insideGROWER

October 2017

CONTROLLED ENVIRONMENT AGRICULTURE

What About Hops?

If you're looking for a niche to help you stand out, this crop could be your answer

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Carving the Niche

Small to mid-sized greenhouse growers know the best way to make a living is to offer something that others can't—whether it's superior quality, different sizes, unique varieties or some other way to differentiate.

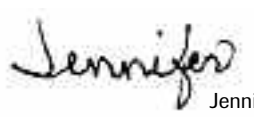
That's where some of our stories take us in this issue—they provide opportunities to carve out a niche. Take, for example, our cover story on hops. Don't be mistaken—this story isn't a wholehearted endorsement to run out and invest in growing hops. However, we want to be on the forefront of new potential crops for greenhouse growers and hops could be one of them. They have a unique angle, for sure—growing them in a greenhouse allows a grower to manipulate inputs to create a much faster turn than in the field, providing more harvests a year versus one outdoors. There are some downsides, though, so turn to page 10 to see if it's something you might want to consider.

Another potential crop is growing goji berry plants for retail sale. These berries have been touted to have multiple health benefits, and they are chock-full of vitamins and antioxidants. They can be eaten raw, dried like a raisin or juiced. Berries in general are seeing a surge in popularity and these are a nice niche opportunity. You can find complete culture information about growing goji berries on page 30.

And finally, our boss, Chris Beytes, took a road trip recently to visit lēf Farms, a hydroponic baby greens grower in Loudon, New Hampshire (ornamental growers will recognize owner Henry Huntington's name from his Pleasant View Gardens operation and partnership in Proven Winners). This operation has created its own niche by serving the local "neighborhood," which translates to New Hampshire, Rhode Island, Vermont, Massachusetts, Maine, Connecticut and New York. They grow for grocery stores, restaurants, food service and more. Take a look inside their operation on page 14.

When it comes to lettuce and leafy greens, LED lighting recipes can help growers create better products with greater fresh mass, varying tastes and plant coloration, among other characteristics. These differences can help growers create new niche markets with leafy greens as a premium product demanding premium pricing. Take a look at some of the LED lighting research related to lettuce on page 18.

Setting yourself apart is everything in this business. I hope we've given you some ideas to consider in the future and I wish you success in finding your niche!



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CONTROLLED ENVIRONMENT AGRICULTURE

ON THE COVER

Hops are still an enigma for many growers, especially ones who grow in greenhouses. But as the craft brewing market continues to be popular, perhaps it could be a niche opportunity for you. We explore multiple aspects of hops to see if it would be a good fit for your operation.

DEPARTMENTS

FEATURES

All About Labor, or the Lack of It

NatureFresh Farms, the Canadian greenhouse vegetable grower that built 45 acres of tomato greenhouses in Delta, Ohio, is holding off on its continued expansion plans until it can find the workers to populate future greenhouses. The plan was to expand to almost 180 acres under glass in the next seven years, a plan we detailed extensively in the February 2017 *Inside Grower* print supplement.

However, NatureFresh Farms Founder and CEO Peter Quiring told the *Toledo Blade* the next 45-acre expansion would require 90 to 100 new full-time, year-round employees, and Canadians and Americans don't want to do greenhouse work. They start at $12 an hour entry level with the potential to move up to $18 an hour with more experience. What's really telling is this quote:

"We've interviewed around 600 people in the last two years. Of that 600 people, about 30% to 40% didn't pass a drug test. And we don't care about marijuana, by the way. This is heavy drugs we're talking about," he told *Toledo Blade* reporter Tyrel Linkhorn. "It's a sad fact."

He added they hired close to 300 from that pool, and some never showed up, while 40 were dismissed and 90 quit, some within the first few days.

Sunset Tomatoes & Coal Miners

Mastronardi Produce Ltd., in conjunction with an ag tech startup, has identified former coal miners as a potential source of labor, creating a possible double win for both the workers and the grower. The grower, which has the SUNSET brand of fresh produce, is working with AppHarvest to bring high-tech greenhouses to the Appalachian regions of Kentucky and West Virginia.

More than 10,000 jobs have been lost in Eastern Kentucky due to the decline of coal, according to a statement released by Mastronardi Produce. "The spirit of the region is unmatched and we want to work alongside those hardworking men and women," says AppHarvest Founder and CEO Jonathan Webb. "Our goal is to provide economic development and opportunity for this region."

The plans call for a 1.8 million sq. ft. greenhouse in Eastern Kentucky on top of a reclaimed coal mine. Jonathan says approximately 65% of the U.S.'s population and income live within a day's drive of the site. Mastronardi will be the exclusive marketer for AppHarvest.

LED Growers' Guide

Growers who use LED supplemental lighting for crops like tomatoes, cucumbers and peppers have an additional resource at their fingertips for free in the new download from LumiGrow called "LED Growers' Guide for Vine Crops."

The guide focuses solely on those three crops and offers lighting guidelines for boosting yields, increasing crop quality and eliciting desired plant characteristics. The recommendations made in the guide are based on commercial and research trials. LumiGrow offers smart lighting and adjustable spectrum LED lights for horticulture.

You can download the guide at lumigrow.com.

Pot Town, U.S.A.

The name of the town is actually Nipton, California, with a population of somewhere between 20 and six, depending on which news report you read. Marijuana tech company American Green recently announced it purchased Nipton with the idea to turn it into "the country's first energy-independent, cannabis-friendly hospitality destination."

However, law enforcement in San Bernardino County might have something else to say about that. According to a story on Capitol Weekly, once the news got out about the purchase, the county sent a notice to American Green about a county ordinance barring unincorporated areas (which Nipton is) from all sales, distribution and production of cannabis. The story quotes project manager Stephen Shearin as saying he knows about the ordinance, but still thinks something can be worked out. "That doesn't mean this is not going to happen," he says in the story. "We're concerned about it, but not anxious."

The town actually has some pretty cool roots: it was literally at the crossroads of two mining wagon routes in the early 1900s (anyone hearing Clapton in their head yet?), and consisted of a hotel and a trading post, among a few other buildings. American Green bought everything for $5 million, including an RV park and campground. Here's the plan, according to the company's media release: "Ultimately, the company would like to offer a variety of commercial and recreational attractions including: CBD and mineral baths, cannabis-product retail outposts, artists-in-residence programs, culinary events, and Bed-and-Breakfast lodging to complete the charming, small-town experience."

Howler: An OMRI-listed Fungicide

Growers will have another tool in their belt with Howler, a unique trademarked biological fungicide from AgBiome that will be marketed by AgBiome Innovations. This fungicide is OMRI-listed for use in certified organic production and has an excellent non-refrigerated shelf life. According to the company, Howler is a "revolutionary fungicide that harnesses the power of the plant microbiome to create an efficacious fungicide with multiple modes of action that provide preventive, long-lasting activity on a broad spectrum of soilborne and foliar diseases."

It can be used effectively in all phases of production and combats botrytis, phytophthora, Pythium, rhizoctonia and more. It's effective on lettuce, peppers, spinach, strawberry, tomato and others.

Find out more athttp://agbiome.com/howler/.


Photo: Alton N. Sparks, Jr., University of Georgia, Bugwood.org

Combating Pepper Weevils (plus Mobile Education)

Sharing is caring and the folks at NatureFresh are hoping that sharing will result in better results for everyone when it comes to taking down pepper weevils. One of the company's IPM Managers (aka co-captain of the Bug Brigade) Tina Friesen, recently wrote a blog post on the NatureFresh site about dealing with the pest, which has been a thorn in the side of Ontario greenhouse growers for a while now.

While they're working on it internally, it's a larger problem impacting lots of growers. So now there's a pepper weevil message board designed specifically for industry growers to share their thoughts and how they combat the pest. It's free to register and view what others are doing, as well as contribute what you're up to: http://weeviltalks.proboards.com/

Stateside, NatureFresh deployed its mobile Greenhouse Education Center again during the summer for a third year; it's a 38-ft. custom-built vehicle that shows exactly how the company grows its vegetables in a greenhouse. The company employs college students to run the mobile GEC and act as brand ambassadors, and so far, it's been working to help steer consumers toward the NatureFresh brand.

"We are able to immediately impact consumers purchasing decisions at store level with the knowledge we share about how we grow greenhouse vegetables," says Cole Burkholder, GEC Team Member and third year Environmental Science Major from Ohio State University. "The look on people's faces when we explain the greenhouse growing process and they see the live plants with real fruit, it's priceless, you kind of see that 'a-ha' moment in their eyes. We've even had customers show us their shopping carts when leaving to show us the tomatoes or bell peppers they have purchased because of our conversation."

New Container Growing Unit

A Finnish company called Exsilio has created a redesigned container for cultivating lettuce greens and herbs, among other veggies, in urban environments called the EkoFARMER. And now the company wants to partner with restaurants, farmers, researchers and other users with their EkoFARMER product. According to Exsilio, the 13-meter long farming module (approximately 42.5 ft. long) is a turnkey growing solution that "only require a location, water and electricity outlets." Everything else can be controlled efficiently in order to produce optimal yield and flavor.

