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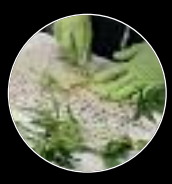
February 2018

A "Bright" Future

New York City-based hydroponic grower BrightFarms on expansion, retaining employees and what "local" means



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Barriers to Opportunity

This issue of *Inside Grower* is all about opportunity. But opportunity, while exciting, is a tricky business because it always comes with barriers. It takes a creative mind, hard work and sometimes a little luck to break down those barriers on the way to success.

As I write this, Canadians and Americans are being warned not to eat romaine lettuce due to an *E. coli* outbreak. Canadian officials identified romaine lettuce as the cause of the outbreak there, but U.S. officials were still investigating. By the time you read this, the mystery may have been solved, but food safety is and always will be a major barrier in growing edible products of any kind for the public. We're working on more stories coming up that will address these issues, but for now, you can turn to page 10 to see how New York City-based BrightFarms works to reduce the potential for food safety issues in all its hydroponic greenhouses.

Despite their best efforts, they did have a recent recall in the Chicagoland market and you can find out how they gracefully handled that, too (spoiler alert, the positive test was actually for a harmless strain of *E. coli,* not the one that can cause illness).

In that BrightFarms story, you also can read how CEO Paul Lightfoot was able to marry his passion (healthy eating in a sustainable way that employs people with a living wage) with a commercial enterprise that's on track for great expansion in the coming years. It's the ultimate story of seeing and seizing an opportunity, with a little help from enthusiastic investors.

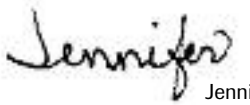
On a different front, just days after California's enormous recreational industry became legit, U.S. Attorney General Jeff Sessions rescinded Obama-era memos allowing leniency for states that chose to legalize recreational marijuana, instead reaffirming prior enforcement efforts. What does it mean? That's still yet to be determined, but it's one more barrier that has to be negotiated.

That said, we see the increasing interest among growers in the U.S. and Canada relating to medicinal and recreational marijuana (also called cannabis, pot, ganja, weed, insert a million other nicknames here). That's why we've tapped Dr. Brian Corr, a greenhouse consultant with decades of experience to write a cannabis-related story for us in each *Inside Grower*, plus an every-other-month column in *GrowerTalks* (see his first one in the January issue). He's been advising cannabis operations for three years and understands the business, as well as the hort of it all. You can read his first article on page 30.

In some cases, a barrier can result in a long-term opportunity. Take for example the question of sustainable peat and management of peat bogs around the globe. Some were being depleted too quickly, but North American industry groups recognized the issue and created guidelines for managing peat properly. You can read about that opportunity on page 20.

And sometimes crops become an opportunity, like greenhouse strawberries. But the barrier is in getting them to produce when people want them (i.e., right now). Freelance technical writer Dave Kuack tackles that topic for us on page 16.

Here's wishing you the ability to see your opportunities in 2018 and remove any barriers that stand in the way of your success.



Jennifer Polanz
MANAGING EDITOR-AT-LARGE
feedback: jpolanz@ballpublishing.com

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A Friend Remembered
G. Victor Ball, Editor from 1949–1997

GrowerTalks general offices are located at:
PO BOX 1660, West Chicago, Illinois 60186 U.S.A.
PH: 630.231.3675 **FAX:** 630.231.5254
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DEPARTMENTS

ON THE COVER

BrightFarms, LLC, has three hydroponic greenhouse locations, including a fourth in the works. This photo was taken at the Rochelle, Illinois, facility. We spoke to CEO Paul Lightfoot to talk about their customers, employees and what "local" means. Photo by Jennifer Zurko.

FEATURES

New Operations in the Works

It's been a challenge keeping up with the announcements of all the new facilities cropping up across the United States. Between greenhouse veg and herb operations, and indoor vertical farms, they're being announced almost weekly. Here are a couple we've caught wind of recently:

- Prairie Produce Farm LLC, a sister company of Del Fresco Produce and Sunrite Greenhouse in Canada, is planning a $30 million, 35-acre hydroponic facility in Pleasant Prairie, Wisconsin, according to local news reports. The first phase will be 15.3 acres and is expected to be completed sometime in 2018. It will provide tomatoes, peppers, cucumbers and strawberries to local grocers and distribution centers.
- Gotham Greens is looking to build a $12.2 million, 95,000-sq. ft. greenhouse in Providence, Rhode Island, on a vacant lot that once housed a GE light bulb factory, according to the *Providence Journal*. To sweeten the deal, the Rhode Island Commerce Corporation approved $2.2 million in tax credits to encourage the development.
- Ceres Greens announced plans to open Vermont's first vertical indoor farm in Barre, Vermont, according to *Vermont Business Magazine*. The 12,500-sq. ft. space is set to open in January 2018 and grow leafy greens and herbs for the local market. One of the founders, Jacob Isham, is a disabled veteran who took part in the Veterans to Farmers program in Colorado and hopes to employ and train veterans at the Barre facility.
- BrightFarms is building a 160,000-sq. ft. greenhouse facility in Wilmington, Ohio (near Cincinnati and Dayton), to grow leafy greens and herbs. That should open in the early summer of 2018, and I talked with CEO Paul Lightfoot recently about that addition and the BrightFarms operation as a whole. (Read more about BrightFarms on page 10.)

New LED Series for Vertical Farms

Fluence Bioengineering, Inc. recently launched three new horticulture lighting solutions for large vertical farms. The new Fluence RAZR Series is built for a wide range of applications, from full-cycle cultivation of leafy greens and microgreens to young plant propagation of vegetable, ornamental and cannabis crops.

"The new Fluence RAZR solutions are purpose-built to address the unique challenges and opportunities associated with vertical farming," says Randy Johnson, co-founder and CTO at Fluence. "Every design consideration that went into the new RAZR Series, from the thin form-factor to modular daisy-chain configuration, is predicated on increasing our vertical farming customers' outputs while reducing their inputs."

The three options are:

- **RAZR4 Array** (pictured)—Ideal for full-cycle leafy green, basil, strawberry and culinary herb production, as well as early-stage vegetative growth for vegetables, ornamentals and cannabis cultivation.
- **RAZR3 Array**—Ideal for full-cycle leafy green and microgreen production, along with propagation of vegetable, ornamental and cannabis crops.
- **RAZR2 Array**—Ideal for tissue culture, seedlings and cutting/cloning propagation, along with ornamental plugs and starter pots.

Each system is designed and built in Austin, Texas. Find out more about each system at https://fluence.science/technology/razr.

New NFT System Available in U.S.

The Finnish company Green Automation has brought its well-developed, fully automated hydroponic NFT system to the United States. The system was developed more than 10 years ago in Helsinki, Finland, and now Green Automation systems are running in Massachusetts, New Hampshire, New York and Illinois. The operations vary in size from 1 to 3 acres, and can produce more than 1 ton of lettuce per acre per day.

"With feet on the ground now here in the U.S., where more than ever the end customer seeks nutritious, locally produced fresh food, the timing is perfect. Consumers are more exacting about consuming food that is produced naturally, without pesticides and on a year-round basis," says Tero Rapila, co-founder and CEO of Green Automation Export. "Our fully automated and inclusive seed-to-harvest system not only uses 95% less water than traditional field farming, but can achieve tremendous product yield for a fraction of the labor costs."

Tero says the system addresses field harvest issues like labor, water-shortages and efficiency. For more, visit http://greenautomation.com/us.

Whitefly Biocontrol Options

Need help with whiteflies? The ATTRA may have some beneficial information about biocontrols. The ATTRA is a sustainable agriculture program developed by the National Center for Appropriate Technology (NCAT). It recently released a tip sheet on eliminating whiteflies through botanical pesticides. Check it out and see if it could help in your operation by visiting attra.ncat.org. The download is free.

A "Smart" Greenhouse

A new solar greenhouse at UC Santa Cruz has successfully produced its first crops of tomatoes and cucumbers that were just as healthy as those raised in a conventional greenhouse, according to researchers at the university.

"We have demonstrated that 'smart greenhouses' can capture solar energy for electricity without reducing plant growth, which is pretty exciting," says Michael Loik, professor of environmental studies at UC Santa Cruz, in a release issued by the university.

The greenhouse is a pretty unique-looking facility and uses Wavelength-Selective Photovoltaic Systems (WSPVs) rather than the traditional photovoltaic systems. Researchers say it generates electricity more efficiently and at less cost than the traditional systems.

According to the university, it works like this: "These greenhouses are outfitted with transparent roof panels embedded with a bright magenta luminescent dye that absorbs light and transfers energy to narrow photovoltaic strips, where electricity is produced."

While the WSPV system does absorb some of the blue and green wavelengths of light, researchers say, it lets the rest through, which allows the plants to grow. Based on the research conducted, about 80% of the plants (20 varieties of tomatoes, cucumbers, lemons, limes, peppers, strawberries and basil) were not affected at all and the other 20% grew better. They also noticed a small water savings with the "smart" greenhouse.

More "Smart" Tech

Sometimes you wish your plants could talk to you and tell you if something ails them. A new technology from a Brazilian company comes close to that by allowing a grower to scan a plant's leaf with a scanner and within seconds evaluate the plant's macro and micronutrients in search of deficiencies.

