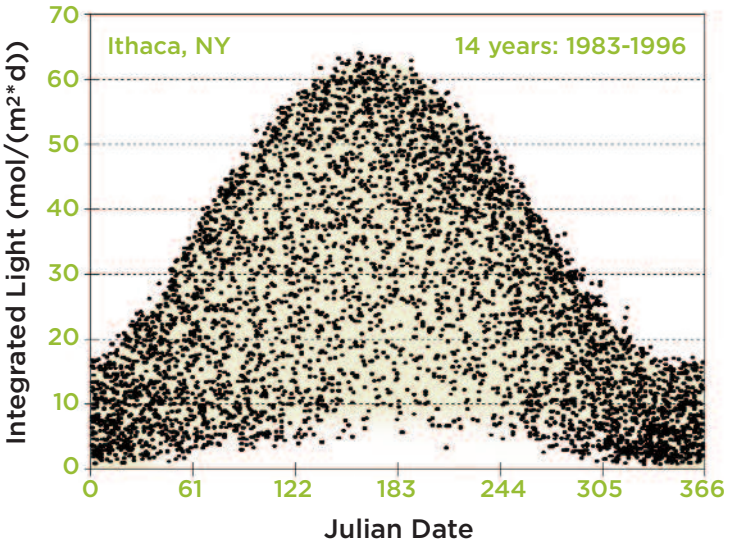

Table 1. Outdoor daily light integral (DLI) in Ithaca, New York, measured over a 14-year period. Each dot represents DLI for one day. Depending on the greenhouse, 50% to 70% of this light will be transmitted into the greenhouse.

Labor misconceptions

Affordable labor will be there when you need it. Intensive agriculture requires a more highly skilled workforce (see "Systems misconceptions"). An inexperienced grower will have a long learning curve and may take several years to reach full production potential. Even with an experienced grower, there's still a learning curve for a new location and new equipment. Many CEA business plans don't take into account that they'll need a highly skilled head grower and haven't taken steps to locate such a person.

We can take weekends and holidays off. You cannot rely on computer control to look after your plants on weekends and holidays. Besides checking the growing environment, daily tasks such as seeding, transplanting, respacing and harvesting will still need to be performed. Your head grower might not want to work 365 days a year; therefore, you must have a plan to provide adequate labor for holidays/weekends.

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