"EkoFARMER is an excellent option for businesses in need of salads, herbs, (edible) flowers or medicinal plants, for example," says Thomas Tapio, CEO of Exsilio. "The social aspect of urban farming is also prominent. For this reason, our solution is suitable for associations wanting to earn some extra income, or societies wanting to offer meaningful activities for the unemployed, for example. This is an opportunity to create new micro-enterprises."

Photo: Exsilio

The module can produce approximately 55,000 pots of salad per year and the price will likely run slightly over 100,000 euros or $113,000 U.S. dollars. Thomas says there also will be a leasing model for a monthly payment.

Find out more at http://ekofarmer.fi.

NOSB Delays Organics Container Decision, Again

In April, the National Organic Standards Board met to discuss the controversial issue of how and if hydroponic and other container-grown systems should be certified organic. While some had hoped for a vote on the issue, others suspected that NOSB would delay the matter. And a delay is what we got.

The committee that produced a "discussion document" recommending the elimination of hydroponic, aquaponic and aeroponic production methods from the USDA organic program presented their case to board members. But the board indicated they want more information, analysis and time.

It's important to note that between the November 2016 NOSB meeting (where they also sent the issue back to committee for further clarification) and this meeting, five NOSB members rotated off the board and five new members arrived.

Lee Frankel, executive director of the Coalition for Sustainable Organics, which supports allowing the certification of these various forms of production, gave his take to their membership on the meeting.

Lee wrote, "The most common theme emerging from the thoughts shared by the board members was the sense that they were 'conflicted.' Most board members expressed that they thought organics is primarily about the soil, but that container systems seemed to have an important place as well in organics."

Lee says, "Most members expressed a desire to find some type of compromise that would restrict some current production of organics but to include enough container production systems to avoid the rise of a strong competitive label (similar to non-GMO certified) for growers using container production systems."

There's also a sense that NOSB wants to make sure the organic community can vet and respond to a proposal. Lee says they want to ensure that "any decision by the NOSB would have credibility in the eyes of the industry, USDA and elected officials." (The NOSB only makes a recommendation to the USDA on how to proceed; their vote does not equal a final rule change.)

So, what can we look forward to? It's possible you could see a revised proposal by this fall, but it's also possible that they won't have something ready to vote on until spring 2018. For now, hydroponics, aquaponics and all other forms of container production can still be certified organic. The NOSB, which meets twice a year, is scheduled to meet in person October 31 to November 2 in Jacksonville, Florida. The meetings are open to the public but will not be broadcast via webcast.

Food Safety Continued

A brand new study was just released by the USDA's Economic Research Service on Food Safety Practices and Costs Under the California Leafy Greens Marketing Agreement (LGMA).

A little backstory: the California LGMA is an oversight program designed to ensure leafy green products are grown, processed and shipped safely. The newest report highlights the costs associated with growers and processors related to the regulations required by the LGMA. These are all field growers, but the report shows some interesting findings related to how expensive it is to meet the California requirements.

For example, the No. 1 and No. 2 costs are for workers implementing the food safety plans—for food safety and clerical staff, and at the foreman harvesting level. The No. 3 cost was for third-party audits, which are often required by buyers, and the No. 4 cost was for lost product associated with animal intrusion (something our greenhouse and vertical growers—hopefully—don't have to worry much about). And rounding out the bottom was the cost of water-quality testing, which only accounted for about 2% of the measured costs.

So why incur these added costs? The report highlighted a rather startling statistic—one you may have heard before. The CDC attributed 46% of all foodborne illnesses with a known food vehicle from 1998 to 2008 to produce. Of that, 23% (the largest category) were from leafy green vegetables.

Grow-Tech's New Plug Design

Called the CatEyePlug (a trademarked product), the new introduction from Grow-Tech LLC can be squeezed with one hand, opening up the "eye" and allowing a cutting to be stuck easily without forcing it into the media. Once you let go, it closes, holding the cutting in place. According to the company, the plug is designed for easy transplanting of delicate plant material like tissue culture, microcuttings and other hard to start plants.

"Grow-Tech works with several companies that produce tissue culture plants," said Edwin Dijkshoorn, CEO of Grow-Tech. "Following the successful launch of our ZenPlug for large tissue culture root structures, the CatEyePlug is designed for small delicate root systems."

Grow-Tech also announced that it joined the Dümmen Orange family of brands. According to information released by both companies: "Grow-Tech will benefit from Dümmen Orange's expertise and innovation pipeline and will be better positioned to serve its customers. Dümmen Orange welcomes Grow-Tech's products and market know-how and its up-to-date understanding of customer needs, especially in the North American market."

Edwin adds this: "We are very excited to be part of this team … The deal between two private equity owned companies was straight forward, recognizing the trend to market consolidation between growers and their suppliers."

The Maine-based Grow-Tech will continue to operate as an independent company.

Traceability Made Easier

Part of food safety is being able to quickly and easily trace products and who was responsible for them down the line. Dynamic Systems has released a new end-to-end traceability system for aquaponic, aeroponic and hydroponic growers using the SIMBA line of barcode tracking and labeling solutions. Previously Dynamic Systems had released SIMBA for field production use.

This system gives the processor the ability to record, label and track products faster and more accurately while including multiple data points. It uses an automated system to track producers through each stage of growth, using tablets or touch screen computers in the growing area to collect details like produce type, nutrients added, start and end time at each stage, harvest date and time, etc. The software is able to collect lot or batch numbers, maintaining traceability from seed through growing and packaging.

It can also print labels, as well as interface to scales and automatic label applicators, for a fully automated process.

To find out more about this system, go to http://dynamic-systemsinc.com/software/produce/.

Philip's Huge New Russian Project

Philips Lighting recently announced it will provide LED horticultural lighting for the largest LED growing facility ever at nearly 62 acres, or 2.7 million sq. ft., about 350 km southwest of Moscow. The facility will grow tomatoes and cucumbers in greenhouses that will be equivalent in size to about 40 soccer pitches.

Philips is working with Dutch partner Agrolux and Russian installer LLC ST Solutions for the installation over the next three months. Philips Lighting will provide light recipes optimized for growing tomatoes and cucumbers, training services, and 65,000 1.25m long Philips GreenPower LED toplights and 57,000 2.5m long Philips GreenPower LED interlights.

The design will reduce the electricity consumed to light the crop by up to 50% as compared with conventional horticulture lighting and uses light recipes to boost quality and crop yields by up to 30% in the darker winter months, says Udo van Slooten, business leader for the company's horticultural lighting business.

The Potential of Hops

Are greenhouse hops right for you? Let's find out.

by **JENNIFER POLANZ**

Hop cones are rather pretty right off the bine (yes, bine, not vine) and they taste even better when added into your favorite brew. The craft brew industry has skyrocketed in the past 10 years, and while current numbers show growth slowing a bit, there's still a need out there for quality hops.

That's where the greenhouse grower comes into play. If you're looking for a niche product to grow, you might want to consider hops. Here, we'll explore multiple aspects of the crop and you can see if it's the right fit for your operation (or if it warrants further exploration).