"The solution, called SMART, involves a portable Near Infrared (NIR) scanner and a mobile app," according to the press release. "SMART is neither a chemical wet lab nor is it intended to replace one. It is an alert tool that allows prompt identification of the nutritional status of a plant, to quickly identify potential deficiencies well before symptoms arise."

Hydro and Aquaponics In, Aeroponics Out

In early November, the National Organics Standards Board narrowly ruled to continue to allow the organic label for farms growing products using the hydroponic and aquaponics methods. The board voted 8-7 against banning those two methods, while they approved banning aeroponics from organic labeling.

The issue has been a contentious one and we've received several passionate emails and comments arguing both sides. We'll continue to watch and report as the NOSB talks about labeling requirements for these growers. In the meantime, traditional organic farmers are threatening to leave the USDA program over the vote.

In a story by *Business Insider*, a Vermont organic tomato farmer told them: "The National Organic Program has failed at the very thing it was created to do: creating trust and transparency between organic farmers and eaters. After a publicized series of failures in defending organic integrity, the Organic Program's Advisory Board decision to embrace hydroponic production as the 'new organic' is the final straw."

On the other side, hydroponic supporters, like the Recirculating Farms Coalition, are calling this vote a victory for the advance of technology and sustainability.

"By siding with current science and recognizing that existing law purposely leaves the door open for various farming methods, the NOSB is sending a critical message that sustainability and innovation are valuable in U.S. agriculture," says Executive Director of Recirculating Farms Coalition Marianne Cufone in a statement on the organization's website. "These goals are at the center of the nationwide local food movement and spur growth of urban and rural farms alike by a wide range of people. Inclusiveness is important in our food system."

Teeny Tiny Tomatoes

At the PMA Fresh Summit, NatureFresh Farms announced they reached a deal with a seed company to sell the tiny snacking tomato Tomberry in the U.S., Canada and Mexico. Eminent Seeds NL has created what NatureFresh calls, "The World's Smallest Tomato," at 0.5 to 1 cm in diameter with an average fruit weight of 1 to 2 grams.

"The Tomberry is unique in size and has caught the interest of our retail partners," says Matt Quiring, executive retail sales manager for NatureFresh. "The snacking trend in North America has exploded and we continue to search for new items that will help grow our snacking category. This pearl-sized fruit's unique size is something hard to miss and even more difficult to pass by without picking up.

"Once a consumer tries them, we are confident that they will be coming back for more. Visually, it is candy to the eyes. From a sensory standpoint, we can back that up."

Tomberry will be grown in the Leamington, Ontario, greenhouse starting in spring 2018, and launched with its own packaging and branding.

The Importance of Biotype

Whiteflies can be a frustrating pest to get rid of and American-Hort's research arm, Horticulture Research Institute (HRI), recently released some information that could help growers of all types figure out how to better combat whiteflies.

The document, called "Whitefly: What's Your (Bio) Type?" references poinsettias, but it's helpful information for leafy green, herb and veggie growers, as well. It homes in on one particular whitefly: Sweet Potato whitefly, or *Bemisia tabaci,* and the two types that growers are seeing, B and Q.

"Biotype B can be controlled using regular methods and even some biologicals. Fortunately, B is the most common biotype in the U.S. Biotype Q, on the other hand, is resistant to many classes of insecticides, such as some insect growth regulators, pyrethroids and some neonicotinoids," the document states.

That's why it's important to know your type because some combinations of insecticides encourage a shift from a mix of B and Q to only Q, which is harder to eradicate, says Dr. Lance Osborne, a researcher from the University of Florida who studied the efficacy of insecticide rotations along with Dr. Cindy McKenzie of USDA-ARS. "That being said, the populations are still manageable with the tools we have," he adds.

Read the full document by visiting http://americanhort.org/HRI/Research, which includes new pesticides to help combat Biotype Q. However, please double-check the ability to use them on edible crops before proceeding. Also, find out more information about Lance's and Cindy's studies here: http://mrec.ifas.ufl.edu/lso/bemisia/bemisia.htm.

Does CEA Growing Make Sense?

That's a very simplistic take, but the basic question that Neil Mattson, associate professor of Horticulture at Cornell University's School of Integrative Plant Science hopes to answer with a new three-year project.

Neil has written multiple times for us in this supplement and we reached out to him upon hearing the news that Cornell was awarded a $2.4 million grant from the National Science Foundation to study multiple aspects of controlled environment agriculture. All told, there are six projects included in the grant funding. Neil says some initial results will be available about a year after the project begins.

"There are several aspects of this grant, which will result in information helpful to CEA growers," he explains. "Even though we focus on CEA in metropolitan areas as our research topic, there will be excellent implications for all CEA growers. Some examples: 1) A 'food systems' analysis of how select metropolitan areas are currently sourcing produce items (where it is coming from geographically) and what market/distribution channels are being used; 2) A greater understanding of the water and energy footprint (how much water and energy) different types of CEA operations use; 3) More work (in collaboration with my colleagues at Rensselaer Polytechnic Institute) on how CO2 enrichment affects plant nutrient density and how lighting strategies can be used to increase plant nutrient density in leafy greens, and we'll be comparing these to field-grown crops as well; 4) We'll be surveying current CEA practitioners to learn about the different job skills they are looking for in employees and gaining a greater understanding of how employees are currently being trained and is this sufficient to their needs, as well as developing online curriculum to fill in some identified gaps."

In essence, the studies will help researchers to troubleshoot any specific issues that CEA growing presents and then come up with solutions for those to make it more effective.

"At this point we're not sure how 'scalable' different types of CEA (greenhouses, plant factories, vertical farms [i.e., sky scraper farms]) are based on their economics, as well as their energy and water use—is it realistic that a city could produce a large share of their fresh vegetables within their own boundaries? And if so, is it environmentally responsible?" Neil notes. "By understanding the pinch points, we hope to guide development of strategies to overcome these problems when possible or help inform sustainable/realistic urban CEA."

We'll stay in touch with Neil as the studies progress to provide updates as they're available.

New Bactericide & Fungicide for Cannabis Growers

Procidic2 from Greenspire Global Inc. is a bactericide and fungicide specifically developed for cannabis and hemp grown indoors or in open fields, and will be distributed by Helena Chemical Co.

"Procidic2's ingredients allow crops to grow the healthy, natural way," says Steve Knauss, President of Greenspire Global. "What sets Procidic2 apart is its formula; there are no added stressors to crops."

It can be used for management of various diseases, including powdery mildew, bud rot and root rot. According to a release from Greenspire, the product works systemically and on contact, as it's rapidly absorbed into the plant and moves toward the apex, allowing new tissues to be free of infection and reducing the risk of future growth of bacteria and fungi. They recommend using it as a preventative or at the first sign of disease.

It's available in 1-gal. containers and can be applied via regularly scheduled spray programs or in tank mixes with no REI. Procidic2 has even been approved under the Washington State Department of Agriculture organic food program for use in organic production.

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A "Bright" Future

Greens hydroponic grower BrightFarms has an ambitious mission to provide local, healthy (and tasty) offerings to customers while providing a living wage for its employees.

Story by **JENNIFER POLANZ**,
photos by **JENNIFER ZURKO**

BrightFarms Head Grower Nick Chaney of the Rochelle, Illinois, greenhouse shows how leafy greens and herbs are started in a styrofoam raft system.

The milestones for BrightFarms LLC, a New York City-based hydroponic grower, are coming fast and furious for a company that only raised its first round of financing in 2011. Those milestones include three established greenhouses in Bucks County, Pennsylvania; Culpepper County, Virginia; and Rochelle, Illinois; and plans for a fourth to open sometime mid-year in Wilmington, Ohio (greater Cincinnati area).

The success of those operations in providing pesticide-free leafy greens and herbs to local grocers (we'll talk more about local in a bit) have driven talks for a fast expansion plan. How fast? How about 15 more greenhouses in three years across a good chunk of the United States, according to BrightFarms founder and CEO Paul Lightfoot.

"My official answer is not fast enough," Paul semi-jokes about the expansion plans, adding they brought on Erik Lallum, vice president of construction, to oversee the rapid development. "There is so much demand for a local salad program in supermarkets right now, there simply aren't commercial-scale local salad programs. All the major salad producers are structurally not local in almost all the country, and most of the existing local farms are not really salad suppliers to supermarkets and they can't easily be."

Therefore, there's a niche to fill in grocery stores all over the country to supply the nutritious leafy greens and herbs that customers crave, and Paul wants his greenhouses to be nearby to fill it, not 250 miles, 500 miles or even 1,000 miles away.

What IS local?