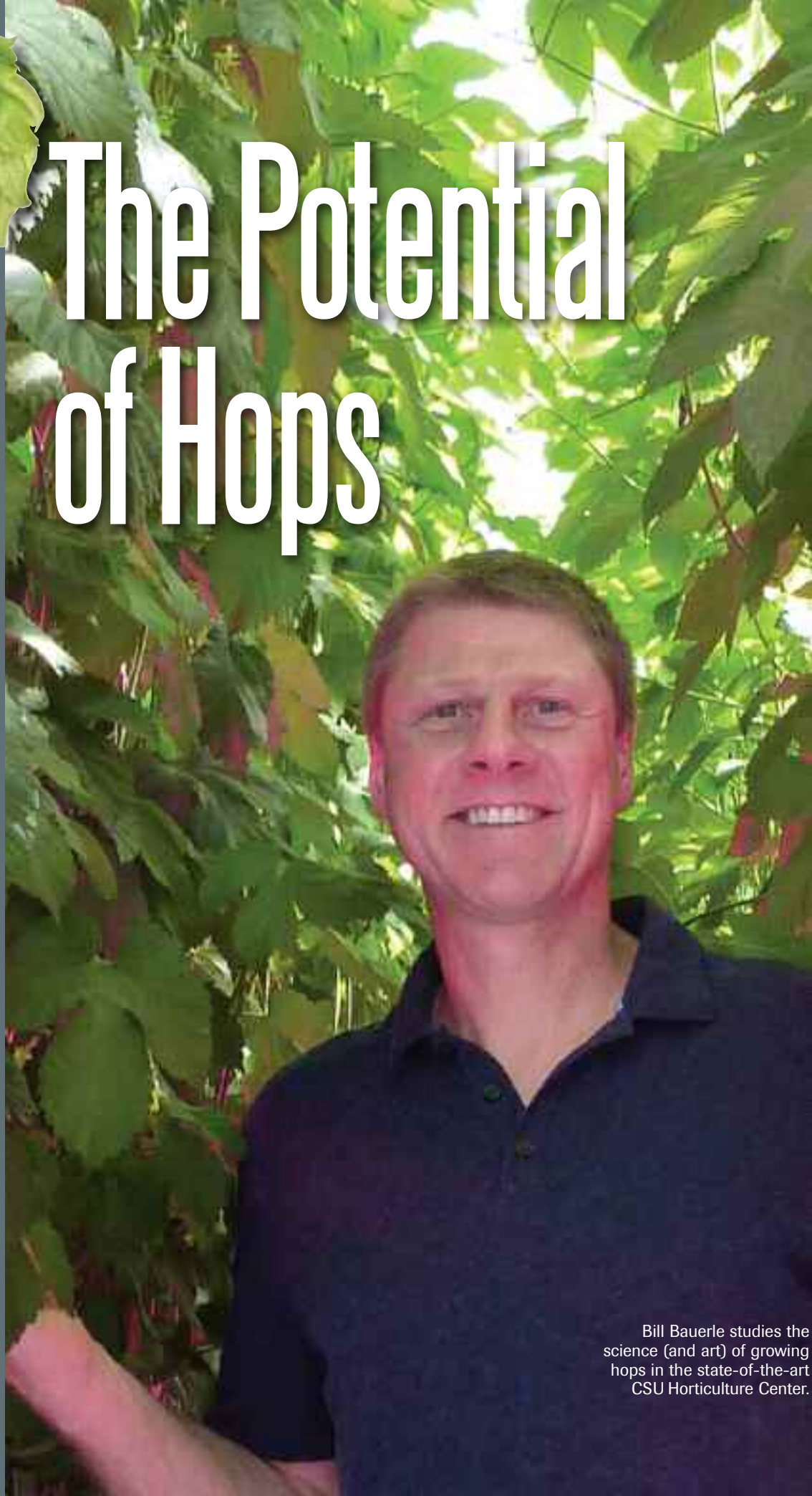
THE HOPS MARKET

First let's take a look at demand. According to the Brewer's Association, an organization for small and independent craft brewers, the craft brew industry grew by 6% last year. That's slower than the double-digit growth that had been seen each of the previous couple of years. But as more craft brewers come online, they seem to be searching for unique varieties that create different flavor profiles and varying degrees of bitterness, along with the traditional, more popular varieties.

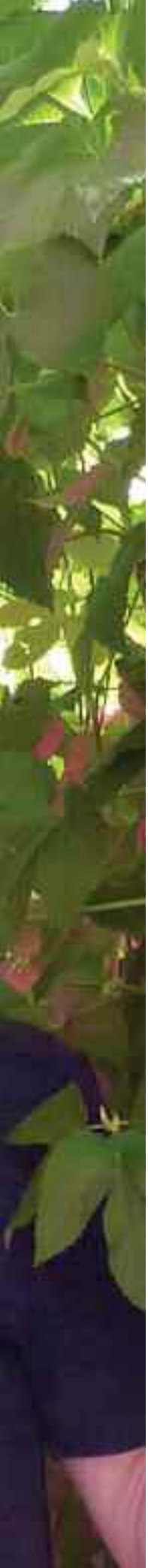
The industry is going through some contraction, too, with brewing giant Anheuser-Busch InBev buying up several small craft breweries, such as Goose Island (Chicagoans!), Blue Point, 10 Barrel, Wicked Weed and Kona Brewing, among others. It's not just A-B, either, as MolsonCoors bought Revolver Brewing, Hop Valley and Terrapin. As those craft breweries move into the portfolios of larger brewers and get wider distribution, it creates somewhat of an opening for smaller, independent breweries to compete in their regions, touting locally brewed beers.

WHAT'S INVOLVED

For the nuances of growing hops in a greenhouse, we turned to plant stress physiologist and craft beer lover Bill Bauerle, a professor at Colorado State University who's studying the science (and art) of growing *Humulus lupulus* under glass in the state-of-the-art CSU Horticulture Center. Right now, he's working in a 40-ft. wide



Bill Bauerle studies the science (and art) of growing hops in the state-of-the-art CSU Horticulture Center.



by 80-ft. long greenhouse bay that totals 3,200 sq. ft.

His five varieties (Cascade, Centennial, Chinook, Galena and Willamette, which are all publicly released by the USDA) are grown hydroponically in an artificial substrate, allowing precise control of nutrition and drip irrigation. He's experimented with several different types of media and has found that most inert media like perlite and coco coir will work.

He's tried multiple types of starts—like from rhizome, rooted cuttings and tissue culture—and hasn't yet settled on which is best. The crops are lit with two types of LED lighting: top lights and intracanopy lights, allowing Bill to control the photoperiod and manipulate flowering.

Bill says different varieties respond to different cultural changes, like daylength, temperature and nutrition, so one size does not fit all. Part of the key, too, in growing hops indoors is having enough room vertically—they grow very quickly. There also are early-, late- and middle-flowering varieties, so the results can be variable based on the plant.

"Basically, what I'm seeing there is, because we're in a controlled environment, we can actually flower the plants in a lot earlier stage than you can in the field," he adds. "You can shorten that window up. The detriment in doing that is you possibly jeopardize your yield … because the plant is smaller if you ask it to flower sooner rather than later."

Colin Clark is the head grower of Hydro Hop Farms, the only commercial hydroponic hops farm in the country (so far). The 5,000-sq. ft. greenhouse in Northern Colorado contains 2,000 Columbus, Chinook and Cascade hops plants.

"I saw the demand of craft beer skyrocketing and realized the production and distribution of hops was very limited," says Colin, whose background is in hydroponic greens. "I wanted to change that by creating top-quality hops in any climate at any location during any time of the year."

He's found hops require more work over the winter and in early spring, since it's a perennial.

"This was a new challenge for me, but we quickly found success in our methods," he notes. "Growing 25-ft. hops on a 10-ft. trellis was also a challenge that we were able to overcome by using techniques perfected in the hydroponic tomato industry."

Colin says right now he only harvests for one extended season, April through October, but he believes with proper lighting and controls, growers can get multiple harvests per year.

Back at CSU, under the Philips LED fixed lights and with individual nutrient injectors for each variety, Bill can get a minimum of three turns with a maximum of five turns a year. And though hops are fast and relatively easy to grow, there are still pest issues to contend with.

Bill has seen spider mites and thrips, and to a lesser extent aphids. In terms of diseases, the possibility for powdery mildew, verticillium wilt and a few others exists. He's gone biological in combating pests, incorporating predatory mites into the greenhouse. Colin also has contended with aphids, caterpillars, mites, thrips and grasshoppers.

"I've created an intense IPM program that utilizes the appropriate pesticide application mixed with the usage of beneficial predator insects," he says.

WHERE'S THE NICHE?

So how could an ornamental or herb and veggie greenhouse grower compete in this space? Here's the rub—field-grown hops can only be harvested one time a year, in the fall. In the greenhouse, depending on a multitude of factors, turns seem to range from one or two up to five. The beauty in that is a steadier supply of hops, as well as a larger niche of "wet" hops, or freshly harvested product.

"Wet hops are a rarity," Colin says. "(They are) usually harvested within hours of being dropped into the brew kettle. Wet hops are usually sold at a higher price per pound than dry hops. Five pounds of wet hops equals one pound of dry hops."

Some brewers create specialty brews as soon as those cones are off the bine featuring the wet hops, which creates a "buzz" (forgive the pun) around exclusive seasonal releases. Examples include Founders Brewing Co.'s Harvest Ale, Sierra Nevada's Northern Hemisphere, Deschutes Brewery's Hop Trip and 3 Floyds Brewing Co.'s Broo Doo. They're rare, though, because of the difficulty of harvesting and quickly getting the hops into the batch.

Greenhouse growers also have the potential to maximize the essential oils and flavor profiles of the hops by manipulating the nutrients provided at the flowering stage, which can be a unique marketing position for a hops seller. For example, some hops are called bittering hops, which are added in the beginning of the brewing process, and they have higher alpha and beta acid contents. They're important to the brewing process, but very little of this flavor profile actually persists into the final taste, Bill says. Other hops are called aroma, which have lower alpha and beta acids, but higher flavor compounds are added at the end of the brew to give the beer more flavor.

Another positive is the ability for a small or mid-sized grower to create a relationship with a brewery to supply one or a few local establishments consistently. Colin says while he doesn't necessarily contract with brewers because right now demand is outpacing production, he does build those relationships.

"I do encourage every brewer to come out to the farm and inspect the cones before we harvest," he says. "I feel the close connection between the brewer and the farming practice is important."

The team at Rough Bros. Inc., a commercial greenhouse company in Cincinnati, recognized the potential for greenhouse hops as well. They featured a hydroponic hops system in the booth at Cultivate'17 in Columbus and saw lots of interest from smaller growers looking for a unique niche.

Rough's Keith Bemerer says the system can work one of two ways—a greenhouse grower working with brewers to grow their hops or a brewer adding a greenhouse on-site to grow their own hops. Either way, Rough is creating a turnkey approach with two different sized greenhouses available: a 30-ft. by 108-ft and 30-ft. by 60-ft.

"That way we keep it simple," he says. "The beauty of this system is the house is expandable; if the person wanted to put another range on they could do that."

THE DOWNSIDES

As with many crops, there are downsides to hops and the main one is labor. Both Bill and Colin commented about how difficult it is to harvest hops.

"The cones develop throughout the entire plant … you can't ask it to flower at different portions of the bines at different times," Bill explains. "That's why it's so intensive out in the Pacific Northwest because all of these hops come into ripening all at the same time."

He adds that out in fields it's about three weeks to a month of constant picking by hand to get all the plants harvested, and the same thing happens in the greenhouse, but as of right now there's no automation that can do it for ▶

MORE RESOURCES

- Learn more from Colorado State University Professor Bill Bauerle at www.hoponics.com.
- Colin Clark of Hydro Hop Farms has created the Hydroponic Hop Manual for those interested in learning the ins and outs of growing hops indoors. It can be found at www.hydrohopfarms.com.
- Find out more about the hydroponic hops turnkey greenhouse at www.roughbros.com.

you. It's not like in the field, where they've been able to develop some automation to pick the flowering hops.

Colin's comments were similar, noting that it's a pain point for greenhouse growers looking at adding hops. "To find a proper balance between yield and labor, two harvests per year is what I recommend," he says.

Keith at Rough says the greenhouses they're proposing for hydroponic hops growers would be mostly automated with fertigation and growing equipment coordinated through an environmental controls system, allowing one person to run the house for most of the growing time except for harvest.

The market is still an issue, as well. The wet hops would have to continue to command a premium price, which likely wouldn't happen if there are more wet hops available with increased commercial production. So in the end, it would—as with all greenhouse crops—come down to decreasing input costs and labor costs to make a profit or creating a premium product through exclusive varieties and enhanced flavor.

GLASS HALF FULL?

Colin sees a promising future for greenhouse hops as long as others jump on board to create niche markets.

"It will take more than my efforts to create a new industry out of hydroponic hops, but I truly feel that the future looks good," he says. "I've spoken with many other small farms looking to follow in our footsteps next season. I see a slow, steady growth over the next three to five years."

Bill says future success will be based on yield and will depend on brewers paying for a premium product. However, the possibilities are there.

"Like poinsettias or other floriculture crops, you could actually now have hop varieties ripening every week or however often. I didn't know how important that was, but come to find out these breweries have very timeline-specific schedules for how they make these brews project out to months in advance. There is a lot of potential there similar to the poinsettia crop arriving at Christmas."

I think we can all raise a glass to that potential.

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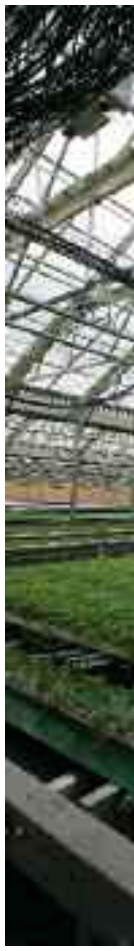
lēf Farms: A Baby Greens Greenhouse

Story & photos by **CHRIS BEYTES**



The Huntington family of Pleasant View Gardens in Loudon, New Hampshire, has long been a force in the Northeastern U.S. bedding plant business, as a Proven Winners partner, young plant supplier and finished plant grower. Now the Huntingtons are branching out into the world of greenhouse-grown veggies—baby greens, to be exact—with the launch of a business venture with the curiously spelled name lēf Farms (pronounced leaf).

This summer, we sat down with Henry Huntington to learn more. Our first question? Why? Wasn't Pleasant View Gardens keeping the family busy enough?

"Absolutely!" Henry answered with a laugh. He went on to explained that the next generation (his son, John, and his brother Jeff's sons Andy and Ben) was coming into the business and the family wanted to diversify their horticultural investments to something beyond bedding plants. Henry said he'd long been intrigued by greenhouse vegetables and also saw a "huge" opportunity in the local food movement—especially in greens.

"Go into a grocery store and what do you see in the lettuce section?" he asked. "You see about this much head lettuce (makes a narrow gesture with his hands) and you see this much baby greens (holds his arms wide). And it's all from California. We saw that as a huge opportunity to grow baby greens locally."

That is, if they could fully automate the growing and harvesting. "The last thing I wanted to do was have a ton of people out there with scissors because that just defeats the whole purpose," Henry said, in recognition of the scarcity and cost of labor.

To oversee the operation, the Huntingtons turned to Bob LaDue, whom they met during their preliminary business explorations. Bob has more than 20 years of greenhouse greens experience, most notably at Cornell's floating lettuce range. He impressed them with his knowledge and experience, and they realized he was key to the success of their venture.

They broke ground September 1, 2015, with the hopes of being in production by June 1 of the following year, but delays with the Finnish hydroponic system (see sidebar) pushed back the first sowing until the fall of 2016, with the first saleable harvest coming in January of this year. They used the fall of 2016 to work the initial kinks out of the system—something they're still doing as they transition through the seasons.

SALES THUS FAR

Their first eight months of effort has been in five markets: grocery stores, restaurants, hospitality, institutional food service and distributors. Distributors were the first to jump on board, selling anywhere from 50 to 300 cases per week across New England. In fact, they recently signed on with the nation's two largest, Cisco and U.S. Foods. We assumed the first customers would be small grocers, not big distributors. Henry assumed that, too.

"Yeah, I thought we were going to get into the supermarkets before we got into the distributors," he agreed. "I thought they were going to be the tougher ones."

He admits it's been a slow start because of price resistance, but lēf has held firm, saying, "We think once people try this, they'll like it—especially the higher-end restaurants." Henry says the distributors wanted him to lower his price, arguing that at $5.00 a pound, they might sell 20 cases a week, whereas at $3.50 per pound, they'd sell 200 cases a week.

"We said we were willing to start out at 20 cases a week because we were confident it would build," he says. "We've stuck to our guns,

Center: A sea of baby greens and a gutter just headed to harvest.
Above: Henry Huntington, president and CEO of lēf Farms, spends about half his time at the family's new baby greens facility.

and I'm glad we have, because it has built."

One of the reasons they haven't yet cracked the grocery stores is because of another regional greens competitor that hit the market six months ahead of them, and to whom the stores have made commitments. But Henry is confident in lēf's superior quality and says those chains are coming around. "They now have determined that they want the product; now it's just a negotiation on price."

lēf is at about half capacity right now, Henry says. They spent a year learning to grow in the hydroponic gutters at their PVG R&D facility, where they were able to achieve 3 lbs. of greens per trough. "Right now, we're getting maybe a pound and a half per gutter, so we know that once we get some of these kinks worked out of the system, we can get three pounds. And that's when we'll really hit our stride and make some money on this product."

The first seven months have offered a few challenges, such as having to battle neighbors over light pollution from the greenhouse's HID lights (they got past that one by promising to put in a blackout curtain when they do their next expansion). Meeting food safety requirements is an ongoing task. For instance, every bag of greens goes through an x-ray machine to scan for foreign objects.

"That's been interesting," Henry says of food safety. "You don't have anywhere near that on the flower side of things, right? And with all the new FSMA [Food Safety Modernization Act] regulations, just trying to figure out how to manage that within a new organization. The good news is we were more proactive about it." He points to one example: the extra thick and durable floor coating in the packing area (which cost an extra $50,000).

"We're starting out way ahead of where most companies are, especially in this region. We're not in an old barn that has swallows up in the rafters. So when the state came in and did their inspections, they were blown away by how clean we were because their experience is not that."

But the biggest challenge has simply been learning the growing system and the crop's requirements as they transition from season to season.

"I just want to get through a year," he says with a weary chuckle.

ENTER THE MACRON

Then there's that funny name, lēf Farms. We asked Henry if he knew what the little line over the "e" is called.

"A macron," he answered.

"Very good! Not too many people know that," we replied.

"Thank you," he said with a smile. "Our IT guy figured out a way to change everybody's computers so when they spell 'lef'" it automatically puts in the macron."

He then explained the genesis of the name.

"Based on our experience with Proven Winners, we knew that we needed to be different, we needed to stand out. Even though we might be one of only one or two local producers, there is still a whole [produce] case of California lettuce and greens out there. We wanted our packaging to be different, we wanted a different name, we wanted to be able to tell our story—about how it's sustainably grown and pesticide free—all that kind of stuff. We wanted to build a brand that was recognized."

Speaking of building, the column stubs for phase two of lēf Farms are already being set. The current production line will support 150,000 sq. ft. of greenhouse, and the cooler and packing line can support 300,000 sq. ft. "At the minimum, that's our goal," says Henry.

"I think we've got a lot of room to expand just in this small market that we've started in, this northern New England marketplace," he concludes. "There are markets that we haven't gotten into yet, like home-meal-delivery services. And if we can take it to other parts of the country, that would be something we'd like to do, too. We'd like to be able to build a national lēf brand."

At which point, everyone will know what a macron is. ▶

The Finnish Line

We got the details on lēf Farm's hydroponic system from VP/COO/ head grower Bob LaDue

The seeders are unique, featuring vertical spinning disks that drop the seeds into the gutters passing beneath.

Young greens that have just come up from germinating underneath the main layer of gutters. In about 10 days, they'll have traveled to the other end of the greenhouse and will be ready to harvest.

Spinning stainless steel blades shear off the baby greens as the gutter passes below.

Greens are fed by variety to the bagger as needed for the blend they're making.

The system comes from a Finnish firm called Green Automation, which claims 2.1 million sq. ft. of automated salad greens systems installed over the last 30 years.