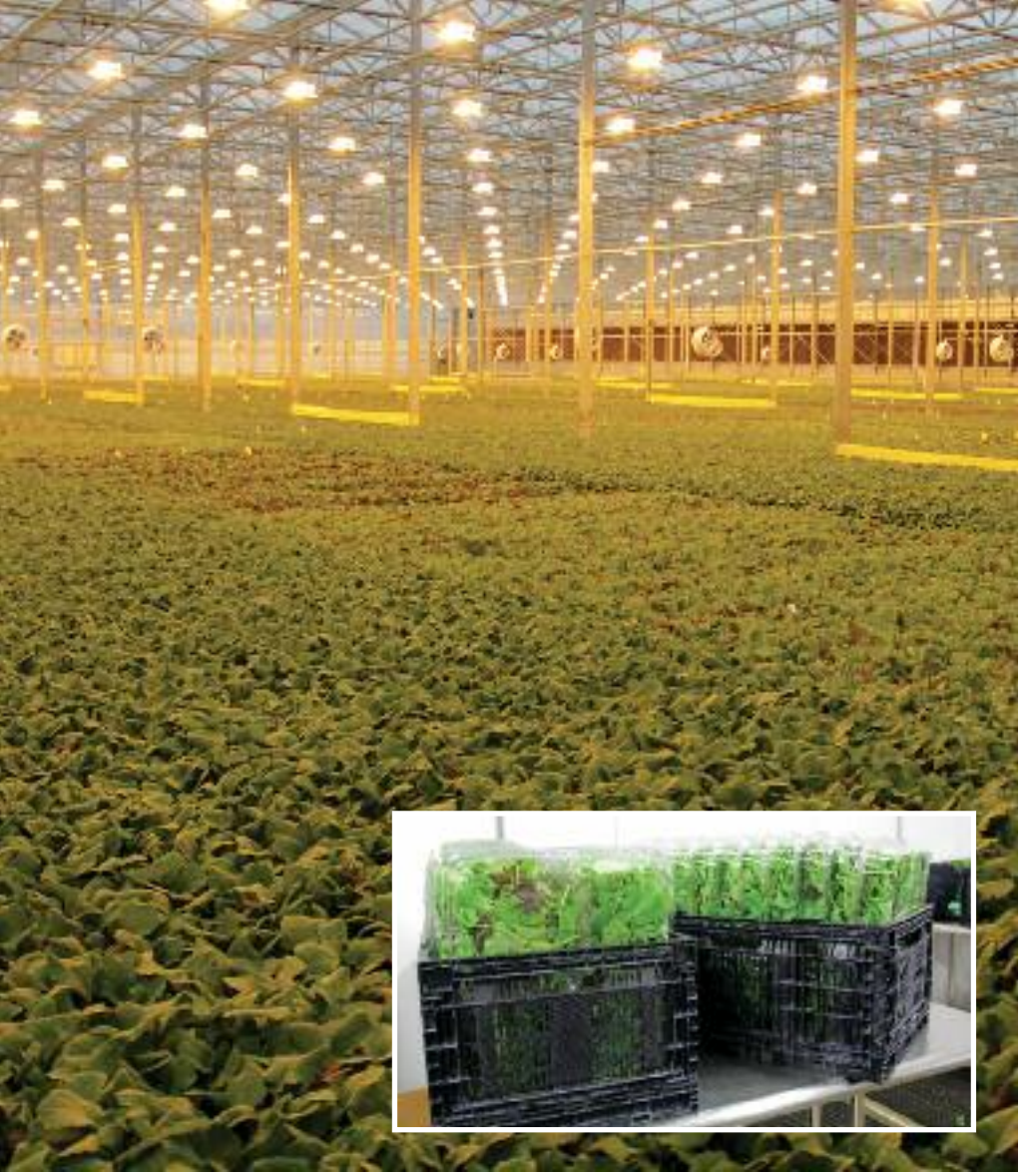
That's one of the questions that keeps Paul and his team up at night. Paul's background is in the food supply chain, and his personal passion is eating in a way that's healthy *and* good for the environment, which aren't always congruous.

"I came up with this insight that maybe you could do partnerships with supermarkets in a way that could create a network of commercial-scale greenhouse farms to bring local produce to consumers."

The first greenhouse, a 56,000-sq. ft. facility in Bucks County, Pennsylvania, received financing in 2011 and was built by 2013, seeing profitability by summer of 2014. That stability helped attract partnerships with Giant Food to serve the Washington, D.C. metro area.

Since then, BrightFarms has established relationships with food retailers like Albertson's (which has a presence under multiple brands in 35 U.S. states), Walmart, Ahold (which owns multiple brands, including Peapod, a delivery service) and Kroger (again, owner of multiple brands). Those four account for 60% of the grocery stores in the U.S. and BrightFarms also partners with larger regional players like Mariano's in the Chicagoland area.

But Paul didn't want the leafy greens to travel far to get to retail, so the plan is to have greenhouses strategically located to serve their markets. That's why the greenhouse that serves lower Wisconsin and the Chicagoland area is located in



The plants are grown under HPS supplemental lighting. The crop rotation times range from 23 days for basil to just 11 days for kale in the summer. ■ Inset: Here, clamshells of the kale mix are waiting for final packing. BrightFarms CEO Paul Lightfoot says he would like to explore different means for packing the leafy greens beyond the clamshell.

Forward Progress

Hydroponic growing is a specific subset of horticulture, and it takes a skilled grower to deftly navigate multiple crops and react to day-to-day challenges. BrightFarms CEO Paul Lightfoot is keenly aware of what it takes to make his greenhouses successful.

"Generally, we end up moving a grower into the market," he says. "We just can't count on the market to produce enough of what we need, so we're just starting to hire tons of people early in their careers and we're making them apprentices and assistants in our existing greenhouses."

That way, the apprentices—who many times are hired right out of college or within a couple of years after—receive upwards of 12 to 18 months of experience on the ground. For example, Rochelle, Illinois, greenhouse Head Grower Nick Chaney spent two years there and will be moving in March to head up the new Wilmington, Ohio, facility (Nick's originally from Ohio, so it works out nicely). At that time, the next assistant in line will move up at the Rochelle location.

The other part of the people equation is a labor shortage agriculture-wide. Paul's solution (and one of the company's founding missions) is to pay all employees a living wage and provide health care coverage.

"We think in many ways that's not at the leadership level, that's at the crop level, and since we're an organization that's mission-driven and has a social purpose, one of our tenets of our culture is we pay everybody a living wage from the first hour of their first day," he explains. "We're always paying more than the other ag jobs. So not only are we getting better people and better productivity, but we're not subject to that same shortage."

Rochelle. Think of its market as a wide megaphone, with the greenhouse as the mouthpiece.

Still, the conundrum is how far is too far? What constitutes local? "We have to be honest and say it's what people believe. It's authentic for consumers so we don't really know yet," Paul says. "We know that it's different in the Northeast compared to the Midwest; we know that it's different sometimes from market to market, so when we grow we're asking and learning. We don't have a hard-and-fast rule."

The power of listening

As the definition of local changes, so does some of the product mix offered. There's a stable of base SKUs company-wide: baby kale, spinach, arugula and spring mix, but every greenhouse talks to their partners to answer the demand for their consumers.

Case in point: the Rochelle greenhouse, currently under the direction of Head Grower Nick Chaney. This 160,000-sq. ft. greenhouse located smack in the middle of farm fields is filled with spinach, lettuce and kale mixes, and basil. We recently visited the greenhouse to get the lowdown from Nick on how the greenhouse operates and what his relationships are like with his retail partners.

One of his high-end regional retailers, Mariano's, asked BrightFarms for more basil varieties because their customers were loving it. Within weeks, Nick had seeded multiple trials for Mariano's people to trial. Within a few more weeks, new varieties of basil were on the shelves. "That fast feedback loop is almost unheard of," Paul says.

Another example is how the "Sunny Crunch" was born. It's a green leaf/iceberg hybrid that has the crunch of iceberg with the nutritional value of green leaf. "They asked us for innovation, and we came together and brainstormed," Nick says of the process.

He continues to look for ways to fill niches for his customers, like the possibility of growing microgreens for pea shoot and wheat grass smoothies. The greenhouse has already differentiated itself with offerings like a custom blend of kale that includes Siberian, Lacinato, Red and Russian kale.

"We're the only ones that have the kale blend, different types of basil and different lettuce blends," Nick adds. ▶

In the greenhouse

Part of the success of BrightFarms may be attributed to the automation used to reduce the amount of touches for employees, of which there are 35 at the Rochelle location, including drivers. Plants are seeded by machines, and once the proprietary reusable foam hydroponic raft splashes down into the water, an employee monitors, but doesn't touch anything until it comes out of the greenhouse on a conveyor belt heading for harvesting (and only then to pivot the raft onto another conveyor). Harvesting is all done by machine, as well. A Priva environmental control system regulates the curtains, vents, fans and boiler.

When it comes to the growing process, all BrightFarms greenhouses follow an IPM program that doesn't involve pesticides. It's part of the company's mission and it's on all the packaging—which can make the job of grower a little trickier than in a traditional greenhouse. In fact, it's why the foray into tomatoes didn't quite work out. It's also why growing healthy, sturdy plants from the beginning is so important.

"We feel very strongly about the plant above the raft, but also below the raft," Nick says of the root systems and the healthy ecosystem that's needed in the water. "I've been researching organisms to go into the water to consume Pythium that will be tolerant of what's added to the pond," he adds, noting Pythium is his main battle when it comes to his spinach crop.