It features 19 ft.-long plastic gutters that move automatically through the facility—from filling and sowing to germination, finishing and harvest, then back for cleaning and refilling—all controlled by computer. It takes just 14 days, start to finish, for a gutter to travel through the system. That's why they choose baby greens over standard greens: With such a quick turn, there's little risk of insects or diseases, allowing lēf to grow pesticide free.

One major change lēf made to the system was the use of a peat-based media rather than the rockwool that Green Automation usually uses. Bob says they didn't want to deal with the disposal headaches of rockwool. This required a redesign of the gutters and their integrated irrigation channel, which added time to the project. Each gutter has two long, narrow channels filled with soil.

The seeders are interesting: vertical disks with vacuum holes on one side that drop seeds into the gutters as they pass underneath. Multiple seeders allow for fast changeover of varieties because there are multiple varieties growing at all times. That's how lēf makes their mixed greens recipes.

Once sown and watered in, the gutters are put under the main layer of gutters for a few days to germinate. Then they're conveyed up to the main layer for growing on, moving slowly from one end of the greenhouse to the other, eventually getting spaced out just a bit.

After 14 days, the gutters move into the 38F (3C) cooler/packing area, where a pair of horizontal spinning blades slice off the young greens, leaving just the stems. The gutters head back to the production area for emptying, washing and refilling, while the greens get sorted by variety onto multiple buffer lines.

The computer knows which blend is being created and calls for the appropriate greens to be conveyed to the filling machine—a towering hulk in the center of the packing room. Greens are sorted and bagged, x-rayed for foreign objects, then boxed. The whole system takes minimal human input.

Currently, lēf Farms offers three baby greens mixes: Smooth (leaf lettuce, pac choi, mizuna and oakleaf), Spice (arugula, mustard, cressida, mizuna and leaf lettuce) and Balance (red and green kale). All are offered in 5-oz. retail and 1½-lb. institutional bags.

The packing machine turns loose greens into mixed bags.

Each bag is x-rayed before boxing to spot any foreign objects. E-coli and other diseases are prevented through strict sanitation protocols.

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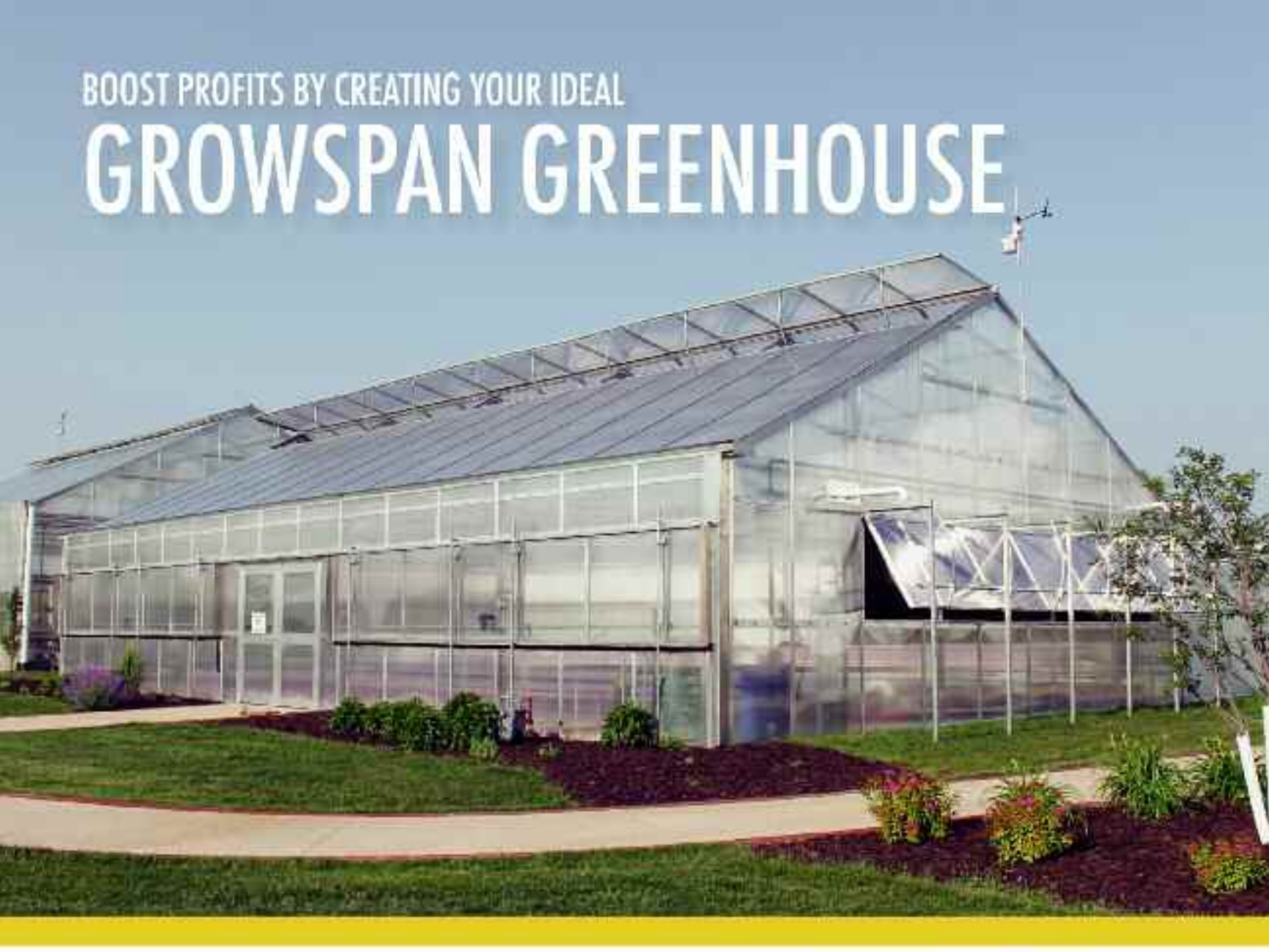

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Figure 1. Young lettuce plants in the researchers' light quality chamber.

Static Cookbook

Effects of light quality on indoor lettuce production.

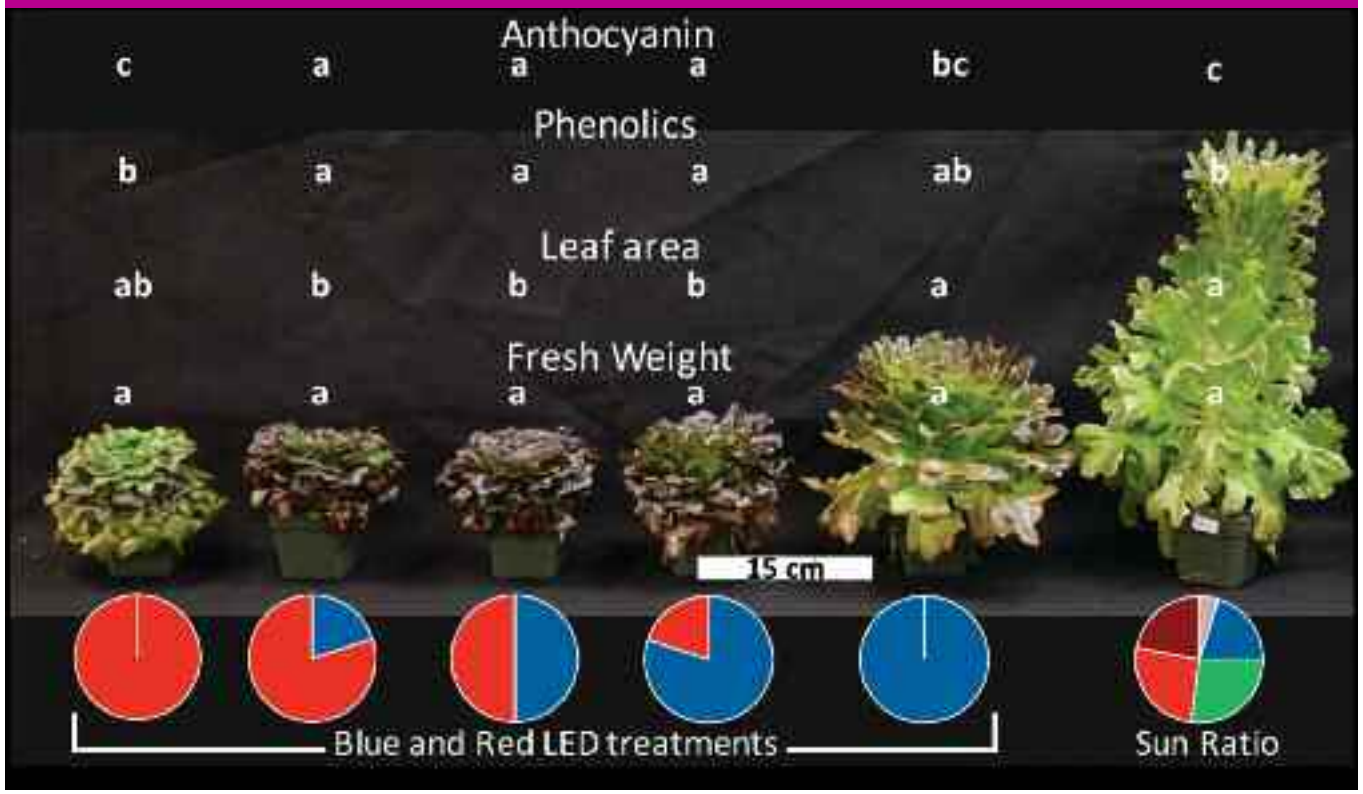
by **HANS SPAHOLZ & RICARDO HERNÁNDEZ**

The production of leafy greens—such as microgreens, leafy lettuce and head lettuce—in closed growing environments commonly called vertical farms (VF) has gained much interest across the U.S. In order to produce healthy, high-yielding crops under VF conitions, it's imperative to monitor and control the different environmental factors, such as humidity, temperature, carbon dioxide, nutrients, light intensity and light quality (spectrum).