The importance of cleanliness

It's clear upon entering the Rochelle facility that food safety is of the utmost importance and is taken very seriously. Before we could tour the greenhouse, we had to don hairnets (men with longer beards also wear beard nets) and wash our hands thoroughly. We stepped through the first door into a footbath and there were several more stationed throughout the greenhouse. Workers wear arm sleeves and aprons, as well.

The vast majority of the harvesting and cooling process is automated, as well as packing for some of the SKUs so employees only minimally handle the produce before it gets loaded onto trucks and shipped out within 24 hours of leaving the raft. Consequently, that process allows BrightFarms to have product on the shelf that's about a week fresher than the traditional salad offerings from California farms that go through processing facilities and long-haul trucking.

BrightFarms recently had a recall at the Rochelle facility, but in talking with Nick further about it, the removal of assorted leafy greens from the shelves was more out of an abundance of caution. Initially testing showed *E. coli*, but not a specific strain. The recall was ordered and then later it was determined to be a different strain that would not result in illness (not the 0157:H7 strain). He adds they're in the process of going through a Safe Quality Food Institute certification to assure a rigorous food management system.

"Every day we scrub things down and test to make sure," Nick says. "It's as crucial for the health of our customers and of our plants."

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Transitioning to the Big Leagues

A cannabis company uses Lean Flow to move from warehouse to greenhouse for more productivity and bigger yields.

by **MIKE HENDERSON & DAN GRACE**

Dark Heart Nursery is California's largest and most well-respected provider of young cannabis plants—or clones, as they're called in the cannabis industry. For the last 10 years, they've been serving the medical cannabis industry by providing premium quality plants to growers throughout the state.

Dark Heart currently operates out of a high-tech, 20,000-sq. ft. indoor production facility in Oakland and that facility isn't nearly able to keep up with customer demand, especially during the spring season. As such, they're working to develop a new modern greenhouse facility in which to grow their business.

At the same time, California's cannabis industry is going through monumental change. Beginning in 2018, the state is implementing new regulations and opening the market for recreational cannabis sales. They expect those changes will lead to increased opportunities *and* stronger competition in their part of the industry. Ultimately, they believe this will lead to lower prices and increased pressure to improve efficiency.

In preparation for these changing dynamics, Dark Heart has begun to increase their focus on improving operational efficiency. It was for that reason they started working with FlowVision to improve existing workflows and design production systems for their new greenhouse facility. Lean Flow techniques have been successfully implemented across all industries, and especially in the Green Industry. FlowVision has helped hundreds of growers become more profitable and they're now beginning to help cannabis cultivators do the same.

Taking the first step

In 2016, FlowVision was contacted by Dan Grace, President and CEO of Dark Heart. Dan wanted to begin implementing Lean Flow in his current warehouse facility, knowing that eventually he would build a greenhouse.

The first step was an eight-hour Lean Flow Training workshop that focused on Dark Heart's specific processes. During the workshop, the Dark Heart employees learned the Lean Flow tools used to design a very efficient nursery. They learned how to use the tools and applied them to their business. Those tools are in four main categories: Data Collection, Calculations, Design and Implementation.

Here's how Dark Heart improved all of their processes in each of these categories:

Data collection

The process flow shows what process steps are used to take the product from beginning to end. Dark Heart collected processes flow for all production products. For example:

Prune ➔ Slice ➔ Stick ➔ Bridge ➔ Pull ➔ Ship

Work and grow times at each process were collected so they could be used to calculate the number of people and machines that would be required for current and future requirements. Annual demand for each product and growth was projected, so they could determine the space requirement throughout the year.

Calculations

- Takt time (the average time between the start of production of one unit and the start of production of the next unit) was calculated and is the key Lean Flow design driver. It determines the rate at which each process needs to produce to meet the customer demand in the available work time (without running overtime).
- Weighted standard time calculations look at every product that's utilized at a process and, based on demand and work time, identifies the weighted average.
- Resource requirements are calculated and identify the number of people, machines and storage space required to produce products for today and future volume.

Pruning …

Lean Flow helped Dark Heart Nursery improve productivity in their progressive sticking line with three steps of the process:

An example of the three calculations may look as follows:

- *Takt time*—If you need to stick 10,000 products per day to meet your customer demands and you work eight hours per day (28,800 seconds) you would need to stick one unit every 2.88 seconds (28,800 seconds ÷ 10,000 units).
- *Weighted standard time*—To keep this example easy, let's say all sticking took five seconds, regardless of what plant you were sticking.
- *Resource requirements*—If sticking is all manual work, the number of people we need in sticking is 1.74 people (5 second work time ÷ 2.88 second takt time).

In a Lean Flow facility, these calculations aren't just used for facility design at capacity. Lean Flow customers use them every day to determine the number of people, machines and space requirements throughout the season, which allows them to increase productivity by more than 30% by staffing processes appropriately.

Design

After the resources have been calculated, block diagrams are created to develop a non-scaled view of how material should flow through the factory using blocks to represent people and machine resources. The final facility design is much easier after you complete a block diagram because you now know what the best flow of material is without the biased view of equipment constraints.

Flexible employees are an important part of a Lean Flow facility. Whether you're setting up a progressive sticking line or improving your employee utilization by designing a shipping "supermarket," teaching employees multiple jobs will improve a nursery's efficiency. By using these Lean Flow tools, Dark Heart can use the above steps and lay out their new greenhouse to get the best flow and resource utilization.

After the design is in place, it's time to create the action plan to implement Lean Flow. Every task needs to have a responsible person and a completion date assigned to it. To keep the project on track there needs to be, at minimum, a weekly review of all tasks.

Implementation

Dark Heart wanted to test their newly learned skills in some pilot areas. They first set up a progressive trimming line for clones where three operators would pass a tray of plants down a line and each person would trim approximately one third of the tray. If one person got behind, the other people would share the work. If someone got ahead, they would do more. The goal was to work as a team and share the workload.

IPK stands for "In-Process Kanban," which is a communication signal that tells each employee when to build products at their workstation and when not to build. This way, they all work in tandem and the line is balanced.

In the past Dark Heart would have one person trim the entire tray. The productivity improvement was shocking—50% increase in productivity (one third more output with the same number of people).

The second progressive line that was tested was for the Prune → Slice → Stick processes. This progressive line yielded a 26% improvement in productivity, plus higher yield since sticking is done seconds after the pruning takes place. The payback for the workshop and consulting was less than three months.

Dan said, "We have found FlowVision's approach effective in part because it focuses on highly practical solutions. Most of their recommendations focus on simple changes in workflow and rudimentary equipment. Their focus is on optimizing the people, equipment and facilities that you already have."

MIKE HENDERSON is Founding Partner and Owner of FlowVision and **DAN GRACE** is president and CEO of Dark Heart Nursery in Oakland, California.

… slicing …

… and progressive sticking.

The Berry Best

By combining June-bearing and everbearing varieties, growers can produce strawberries during periods of premium pricing.

by **DAVID KUACK**

Trying to decide which strawberry varieties to grow in a controlled environment production system can be a challenge for growers using field-bred varieties. Mark Kroggel, lecturer at Ohio State University, said growers can produce strawberries nearly year-round by combining greenhouse and field production.

JUNE-BEARING VARIETIES

Traditional strawberries grown for field production are referred to as June-bearing varieties and are short-day plants.

"These plants require certain photoperiods to begin flower initiation, just like poinsettias," Mark said. "The strawberry plants are transplanted into the field and develop vegetatively during late summer and early fall."

The critical photoperiod when flower initiation begins varies between varieties, he explained. Many of the short-day varieties start to initiate flowers when there are 12 to 13 hours of daylight. Flower initiation occurs within the plant crowns.

During the winter, the plants go dormant. In spring, the flowers, which have already initiated during the previous fall, open and bear fruit. In the early spring as additional growth occurs, the plants continue to initiate and produce flowers until that critical 12 to 13-hour photoperiod is exceeded as days get longer. Once the critical photoperiod is exceeded, the plants don't initiate any more flowers.

GREENHOUSE-GROWN SHORT-DAY VARIETIES

When short-day strawberry varieties are grown in a greenhouse, the winter dormancy period is eliminated.

"In the fall, instead of letting the plants go dormant, they can be kept actively growing in a greenhouse using temperature and nutrition," Mark said. "A June-bearing, short-day variety that's planted in August in the greenhouse is going to grow vegetatively until the fall when days are short enough to initiate flowers."

Flower initiation takes place over a period of about 30 days. It then takes about 30 days from flower initiation until flowers appear. And then it takes another 30 days from the time of flowering until fruit is produced. From the beginning of flower initiation, it takes 90 days before fruit is ready to harvest.

Using the natural photoperiod, a grower could plant strawberries in a greenhouse during late summer and early fall to produce a crop by Christmas. Starting in late September, the plants receive 12 hours of natural daylight, Mark said. It takes several weeks for the plants to initiate flowers. Then, in October, there's about four weeks of flower development. In November, from flower to fruit takes another four weeks. In December, the fruit ripens.

In trials at the University of Arizona with June-bearing or short-day varieties, once days start to exceed 12 hours of daylight in April, the plants stop initiating flowers. June is the end of fruiting.

"We've found that six months of fruit production has been the optimal production limit for any strawberry variety in the greenhouse," Mark said. "Aside from short-day plants having a limited flowering season, the substrate usually starts to break down and the plants start to lose their vigor."

This applies to both short-day and everbearing varieties, said Mark. The fruit quality can also begin to suffer if the greenhouse can't be cooled adequately as summer approaches. If night temperatures aren't lower than 60F (15C), the fruit respires too much and fruit quality is reduced.

"I expect the typical crop life for winter production of greenhouse strawberries for most growers is going to be about six months of fruit production," he said.

FLOWER AND FRUIT INDUCTION

Because of the lack of commercially available, actively growing starter plants during the summer, Mark has produced his own tip runners in 38-cell plug trays or 2-in. tree bands. He said permission from patent holders is required to propagate protected varieties.

"We want to start growing the strawberries during the summer, but this is a time of year that there are usually no starter plants available from most commercial propagators," he said. "The very latest dormant runners are available is June. Consequently, we need to produce our own."

These strawberry plantlets are stuck in a substrate and placed on a mist bench until they're rooted in. Rooting and acclimation takes two to three weeks and the plants need several more weeks in the greenhouse to become established enough to transplant into a growing system. The plants are ready to be transplanted when they can be removed from the plug cells or pots with roots and substrate intact.

To produce fruit with short-day varieties during November, an artificial short-day treatment is necessary to initiate flowers when the natural daylength is longer than the flower-inducing daylength. Mark said the high-density propagation stage is the best time to do this. This short-day treatment consists of eight hours of daylight in the greenhouse and then the rooted, acclimated plants are moved into a dark cooler for 16 hours at 60F (15C). This is the optimum temperature for flower induction.

"The plants are moved back and forth on carts between the cooler and the greenhouse," Mark said. "It is labor intensive, but large numbers of plants can be moved relatively easily because ▶

Counter-clockwise from above ■ The typical crop life for winter production of greenhouse strawberries for most growers is going to be about six months of fruit production. ■ Research conducted at the University of Arizona found that six months of fruit production has been the optimal greenhouse production limit for any strawberry variety. ■ Because dormant strawberry runners aren't available from most commercial propagators after June, Mark Kroggel had to produce his own tip runners. Permission is required from patent holders to propagate protected varieties. ■ The cyclical production of strawberry flowers and fruit can be accommodated by staggering planting dates and using different varieties that have varying production schedules.

Photos courtesy of Mark Kroggel, Ohio State University

they are in a dense planting situation. They come out of the cooler at 8:00 a.m., receive eight hours of light in the greenhouse, and then at 4:00 p.m. they are moved back into the cooler."

Growers with rolling benches could potentially move the plants back and forth between a cooler and the greenhouses.

"For the short-day varieties we have grown in the greenhouse, it takes three to four weeks before flower initiation occurs using a short-day treatment," he said. "Once initiation of flower buds is confirmed under a microscope, the short-day treatment is no longer needed, as by that time natural short days are occurring."

Mark said the 24-hour average temperature for strawberries shouldn't exceed 77F (25C) during short-day treatments, as high temperatures can override the short-day treatment.

"If growers live in regions where the temperatures are cool enough to stay below the 77F daily average, they could probably pull black cloth to provide the required short-day conditions for flower initiation as an alternative to moving the plants into a dark cooler," he said. "As long as the plants are kept in that temperature range of 59 to 77F, pulling black cloth won't be a problem. Growers need to monitor the temperature under the cloth to be sure not to exceed the 77F 24-hour average."

GREENHOUSE-GROWN EVERBEARING VARIETIES

Mark said one of the issues with everbearing strawberry varieties is the terminology used to describe them.

"Everbearing varieties are often referred to as being day-neutral, but we don't know of many actual day-neutral everbearing strawberry plants," he said. "Everbearing varieties tend to be facultative long-day plants. They flower all the time, but if they're provided with a longer photoperiod, they produce more flowers."

Mark said one of the ways to keep everbearing varieties flowering during the short days of winter is to provide them with photoperiodic lighting.

"During the short days of winter, the everbearing varieties benefit from an extended photoperiod," he said. "The plants only need two to three micromoles, which is about 20 footcandles. We provide the plants with 12 to 14 hours of light using fluorescent or incandescent lights."

If short-day varieties are in the same growing space, care must be taken not to provide a photoperiod long enough to stop their flower initiation. A 12-hour photoperiod is usually safe for most short-day varieties and will help the short-day types stay active, as well as promote flowering in everbearing types.

TIMING STRAWBERRY PRODUCTION

For growers using dormant runners or propagating their own tip runners of everbearing varieties, flowers must be removed in order to allow the plants to become established before producing fruit.

"These varieties naturally produce flowers as soon as they can," Mark said.

For a period of four to six weeks after planting into the production system, the flowers should be removed to allow the runners to develop roots and leaves, he explained. The plants need to have a good initial vegetative establishment period so they have well-established roots and leaves in order to support the fruit. By removing these flowers, some of the fruit is lost, but this establishment period is necessary.

Strawberry plants produce their first flush of fruit about one month after the flowers appear (short-day varieties) or the flowers are left on the plants (everbearing varieties).

"At some point after the first flush, the everbearing variety plants tend to temporarily stop producing flowers," Mark said. "There will be anywhere from a six-week to a two-month period when no fruit is produced. That is a real issue with producing everbearing varieties. Then there is a massive second flush of flowers and fruit."

Mark said this cyclical production of flowers and fruit can be accommodated by staggering planting dates and using different varieties that have varying production schedules.

"Really high-yielding everbearing varieties have less cyclical production because they produce more crowns more often," he said. "Unfortunately, we haven't found a really high-yielding everbearing variety yet with really good flavor. The June-bearing or short-day varieties have a more linear production cycle and provide fruit during an everbearing low cycle."

Mark said that he recommends that growers producing greenhouse strawberries plant both June-bearing and everbearing varieties.

"With the short-day varieties, they begin flowering at some point either naturally or by being induced," he said. "Their weekly yields are fairly consistent and their cumulative yields are linear. The flower and fruit production of everbearing varieties tend to be cyclical over the season.

"But growers need to know how to manage both types. Being able to produce fruit during November, December and January is critical. This is the period when premium pricing occurs."

For more: Mark Kroggel, Ohio State University, Department of Horticulture and Crop Science, Columbus, Ohio; (614) 292-3767; kroggel.4@osu.edu. Information used in this article first appeared in Urban Ag News Issue 10 (http://urbanagnews.com/magazine/issue-10). For more information on greenhouse strawberry production, check out: Hydroponic Strawberry Information Website, http://cals.arizona.edu/strawberry; Sustainable Hydroponic and Soilless Strawberry Production Systems, www.youtube.com/user/sustainablehydro.

DAVID KUACK is a freelance technical writer in Fort Worth, Texas. He can be reached at dkuack@gmail.com.

For Peat's Sake

The case for Responsibly Managed Peatlands certification.

by **LESLEY SYKES**

Peatlands around the world—from the Indonesian archipelago to remote reaches of the boreal north and the far southern hemisphere—have long been recognized as the source of valuable resources supporting commercial needs ranging from energy generation to agricultural applications.

Simultaneously, peatlands perform vital eco-services, supporting a wide range of biodiversity, sequestering a large percentage of the Earth's terrestrial carbon, and serving as a natural source of fresh drinking water. And culturally, peatlands have served as invaluable repositories of archeological information, helping us piece together the mysteries of the past.

In pursuit of a sustainable development path, it's not surprising, therefore, that the use of peatland resources has come under scrutiny. In response to increasing degradation of peatlands, international agreements—starting with the Ramsar Convention on Wetlands in 1971—have helped build consensus around the need for peatland restoration and responsible management. Even so, to some, the idea of sustainability and the extraction of peat for commercial purposes may seem like a paradox.

Having worked with both the energy sectors and the peat moss industry as a third-party certifier, our certification teams at SCS Global Services recognize that *not all peatland management systems have been created equal.* As manager of SCS's Responsibly Managed Peatlands certification program for horticultural peat moss, I've taken a deep dive to understand what it means to manage these types of peatlands in a responsible manner. I wanted to take a moment here to share what I've learned and discuss the importance of undertaking best management practices.

Peatland uses and abuses

Peat is a thick, muddy surface layer of organic matter consisting of decomposing vegetation such as mosses, shrubs and trees. In some areas, peat deposits have been accumulating for thousands of years.

Peatlands can vary greatly in character and composition. In northern latitudes, Sphagnum mosses are one of the primary components of peat, giving it unique properties for the horticultural sector. In total, peatlands occur on every continent and cover an estimated 3% of the Earth's surface.

Peat has been used as a cooking and heating fuel for thousands of years. Beyond energy, people have found many other uses for peat over the centuries, ranging from non-refrigerated food storage to tanning hides, mud baths and agricultural moisture retention.

In Europe, the population explosion of the 20th century, combined with the growing demand for electric power, led to large-scale peat extraction to fuel power plants. Peatlands were also drained to make room for agriculture, forestry and urban development. For example, Finland, home to nearly one-third of Europe's peatlands, carried out the world's most extensive program of drainage for forestry—approximately 300,000 hectares annually during its peak in the 1970s.