Most of the environmental factors can be measured and quantified relatively easily. For example, nutrients can be measured by monitoring the EC and pH. However, light is one of those variables that's less straightforward to understand—in particular, the spectrum. Light intensity is also a key factor and a range of 10 to 14 $mol \cdot m^{-2} \cdot d^{-1}$ is sufficient to produce leafy greens.

The less-understood key component to light is the light spectrum requirements. The spectrum requirements often depend on the grower's objective. Some spectrums maximize plant growth (dry mass accumulation), plant weight (fresh mass accumulation), plant

Figure 2. Plant responses to different fixed spectrums using LEDs. Different letters show significant differences between treatments on each parameter. Plant responses are ranked from higher to lower according to the letter: a>b>c, ab = a = b, bc = b = c.



architecture (leaf area, number of leaves), plant coloration (chlorophyll, anthocyanin) and plant flavor (bitterness, crunchiness). By changing the light spectrum, we're able to influence these physiological responses.

In our research group, we're focusing on developing recipes that maximize a variety of desirable plant responses (growth, weight, architecture, coloration, flavor, etc.). In addition, we also would like to fully harness the capability of LED technology to create "dynamic light recipes" that change according to plant growth stage. Using dynamic light recipes not only will maximize plant growth, but also reduce electricity consumption. Currently, we've been working on understanding plant responses to "static light recipes" (Figure 1), which we define as providing one permanent spectrum for the entire growth cycle. The result from this research will provide key information to develop and test dynamic light recipes.

RESULTS: STATIC LIGHT RECIPE RESEARCH

The purpose of our research is to find a blue to red light ratio that's best for growing lettuce; a light recipe that considers maximizing both morphological and nutritional components (phytochemicals). To examine different blue and red light ratio recipes, Red Oakleaf lettuce was grown indoors for 42 days under a 13 $mol \cdot m^{-2} \cdot d^{-1}$ DLI with an 18-hour photoperiod. All light was supplied with LEDs and all but one treatment had blue, red or both. The treatments and a summary of the results are detailed in Figure 2.

The "sun" treatment was the only treatment that included additional wavelengths and was created to approximate a sunlight spectrum. This sunlight treatment was set up to satisfy the ratio of each color range by proportion of UV (200 to 400 nm), blue (400 to 500 nm), green (500 to 600 nm), red (600 to 700 nm) and far-red (700 to 800 nm).

Two things should be noted about this specific light recipe: First, from the plants' point of view, the UV portion of this recipe was satisfied only with UV-A and completely lacking UV-B (UV-B is needed to illicit certain UV-B plant responses). Secondly, this recipe had similar energy consumption as to the rest of blue:red ratio recipes; however, due to the fact that different LED colors have different efficiencies in converting power into light, the "sun" treatment has lower total photosynthetic active radiation (400 to 700 nm), but the biological active radiation (300 to 800nm) remained the same among all treatments.

In our study, lettuce plants under the various light treatments had similar fresh weight after 42 days. This means that if the grower is selling lettuce by weight, any of the tested recipes will provide the desirable weight. More interestingly, the blue and red light ratio treatments had a much larger effect on leaf area.

For example, the "sun" and 100% blue ▶

light treatments had the largest leaf area, while all the remaining treatments were significantly lower. It should be brought to attention that the 100% blue light treatment had a unique leaf area response, since the increase of blue light is known to decrease leaf area. The 100% blue light and "sun" treatment both had 38% more leaf area than the lowest performing treatment for leaf area (80% blue and 20% red). If the grower is selling by the head, then using a treatment that increases leaf area will be more beneficial.

In addition to these morphological traits important for product quality and marketing, the impact of light treatment on nutritional and antioxidant phytochemicals is also of interest to our work. For phenolic content, the ratio of blue to red light didn't have a significant effect, as all treatments that contained blue and red had the highest concentration of phenolic content (100% red and "sun" treatments were significantly lower in phenolic content, with 100% blue having content statistically similar to both the high and low groups).

This trend was similar for anthocyanin concentration as well. If the grower desires to create a new product that's tailored towards nutritional content and potentially create a product with a "guaranteed" antioxidant concentration, then a recipe that increases anthocyanin and phenolic concentration is preferred.

However, if we want it all (large leaf area, large weight, high phytochemical content) then we have to look for a better approach by using dynamic light recipes that promote vigorous growth at one stage, while "finishing" a crop with a light recipe that triggers max coloration and nutritional content. We're currently working on developing those dynamic light recipes.

In horticulture, LED light systems can be categorized as either "fixed" spectrum fixtures or "tunable" spectrum fixtures. Fixed spectrum fixtures come with a certain ratio of colors, typically red and blue, and are not tunable. Fixed spectrum LED systems often have higher electrical efficiency (use less electricity) and are also more affordable.

Meanwhile, "tunable" LED systems come with an interface—either physical dials or a software-based method—which provides growers the ability to change light intensity and spectral quality using the same fixtures. These tunable systems also have the capability to create entire preset programs that change light recipes over time. This gives each grower the ability to create custom light recipes that fit their specific needs.

For growers with fixed spectrum fixtures, the presented results can be helpful information for choosing a lighting system. For growers with tunable fixtures, we hypothesize that our next phase of results will provide recipes that maximize both growth and plant quality to a greater extent than what a fixed spectrum can provide. IG

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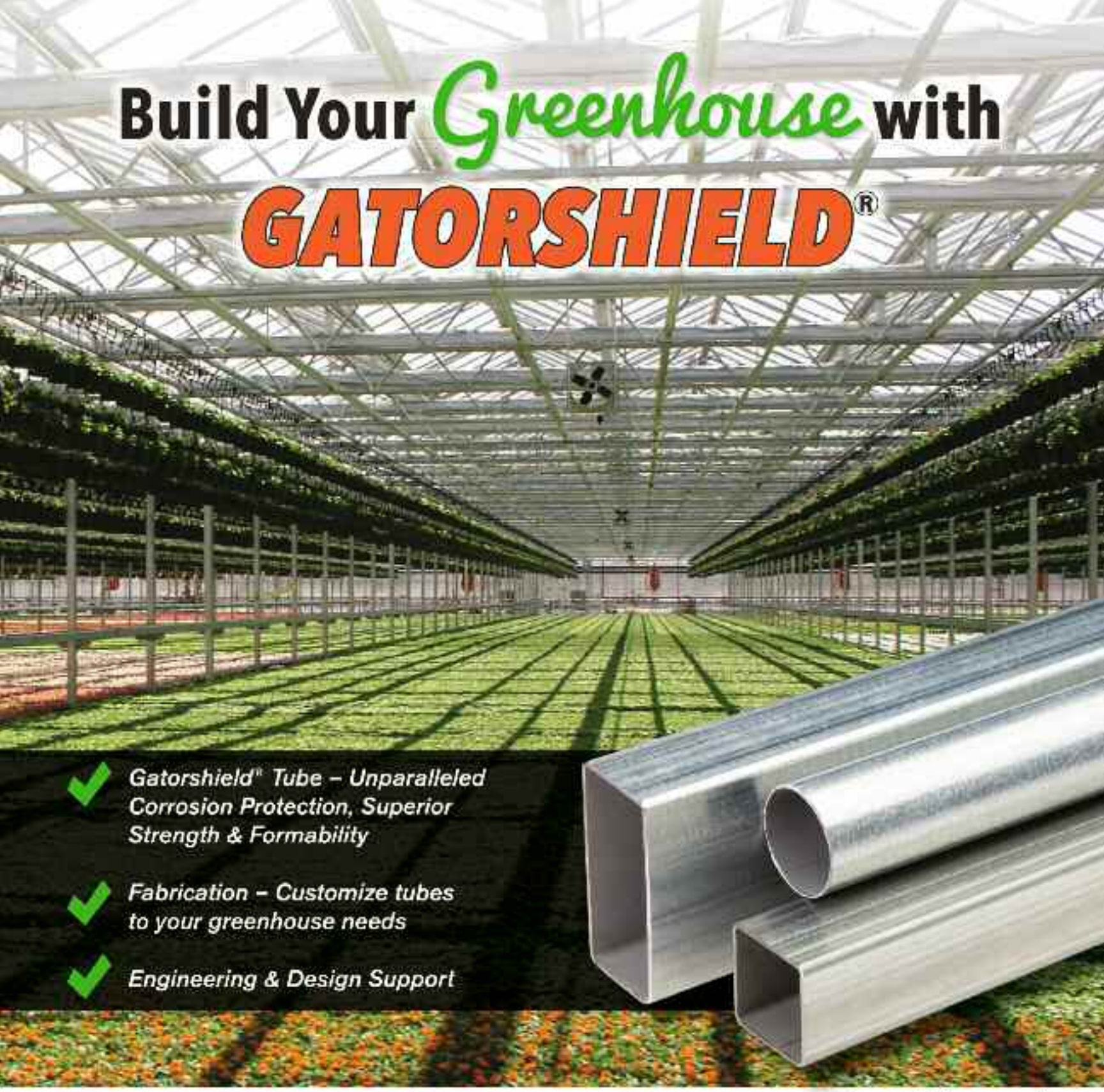

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Keeping Control

Having success with container edibles means being vigilant in the early stages.

by **RYAN DICKSON**

Consumer demand for culinary herbs, leafy greens, and fruiting and vegetable crops grown in containers is increasing. A big difference with container edibles is that growers are restricted from using many agri-chemicals commonly used in ornamental production—mainly pesticides and plant growth regulators. Therefore, growers must rely more on biological pest control options and good cultural practices to produce high-quality edible crops. This article reviews common strategies for pest and quality control in container edibles.