Extraction of peat at rates far faster than it can accumulate has led to significant damage and controversy. Today, peat is considered neither a renewable fuel source nor a fossil fuel, but something in between. In 2006, the International Panel on Climate Change (IPCC) reclassified peat as a "slowly renewable fuel" in order to highlight its differences. While the use of peat for power generation has declined significantly in Europe, some countries still rely on peat as a relatively inexpensive heating source.

Peatlands in Southeast Asia have also been in the international spotlight due to a complex set of issues involving private industry, governments, smallholders and environmental groups. In Indonesia, for example, vast peatlands have been deforested and drained for palm oil plantations. These drier conditions have led to fires that destroy ecosystems and smolder for months. Peat fires have contributed to Indonesia's status as one of the world's top polluters. In 2016, Indonesia's president set up the Peatland Restoration Agency in an effort to restore and re-wet degraded areas.

In addition to these challenges, there's growing recognition that peatland degradation is contributing measurably to climate change. Peatland use typically involves lowering the water table through drainage. The resulting decomposition of stored organic matter has resulted in greenhouse gas (GHG) emissions. Appropriate water management is imperative for reducing GHG impacts.

On the other hand, one of the most cost-effective means of carbon sequestration is investment in peatland restoration. According to the International Peatland Society, "In terms of GHG management, the maintenance of large stores of carbon in undisturbed peatlands should be a priority." As a result, peat extraction is strictly controlled today and an international consensus has emerged in support of the protection, restoration and responsible management of peatlands.

The development of responsible management standards

In North America, peat wasn't a competitive fuel source as it was in Europe, given the availability of oil, coal, natural gas and hydroelectricity. However, the Sphagnum peat mosses that build up and become compacted in peatlands are prized for horticultural applications. Horticultural peat moss is attractive to home gardeners and the commercial horticulture industry alike due to its function as a soil conditioner. Among its many benefits, peat moss helps retain soil moisture, reduces compaction, functions as a sterile planting medium and an effective seed starter, supports soil aeration, adds substance to sandy soils, helps soils hold nutrients more effectively and increases absorbency.

The Canadian Sphagnum peat moss industry was specifically created to supply peat moss for horticultural uses. Canada has tremendous peat moss resources, estimated at over 113 million hectares. According to the Canadian Sphagnum Peat Moss Association (CSPMA), of this area, just 0.03% of this land area have been or is used for peat production—a tiny fraction of the quantity that's naturally generated in undisturbed bogs. The Canadian industry, along with universities and national and provincial governments, has been proactive in research related to science-based restoration techniques and responsible management practices.

In 2012, two of the leading industry groups, the CSPMA and the Québec Peat Moss Producers Association (APTHQ), partnered with SCS to develop the Responsibly Managed Peatland certification program. The voluntary program provides a streamlined set of management practices for operations in Canada and around the world. Through an annual third-party assessment, participating companies can demonstrate their commitment to responsibly managing peat resources and conforming to relevant national and international laws.

As with any certification program that works from a holistic assessment framework, environmental, social and economic aspects of peatland management are all considered. The program reinforces the eco-services provided by peatlands, including those related to biodiversity, hydrology and carbon sequestration. It includes specific criteria for the restoration and rehabilitation of peat bogs based on scientific research and site-specific characteristics.

The program also ensures social benefits to workers and local communities, and brings economic benefits by creating competitive advantages in the marketplace. Since its inception, the program has gained market share and has earned a reputation as the leading certification system to ensure best practice management standards for peatlands.

Earlier this year, SCS launched a public consultation process to collect input from stakeholders and update the standard. SCS collected, analyzed and incorporated feedback from a number of diverse parties, including academia, NGOs and private industry players. The new standard, scheduled for full implementation in 2018, can be found on SCS' Responsibly Managed Peatlands webpage: www.scsglobalservices.com. Interested parties can submit comments to SCS on an ongoing basis by completing the Stakeholder Review Form.

LESLEY SYKES is Manager of Sustainable Agriculture for SCS Global Services. To find out more about the Responsibly Managed Peatlands certification program, contact her at lsykes@scsglobalservices.com or call (510) 452-6823.

Top to bottom ■ Sphagnum sp., also known as "peat moss." Decayed Sphagnum moss is one of the main components of peat. ■ Decayed peat moss. This form of peat is called "blond peat moss" and is generally younger and more fibrous than darker peat. ■ Boardwalk on a peatland. ■ Harvested peatland.

Growers' Choice

Which system is the right one for your lettuce production?

by **ANNE BENNETT-CIAGLIA**

The implementation of a growing system for production of year-round and pesticide-free fresh lettuce has clearly been driven by increased population and consumer demand. The type of system an operator and/or investor will ultimately choose to meet this demand, however, depends on several factors, i.e., business objectives, available capital, operating costs and yields that will provide sustainability as well as profitability.

Prior to start-up of a greenhouse operation, or when expanding an already established one, is the time to decide what type of growing system to install and if an automated system is the best choice to enable you to reach overall objectives of your business plan.

Non-automatic hydroponic/Stationary NFT system.

Your options

There are three main hydroponic growing systems available today:

- **Non-automatic hydroponic/Stationary NFT**—Gutters are stationary and set to a certain distance from each other.
  Manual steps: Substrate filling, seeding, transplanting, adjusting of gutter distance, movement of gutters through greenhouse, harvesting and cleaning of gutters
  Growing area: Walkways are required to give access to the plants during the growing process. If using different gutter types for each phase in the growing cycle, the growing area can be utilized efficiently, but several rounds of transplanting will be needed.
  Crops: Lettuce, herbs

- **Fully automated hydroponic NFT**—Fully automated system. No transplanting required, as seeded directly into narrow gutters. No manual labor needed in the greenhouse.
  Manual steps: Every phase in the growing process is automated—substrate filling, seeding, movement through the greenhouse, transportation by conveyor belt to harvesting area, harvesting and cleaning of gutters.
  Growing area: No walkways needed. Gutters are moved automatically through the greenhouse. The distance between the gutters is adjusted automatically, giving the plant just as much space as it needs in each phase.
  Crops: Baby leaf lettuce

- **Floating rafts/Deep water culture**—Plants are placed in floating cassettes in a pool of nutrient solution. The roots are in constant contact with water.
  Manual steps: Substrate filling, seeding, transplanting harvesting and cleaning of trays is done manually.
  Growing area: Access points needed for transplanting, as plants are repeatedly transplanted into a different raft to adjust for the needed spacing. The plants are typically moved/pushed automatically from germination area in greenhouse to the harvesting area during the growing process, minimizing need for walkways.
  Crops: Lettuce, herbs or baby leaf lettuce

For your consideration

The answer to the question of *which* system to install depends on one key factor: efficiency. And the most important components to determining if efficiency can be achieved are yield and labor. Each of the three methods for lettuce production feature different yields per square foot, as well as the amount of labor that will be necessary to operate the greenhouse.

Yield (pounds of lettuce per square foot) in a greenhouse is expensive when compared to the growing area in an open field and, therefore, must yield more to make it profitable. In addition, the more advanced and costly the system, the higher yield is needed to achieve profitability. And the more expensive to build and operate a greenhouse (i.e., heating and cooling, depending on location), the more efficient the growing system needs to be.

If you're in a perfect environment for lettuce production (land is inexpensive, no heating needed and labor is readily available), an investor doesn't necessarily have to opt for the most advanced growing system. However, if the location is such that land is expensive and the climate requires significant energy for heating due to snow loads in winter and/or cooling in warmer months, as well as the possible need for hurricane-proof structures, the level of capital expenditure would require a more highly advanced, efficient growing system.

One good metric to consider when choosing a growing a system for your greenhouse is the percentage of actual growing area compared to the total greenhouse area (net grow area). Automated and floating raft systems typically require little or no space for walkways to access the plants during the growing cycle, which increases the net grow area. It's not only important how large the net grow area, but also how efficiently it's utilized, i.e., the spacing between the plants.

Most growing systems space the plant distance efficiently toward the end of the growing cycle. The space efficiency in the ▶

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early stages varies dramatically. Even after a small plant has been transplanted from a seedling tray to a growing gutter, it requires very little space compared to a mature plant, but the distance between plants is often set and based on the space needed for a fully-grown plant—leaving a lot of space unused during the initial growing phase.

To optimize the growing area, the principle must always be to give the plant as little space as possible, but as much as it needs for healthy growing. Subsequently, to achieve this, the space between the plants must be adjusted during the growing process. A fully automated growing system places the seedlings directly adjacent, and as the plants grow, the distance between the plants is automatically adjusted.

The second key component in the growing system decision-making process is labor. Labor, as mentioned above, has become a prohibitive factor for many growers. The required labor to operate a hydroponic system varies significantly. While some simple systems are operated completely manually, the most advanced systems don't require any interaction with the plants.

Yield potential and labor are connected in some systems. For example, in a non-automatic gutter system, the space efficiency (thus yield) could be increased significantly if workers could permanently adjust the gutter distances according to the constant growth in plant size. Yield per net growing area could come close to the yield of an automated system, but would require considerably more labor and a significant loss of space to enable manual access to the plants.

A fully automated hydroponic NFT system.

Additionally, transplanting is labor intense. Assume a non-automated system would have one transplanting stage from tray to channel and one addi-

tional transplanting stage to a larger channel as the plant size increases. When analyzing the total labor cost for any system, we propose to look at three types of labor:

- **Direct growing system**—The labor needed to operate the actual growing system. This typically takes place in the greenhouse (activities: transplanting, gutter/tray movement within the greenhouse, as well as to and from the greenhouse).
- **Plant processing and system processing labor**—Harvesting, cutting, cleaning of growing equipment (trays and gutters), medium filling and seeding.
- **Supervision and maintenance**—All activities not directly related to the growing operation system, such as maintenance, repairs, system management and supervision.

The labor needed for each category differs significantly, depending on the growing system used. Non-automated will require minimal maintenance of the growing system, but may need up to 10 workers per acre for medium filling, seeding, transplanting, cleaning and movement of gutters and trays.

The most advanced automated gutter system has automated all steps and requires no workers in the direct growing system and plant processing and system processing. The only labor needed is in supervision and grower expertise and maintenance.

Floating rafts/deep water culture system.

If you're considering switching systems or are just jumping into hydroponic growing, hopefully these guidelines will assist you in choosing the right growing system for your crops and operation.

ANNE BENNETT-CIAGLIA is a freelance writer for Green Automation Americas LLC, which is located in Wellington, Florida.

Using BCAs Right

Five common CEA pests and how to prevent them.

by **TAMI VAN GAAL**

Most growers producing edible and medicinal crops utilize biological control agents (BCAs) as part of their integrated pest management plans for a number of reasons. Top concerns include a desire to reduce chemical pesticide use, a lack of effective and allowed products for a specific crop, and a need to slow the development of resistance within a pest population. The BCA species used will depend on the target pests and the crop production methods.

Think of BCAs as a protective shield over the crop. This shield is most effective if it's in place before the pests are present. Therefore, the best plans will call for a focus on prevention over curative control, achieved by releasing BCAs at sowing, sticking or transplant, and continuing at regular intervals until the crop is harvested. Early prevention is especially important when there's no effective chemical control option available for a crop.

One of the biggest mistakes growers can make when utilizing BCAs is to delay the first release until the pest is present in the production space. Waiting becomes problematic for two reasons: First, delayed release risks establishment of the pest within the crop. Second, delivery of BCAs requires a little planning. With the exception of beneficial nematodes, BCAs can't be stored in advance of use and most BCAs need to be ordered by mid-week for delivery the following week. The risk is that if one waits until the pest is seen to order BCAs, it's possible that more than a week will pass before the BCAs are delivered. It's far better to order in advance for known crop cycles. Some growers place routine orders weeks or months in advance. Talk with your supplier to implement this practice for your operation.

Now that we understand the need to focus on prevention when using BCAs, we can discuss the best options for preventative use. BCAs generally aren't crop specific.

With a few exceptions, what works great in lettuce will also work great in tomatoes and cannabis crops. Remember that BCAs target insect and mite pests; these tiny warriors don't sting or bite the people working in the crop.

Sachets provide great protection in medicinal marijuana.

BCAs are living, breathing organisms, so it's important to care for them properly prior to and during release.

The table below details information regarding storage and release of some popular BCAs that will help to maintain health and viability. Always unpack your BCAs immediately upon arrival, verify viability and report concerns back to your supplier as soon as possible.

BCA Product	How to Check Viability	How to Store	How to Release
Aphidius colemani Blister packs	Select aphid mummies without exit holes from the blister pack. Place in a ventilated, clear container at 70F (21C) away from direct light. Assess emergence after seven days by observing mummies for exit holes or counting adults.	Store unopened blisters out of direct light at 43 to 46F (6 to 8C) and release within 18 hours of receipt.	Place opened blister packs in the crop canopy (shaded from the light source) and allow the adults to emerge naturally.
Aphidius ervi Bulk mummies	See viability notes for *A. colemani.*	Store unopened bottles out of direct light at 43 to 46F (6 to 8C) and release within 18 hours of receipt.	Open the bottle in the production space to allow emerged adults to move into the crop. Release late in the day or under reduced light levels in a shaded area. Replace the vented cap on the container and store the bottle at room temperature out direct light. Repeat the releases once per day until all adults have emerged.
Dalotia coriaria aka *Atheta coriaria* Bulk larvae and adults	Scatter a small sample from the container on white paper. Observe active movement in adults and larvae.	Store unopened containers in a dark location at 50 to 60F (10 to 15.5C). Release within 48 hours of receipt.	Release late in the day or under reduced light. Place small piles of 25 to 50 *Dalotia* with the carrier on the surface of the potting media, at various locations in the crop to achieve the desired release rate. Alternatively, make piles directly on the greenhouse floor or in pots of media under benches. For breeder boxes, request the GGSPro bulletin.
Hypoaspis miles Bulk mites	Scatter a small sample on white paper and observe mite movement under magnification.	Store at 50 to 60F (10 to 15.5C). Release within 24 hours of receipt.	Apply to growing media at end of day or under low light conditions.
Amblyseius andersoni, A. cucumeris, A. swirskii and *Neoseiulus californicus* Sachets	Option 1: Clip a sachet to a binder clip, set the flat side of the clip on a sticky card and watch for the mites to spread out on the sticky card. Option 2: Cut open the sachet, sprinkle contents on white paper and observe activity under a microscope.	Crack open the box of sachets to prevent buildup of CO_2 and heat. Store the opened box out of direct light under moderate humidity at temperatures of 50 to 60F (10 to 15.5C). for several days. Best if placed in crop within 18 hours of receipt.	For hook sachets, hang sachet in the crop canopy, out of direct light. For stick sachets, simply insert the stick into the media so the bottom of the sachet just barely touches the media.
Neoseiulus fallacis Bulk mites	See *H. miles.*	See *H. miles.*	Rotate container to mix carrier and mites uniformly, then sprinkle over crop foliage.

Aphids

Parasitoid wasps are the primary preventative tool for aphid control. A blend of two species of wasps, *Aphidius colemani* and *A. ervi*, is a perfect choice for prevention, providing protection against a wide variety of small and large aphid species.

Aphidius ships as parasitized aphids, called aphid mummies. The adults will emerge after shipping and are simply released into the crop. Release is particularly easy with *A. colemani* blister packs.

Aphidius are effective in both greenhouse and warehouse situations, and are most commonly used with lettuce, leafy greens, herbs, peppers, medicinal marijuana and pharmaceutical tobacco. Release rates start at five to 10 per 100 sq. ft.

Fungus gnats

Fungus gnats are problematic in both greenhouses and warehouses, impacting all crops. Prevention depends on the media used in production.

For universal prevention regardless of media used, turn to the predatory beetle *Dalotia coriaria* (formerly known as *Atheta coriaria*) and the predatory mite *Hypoaspis miles*. Both are released once, early in the crop, and will establish in the production space. *Dalotia* can be also be sustained in breeding boxes, long-lasting colonies that are easily supported. Release *Dalotia* at a rate of 25 to 50 per 100 sq. ft. and *Hypoaspis* at a rate of 1,000 to 3,000 per 100 sq. ft. ▶

Spider mites

Spider mites are the scourge of a number of CEA crops, including strawberries, cannabis, cucumbers, peppers and tomatoes. Prevention is worth its weight in gold and can be achieved with several species of predatory mites, including *Amblyseius andersoni, Neoseiulus californicus* (formerly *A. californicus*) and *N. fallacis*. Choose *andersoni* or *fallacis* for cooler conditions and *californicus* for warmer conditions. For tomato and cannabis, the best choice is *andersoni,* as it also provides protection against russet mites, which are extremely difficult to control once established in a crop.

The most efficient means of providing preventative control is to use controlled-release sachets, which are hung in the crop and replaced every four to six weeks (every four weeks in warehouse applications or on cannabis). *A. andersoni* and *californicus* are available in sachet form. Place sachets at 10 per 100 sq. ft. for most crops and a bit more densely (15 per 100 sq. ft.) for stronger protection in cannabis. *N. fallacis* is available only in bulk form, requiring weekly releases to maintain the protective shield. Release *fallacis* at a rate of 100 to 150 per 100 sq. ft.

Thrips

Thrips can attack all CEA crops, though they're less common on lettuces and leafy greens. Preventative control is best achieved with predatory mites, either *Amblyseius cucumeris* or *A. swirskii.*

A. swirskii are more aggressive feeders, but require higher temperatures, so their use is generally limited to summer months in greenhouses. There's one more limitation to consider for *swirskii:* The oils in tomato tissue make *swirskii* less effective.

Utilize sachets for efficient release for preventative programs. Stick sachets are especially nice for use in propagation and young plant stages. Use mini sachets on hooks or sticks at a rate of 20 per 100 sq. ft.

The tiny parasitoid *Aphidius* wasps keep aphids at bay.