CONTROLLING INSECTS AND DISEASES

Preventing and controlling pest and disease outbreaks is one of the biggest challenges when growing edible crops. However, with a little knowledge of biological pest control options, you can begin to stock your grower toolbox for success.

Biological control agents can be very effective if used properly. Common commercial products include beneficial bacteria and fungi (for example, Trichoderma, *Bacillus subtilis* and various mycorrhizae), as well as predatory insects and nematodes (for example, *Steinernema* nematodes and Amblyseius mites). These products are most effective when applied early and at regular intervals to suppress and reduce pest populations.

Cutting-edge information on using biological and alternative pest control strategies include research by Raymond Cloyd at Kansas State University, Lance Osborne at the University of Florida, Rosa Raudales at the University of Connecticut, Anissa Poleatewich at the University of New Hampshire, and Margery Daughtrey at Cornell University, as well as at www.greenhouseipm.org.

A few non-biological options are available and are safe to use on edible plants. These include products such as horticultural oils, peroxides and potassium bicarbonates. Additional strategies include using good greenhouse environment and cultural practices. For example, lowering humidity with proper ventilation and avoiding over-watering help prevent root and foliar diseases.

REDUCING SOFT AND LUSH GROWTH

Plants with soft and lush growth tend to be more susceptible to pest issues and damage easily during shipping. We tend to think of soft growth as excessive stem stretch and leaf expansion. We can minimize soft growth and increase plant tone by focusing on a few cultural practices.

We can start by looking at plant density per container. Too many plants can promote initial stem stretch after planting, which can result in toppling as shown in Figure 2. Too few plants can result in an overall sparse looking container that's undesirable. Consider running simple tests to see what plant density works best for your crops.

Too much nitrogen (N) and phosphorus (P) from the fertilizer promotes soft growth. Fertilizer nitrogen also comes in three forms: ammonium, urea and nitrate. Fertilizers high in nitrate (>70% of N as nitrate) typically promote toned and higher-quality plant growth.

If mixing water-soluble fertilizer into your irrigation water, a good starting point is to irrigate with approximately 150 ppm N of mostly nitrate and 20 ppm P in the water. You can then increase or decrease fertilizer rates depending on how plants perform. ▶

Figure 1. Container edibles packaged and shipped to grocery stores.

Figure 2. Basil that toppled over after overhead irrigation.

In addition to fertilizer, over-watering and not allowing the substrate to dry between irrigations also promotes soft growth and root diseases.

Warm temperatures tend to speed up plant growth, but also promote stem stretch and leaf expansion. Growing cool has the opposite effect, slowing down growth and resulting in more toned and compacted growth. Species differ in their temperature optimums—lettuce prefer cooler temperatures, whereas basil and tomato perform best at warm temperatures (above 70F/21C).

Figure 3. Plastic hanging from a travelling irrigation boom used to brush container edibles.

Depending on your climate, consider using DIF to control plant stretch. Positive DIF means that days are warmer than nights, which is common under natural conditions and promotes some stretch and leaf expansion. Negative DIF means that days are cooler than nights, which tends to reduce stretch and keeps plants more compact. The larger the DIF, the greater the effect, with 5 to 15 degrees F being a typical target range. If negative DIF isn't possible, dropping air temperatures for a couple hours before and after sunrise is usually effective. Then let the greenhouse slowly warm back up as sunlight increases.

Some greenhouse operations use mechanical conditioning strategies to tone plants. An example is shown in Figure 3, where plants are brushed periodically using soft plastic hanging from irrigation booms. This disturbance causes plants to release a natural hormone that makes them more compact with thicker leaves. The same happens with blowing air or strong wind. In this scenario, avoid brushing wet foliage and sterilize the plastic regularly to help prevent the spread of disease.

UNDERSTANDING THE DIFFERENCES

Figure 4 shows a fairly common scenario where multiple edible species are grown in the same production space. This presents a potential challenge in that plant species sometimes differ considerably in their cultural needs.

Lavender, thyme and rosemary are examples of species that

tend to prefer a drier substrate and are more sensitive to high fertilizer salts. When placed under the same irrigation and fertilizer regime as tomato and cucumber, which use more water and tolerate higher salts, it's easy to over-water and over-fertilize these crops. Basil is sensitive to chilling injury below 55F (12C) and is less compatible to grow with species that perform better at cooler temperatures, such as chives and lettuce.

Figure 4. Multiple container edible species grown in the same production space.

Species tend to differ in how quickly they grow into an acceptable crop or crop time. For example, thyme tends to grow slowly and requires a longer crop time compared to tomato. Assigning the same crop time to all crop species may result in variability across products. Accurately determining crop times and scheduling appropriately is critical to supplying consistent and uniform plants to your customers.

BRINGING IT ALL TOGETHER

The key to successfully growing container edible crops is a combination of proper knowledge and use of biological pest and disease control options; understanding how water, fertilizer and environmental conditions affect plant quality and growth; and knowing how species differ in their cultural needs.

As a simple management strategy, growers may consider grouping species that have similar cultural needs together in the same production space. For example, crops such as lavender and thyme tend to perform better with lower fertilizer levels and drier soil compared to tomato and cucumber. Placing these species in separate zones can help you supply water and fertilizer regimes to match crop needs.

Consider training staff on scouting for insects and diseases, cultural practices and recognizing problems in the crop as a way to improve the quality and consistency of your container edibles. IC

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Having Substrate Issues?

When growing hydroponic leafy greens, lettuces, herbs and microgreens, make sure the substrate, crop and production system are compatible.

by **DAVID KUACK**

Growers who produce ornamental or vegetable plants in containers and who aren't recirculating their irrigation water have fewer concerns about the substrates used to grow those plants.

"Growers who use loose substrates like peat, perlite and coir in hydroponic production systems may have issues with managing hydroponic systems that need to run clean," said Tyler Baras, special projects manager at Hort Americas. "Debris from these loose substrates can lead to clogging of irrigation lines in hydroponic systems like nutrient film technique [NFT]. In the case of a deep water culture floating raft system, the goal is to flush the system as infrequently as possible because there is so much water involved. Growers want to keep both of these hydroponic production systems fairly clean.

"The loose substrates used by traditional ornamental plant growers can break apart, so that there is some peat and perlite floating in the system or sinking to the bottom of the pond or water reservoir."

Rens Muusers, technical account manager for the U.S. at Grodan, said whether a hydroponic crop is grown in a greenhouse or a vertical farm, the substrate does much the same thing.

"The substrate has the same type of functionality regardless of the type of facility it is used in," said Rens. "One of the main considerations is what kind of production system is going to be used and how does the substrate fit into that system."

One of the first things to think about, said Rens, is how and for how long the plants are going to be propagated. "If the seedlings will be kept longer in a propagation area, then a larger amount of substrate will be needed to allow adequate space for the plant roots to develop," he explained. "Holding the plants longer in propagation will also likely require an additional production area to allow for proper spacing of the plants."

Tyler is conducting trials with loose substrates and more commonly used inert substrates for hydroponic systems. He said examples of these inert substrates include preformed plugs, such as Grodan stone wool plugs or cubes, Oasis foam blocks, stabilized medium like synthetic polymer peat plugs (i.e., Jiffy Preforma, Flexiplugs, Flexitrays) and wrapped plugs, which can have an outside coating, such as Riococo Closed Bottom Organic Plugs and Ellepots.

DEVELOPING A STRONG ROOT SYSTEM

In the greenhouse trials that Tyler is doing with lettuces and basil in NFT and deep water raft systems, he's studying the differences between peat and coir.

"Coir has more water retention from what we have seen," he said. "It really depends on the production system, the growers' staging strategy and how the seedlings are watered. There are a lot of factors that are similar and they both have the possibility of being used for hydroponic production."

Left: For hydroponic systems that recirculate water, the substrate shouldn't crumble and fall apart, which could lead to clogging of irrigation lines and filtration systems. Photo courtesy of Tyler Baras, Hort Americas.

Right: Seedlings held longer in a propagation area require a larger amount of substrate to give plant roots adequate space to develop. Photo courtesy of Grodan.