***Dalotia coriaria* (formerly known as *Atheta coriaria*) are nocturnal, predatory beetles that feed on fungus gnat larvae.**

Whiteflies

Whiteflies are most problematic in solanaceous crops, including tomatoes and cucumbers. Unlike other pests, BCA control of whiteflies generally starts at first sign of the pest instead of on a preventative basis. Control relies on parasitoid wasps, including *Eretmocerus eremicus* and *Encarsia formosa*, and requires an active scouting program to assess pest and BCA populations at different leaf clusters on the crop.

Effective, preventative control of insect and mite pests can be achieved with BCAs in all CEA crops. Success simply requires a solid plan and a commitment to early release to build the protective shield. Contact your supplier to start a conversation around a personalized BCA plan for your operation.

TAMI VAN GAAL is CEA Division Leader for Griffin. She can be reached at tvangaal@griffinmail.com.

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Cannabis Crash Course

by **DR. BRIAN CORR**

This new article series will be featured in each issue of *Inside Grower* and will give an overview of cannabis production. Upcoming articles will include more information on genetics, environmental control, crop nutrition, pests and other topics.

How difficult can it be to grow a weed? Well, actually it can be pretty difficult when you must grow it under stringent regulations, monitor growth at all times with security cameras, have a plant-by-plant inventory system, grow a product safe for human consumption, have a predictable harvest, sell into a regulated market, maximize yield and make a profit. When you add to all this a very limited selection of plant protection products and limitations on access to banking and insurance, it's clear cannabis production isn't as easy as growing weeds.

CANNABIS, THE PLANT

Cannabis has been used by humans for about 10,000 years for fiber, food, oil, medicine and as a psychoactive drug. The plant is native to Asia and India, but was carried throughout the world as humans migrated from one place to another. Cannabis was grown for fiber in the earliest days of the United States by George Washington and Thomas Jefferson.

Cannabis grown for fiber, seed or oil is typically called hemp. Cannabis grown for medical or psychoactive purposes is usually called marijuana, although there's some blurring of these definitions. Both hemp and marijuana contain compounds called cannabinoids, but cannabis is usually only considered marijuana if the plant contains significant amounts of delta-9-tetrahydrocannabinol (THC), the compound most associated with a cannabis "high." Hemp, on the other hand, has little or no THC.

The cannabis plant is dioecious, which means male and female flowers are typically found on separate plants. This is of no major significance when grown for fiber, but when grown for medical or psychoactive uses, female plants are desired because the concentration of cannabinoids is much higher in female plants. Unless special procedures are followed, cannabis grown from seed will produce about half male plants and half female plants. The male plants would usually be culled out of marijuana production, which is labor intensive and wastes production space. This is one reason most marijuana is grown from vegetatively propagated plants, to ensure the plants in production are all female.

HOW IS MARIJUANA GROWN?

As is fitting for a plant that's been used by humans for 10,000 years, there are many different ways to grow cannabis. Cannabis for seed, oil and fiber (hemp) is grown in fields like any other seed, oil or fiber crop, except the U.S. federal government and many states have stringent restrictions on what can be grown.

Cannabis for medical or psychoactive use (marijuana) can also be grown in the field, and often is in temperate regions if allowed by local regulations (or grown illegally). However, most of the marijuana grown in the U.S. and Canada is grown in controlled environments.

When marijuana was (and sometimes still is) grown illegally, it must be hidden. This usually resulted in producers growing inside buildings using only artificial light. This method of production still is the leading method for state-legal marijuana production in the U.S. However, greenhouse production is rapidly increasing due to lower energy costs. I forecast greenhouse production will very soon exceed warehouse production.

Whether grown in a warehouse or a greenhouse, marijuana production can be separated into three phases: propagation, vegetative growth and flowering. The propagation and vegetative growth phases must be conducted under long days/short nights to prevent flowering. Flowering occurs under short days/long nights.

Vegetative propagation involves harvesting cuttings (often called clones) from mother stock plants and placing them in a high-humidity, long-day environment until roots develop. Once well-rooted, the plants are transplanted and grown under long days until large enough to begin flower initiation. The length of time under vegetative conditions impacts the final size of ▶

Photo: Nexus Corporation

Greenhouses used to grow cannabis often have metal sidewalls to block the view of the crop, blackout light for photoperiod control and for security.

Reader Service Number 211

the plants—all things being equal, a long vegetative period results in larger plants at harvest, while a shorter vegetative period results in smaller plants.

Initiation and development of flowers only occurs under short days. The critical photoperiod for cannabis varies by cultivar/strain, but is typically less than a 13-hour day/11-hour night. Most producers use a 12/12 photoperiod to ensure flowering.

Warehouse-grown cannabis doesn't need any special equipment to adjust the photoperiod. Lights are turned on for the appropriate length of time and turned off during the desired dark period. However, greenhouse-grown cannabis requires blackout equipment to shorten the day/lengthen the night for flowering during much of the year. Automated blackout cloth is pulled over the crop. Typically, the sidewalls of the greenhouse are opaque, often metal panels, which serve to block light and are often required by regulation for security purposes.

CHALLENGES TO GROWING MARIJUANA

Like any crop, there can be problems during production of cannabis. (Future articles in this space will address environmental requirements, disease and insect control, nutritional requirements and other challenges.)

Cannabis grows best and produces the highest yield with high light levels (daily light integral). In a warehouse grow, this requires large numbers of lights to generate enough light. Even in a greenhouse, supplemental light is required in most parts of the world to have the best yields.

Even in a greenhouse, successful cannabis production requires significant amounts of supplemental lighting.

While there are over 100 diseases reported to affect cannabis, the most troublesome diseases of cannabis are powdery mildew and botrytis.

Similarly, there are multitudes of arthropod pests reported to affect cannabis, but the most troublesome are various mites—both the familiar red spotted spider mites, but also eriophyid mites (e.g., russet mites) and tarsonemid mites (e.g., cyclamen and broad mites).

Photo: Griffin Greenhouse Supplies, Inc.

Powdery mildew is one of the most significant diseases of cannabis.

It's important to recognize some of the most significant challenges to cannabis production are those unique to growing a highly regulated crop for human consumption.

Since the crop is harvested for human consumption, there can be no harmful biological or physical contamination of the crop. Most jurisdictions require testing of harvested marijuana before it can be sold. These tests usually include testing for molds and toxic metals. Since cannabis is a moderately active accumulator of heavy metals, any contamination of the growing medium or fertilizer can be amplified in the harvested material.

Simply meeting the requirements of the local regulations is one of the biggest challenges when growing cannabis and those regulations vary from one location to another. What's allowed in Ontario may not be allowed in Oregon and what's allowed in Maryland may not be allowed in Minnesota. In general, there are requirements to secure the facility, which usually mean fences surrounding the growing area, security cameras and alarms. There are often restrictions on who can be allowed into the growing area and under what circumstances. Bringing in an electrician to do some new wiring is more difficult than it would be if the facility was used to grow lettuce.

Finally, a significant challenge must be recognized—growing, processing or possessing marijuana is federally illegal in all parts of the United States, despite state laws contradicting federal laws. Besides the legal risk to owners and employees of the business, this means there are no EPA-registered pesticides for marijuana production (the EPA is a federal agency), and banking and insurance are limited.

Cannabis is a crop, and like any crop, successful producers must pay attention to cultural requirements, big and small, to be successful. Future articles will take one category of requirements per article and provide critical details for success.

DR. BRIAN CORR is a consultant with over four decades of experience in the greenhouse industry. He has advised legal cannabis producers for the last three years. You can reach him at Brian.Corr@SycamoreHortConsulting.com.

New Products February 2018

Griffin
Altus is a soluble concentrate (SC) formulation of a broad-spectrum insecticide with a unique mode of action (4D). Labeled for use as a foliar spray on many vegetable crops, Altus may be used to control whiteflies, aphids and other harmful insects anytime during the production cycle with a one- to three-day pre-harvest interval (PHI), depending on the crop. Not registered in New York as of December 2017.
Reader Service Number 220

Nature's Source
Bring your soil to life with Nature's Source Plant Biotik. Now OMRI-Listed for organic production, it contains a beneficial microbial complex to feed your soil and produce healthier plants. Plant Biotik aids in nutrient break-down, availability and absorption while reducing nutrient leaching. It helps stimulate root development and increases tolerance to environmental stress. Available in select states.
Reader Service Number 222

Premier Tech Horticulture
Pro-Mix MP Biofungicide + Mycorrhizae provides the perfect solution for growers in need of an organic-certified growing medium. With the most advanced technologies in active ingredients, this OMRI-Listed growing medium will not only improve the overall growth and yields of your crops, it will also increase your plants' resistance to environmental stresses.
Reader Service Number 221

Hort Americas LLC
The Moleaer Inc. nanoBoost Nanobubble Generator delivers a supplementary source of dissolved oxygen that can significantly increase plant growth, improve size uniformity, reduce stress and prevent root diseases under extreme production conditions. Available from Hort Americas, the generator is ideally suited for horticultural applications including hydroponics, greenhouse irrigation and pond management. The self-cleaning generator, which has no moving parts, produces oxygen-enriched nanobubbles that efficiently oxygenate an entire body of water and provides a reserve of oxygen encapsulated within the bubbles. **Reader Service Number 223**

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