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ARGUS CONTROLS

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Tyler said that coir is often used as a substitute for peat. "Often when coir is used, growers have to change their irrigation strategies," he said. "Fine coir holds more water than peat. Once the seed has germinated and is at the seedling stage, the goal is to establish a strong root system regardless of the substrate used. The plug should be dominated by roots. As long as the plug has a large enough root mass once it is transplanted into a hydroponic system, there is a good chance for success."

Growers should consider young plant development strategies specific to the substrates they're using.

"An example would be plugs with some type of wrapping around the outside," Tyler said. "The bottom is open, but the plants should be grown until there are enough roots to cover the bottom of the plug so it doesn't fall apart once it is placed in the hydroponic system."

OPTIMIZING SPACE UTILIZATION

Rens said the length of time growers hold seedlings in the propagation area will impact the size of the plugs that are used.

"This is a major reason why growers are choosing to use 1-in. or 1½-in. plugs," he said. "Growers using 1½-in. plugs would be keeping their plants in the propagation area longer to optimize space utilization. The longer the plants are kept closer together in propagation, the longer the crop can benefit from the microclimate." Additionally, plants held longer in propagation results in less space needed in the final growing area.

"Transplanting small plants into the final spacing is not an efficient use of space," said Rens. "Holding the seedlings longer before transplanting them into NFT channels or a deep water pond requires less space in the final growing area to grow the same amount of plants."

Rens said sometimes transplanting larger plugs can speed up the production of a crop.

"When transplanting plugs from a propagation area that has an optimum microclimate into a greenhouse is like putting the plants out into a desert," he said. "In indoor vertical farms, theoretically the climate is managed in a more optimal way. Growers can manage the microclimate around the plants, but they have to consider how cost effective that is. The space in a vertical farm is going to be more costly than in a greenhouse, so it is even more critical to optimize space utilization in a vertical farm. For any particular type of growing, space utilization is critical. All of these steps impact the substrate that is used. Depending on the spacing, the substrate needs to be able to manage those kinds of processes as well."

DIFFERENT NEEDS FOR DIFFERENT CROPS

Rens said the length of production time for a crop will influence the substrate choice.

"There are significant differences in production when growing leafy greens and lettuce versus growing microgreens," he said. "Microgreen crops require seven to 14 days max; that's a really short crop. A lettuce crop can require as long as 45 days."

There is a relationship between the length of the crop time and the amount of substrate that has to be used as well.

"For microgreens, a thin Grodan Cress Plate is an ideal substrate volume for the crop," said Rens. "But this substrate wouldn't work for a head of lettuce, which requires more volume during the growing cycle. Growers typically use plugs for lettuce."

Although microgreens are a short-term crop, they're not as simple as they seem.

Left: Consider the outside temperature and humidity when choosing a substrate for microgreens grown in a greenhouse. Photo courtesy of Grow-Tech Inc.

Below: Water draining off NFT channels should be run through a filter system to collect any debris before the water is returned to the reservoir.
Photo courtesy of Tyler Baras, Hort Americas.

"If microgreens are being grown in a greenhouse, one has to be aware of the outside temperature and humidity when choosing a substrate," said Siebe Streekstra, account manager for the west at Grow-Tech Inc. "I'm working with a greenhouse grower in Las Vegas who is producing microgreens. It is hard to grow microgreens because the circumstances are so harsh. The humidity is very low and the temperatures are so high that the evaporation is immense."

Siebe said that the grower uses a thick BioStrate mat substrate in order to keep up with plant transpiration. Growers who are producing under harsh climate conditions should consider using a thicker medium.

"This Las Vegas grower is actually moving into an indoor controlled environment production facility where he can control the temperature and humidity," said Siebe. "That should make production much easier and consistent. Growing microgreens in a greenhouse kind of depends on where the operation is located. In general, people in greenhouses don't control their circumstances as well as in an indoor production operation."

LIMITED ORGANIC SUBSTRATES

Tyler said growers doing organic hydroponic production have a more limited selection of substrates.

"Growers who want to grow organically can't use stone wool, foam blocks or any polymer peat plug," he said. "Organic production is generally limited to loose substrates. This would include loose peat- or coco-based substrates and coco plugs. There aren't a lot of options."

If a loose substrate is used and it falls apart into the production system, it can quickly clog the irrigation system. Tyler said it's important to have a solid root structure before transplanting the plugs into an organic hydroponic system.

Whether growing organically or not, when using loose substrates in hydroponic systems Tyler said growers need to have a good filtration system.

"Anything coming off the tail end of the NFT channels is going to have to be run through some kind of filtering stage to collect any debris before the water goes back into the reservoir," he said. "The irrigation lines are usually ¼-in. or smaller and those can clog quickly when loose substrates like peat or coco are used."

For more: Hort Americas, (469) 532-2383; http://hortamericas.com. Rens Muusers, Grodan, info@grodan.com; http://www.grodan.com. Grow-Tech Inc., (888) 805-8916; info@grow-tech.com; http://grow-tech.com.

Some of the information presented in this article appeared in the June 2017 "News from Hort Americas!" e-newsletter, http://hortamericas.com/blog, and the Urban Ag News Blog, http://urbanagnews.com/category/blog.

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Goji Berry Plant Production Tips

by **PAUL COCKSON. INGRAM McCALL & BRIAN WHIPKER**

The goji berry plant *(Lycium barbarum)* is a member of the *Solanaceae* family. This family includes a diverse range of plants sometimes referred to as nightshades. The nightshades include tomatoes, peppers and eggplants, all of which have significant worldwide economic importance.

The goji is grown primarily for its berries, which have gained global recognition and consumption (Figure 1). This recent recognition coupled with its antioxidant and nutritional wealth means the goji berry is now a plant being offered by greenhouses. Currently, there is limited greenhouse production information. This article highlights greenhouse production tips for goji berry.

Figure 1: The goji is grown primarily for its berries.

Greenhouse growing guide

TEMPERATURES

Given that gojis are native to the Himalayas, a temperate climate, their native temperature fluctuations vary greatly. For greenhouse production (See Table 1), day temperatures of 60 to 75F (15 to 23C) and night temperature of 60 to 65F (15 to 18C) are recommended. For rooting, temperatures are higher at 65 to 70F (18 to 21C). If plants are to be held, 40 to 50F (4 to 10C) temperatures can be used. Alternatively, plants can be overwintered by leaving them in an unheated poly house over the winter and providing irrigation as needed to avoid letting the plants dry out.

LIGHT

The goji plant requires full sun. The light requirements for this plant are high, which means 6,000 to 10,000 foot candles or a (DLI) of 12 to 24 $mol \cdot m^{-2} \cdot d^{-1}$ are needed. Low light conditions will not only stunt growth, but may also result in lanky plants with excessive intermodal stretching. These conditions will produce sub-par plants and also will increase lateral growth resulting in the plants crowding each other.

IRRIGATION

The goji plant requires a medium to medium-high level of irrigation. This means that the plants should be watered thoroughly and often. In addition to thorough watering, a constant moisture content should be maintained through the entire root ball and throughout the entire growing process. While the goji prefers to have adequate moisture, care should be taken to avoid standing water in the pots, as this will result in diminished root health and could foster disease conditions. Drought stressing the plants will result in flower and fruit abortion.

CONTAINERS

Goji can be grown in many different pot sizes, depending on the desired plant volume and market. Table 2 outlines the time tables for different pot sizes. One plant per pot should be utilized.

SUBSTRATE

Use a well-drained substrate. Avoid using materials that retain excess moisture. Excessive watering and/or standing water will result in root rot and may cause conditions that favor disease. An 80/20 peat/perlite by volume mix worked well with our research studies at North Carolina State University.

FERTILITY & pH

The goji plant is a medium feeder. A target range of 150 to 200 ppm N with a complete fertilizer should be maintained. Using a calcium plus magnesium fertilizer will be beneficial as the goji is a *Solanaceous* crop and has a high requirement for those nutrients.

If growing out to berry production or for ornamental purposes, as soon as green berries emerge after pollination, it's highly recommended that a calcium plus magnesium fertilizer be added into the fertilizer mix. This will ensure that berry quality is maintained and nutrient deficiencies are avoided.

If stressed, goji fruit will develop blossom end rot, much like a tomato. The target EC levels are 0.6 to 0.9 mS/cm using a 2:1 extraction method, 1.3 to 2.0 mS/cm for SME, and 2.0 to 3.0 mS/cm for PourThru extraction of top irrigated plants during the main growing season.

In a trial conducted at North Carolina State University, nutrient disorders were induced on goji plants. Nitrogen, manganese and phosphorous deficiencies were the first to appear (Figure 2). Iron deficiency was next to manifest (Figure 2). Iron and manganese deficiency can be an issue if the pH is too high. These nutrients should be monitored, as they are most likely to be the nutritional issues growers encounter.

The substrate pH should also be monitored closely in goji. The optimal pH range for goji is 5.0 to 6.5. A pH that's too high

Table 1: Growth stage temperature requirements for goji.

Growth Stage	Day Temp	Night Temp
Rooting	65 to 70F (18 to 21C)	65 to 70F (18 to 21C)
Growing Out	60 to 75F (15 to 23C)	60 to 65F (15 to 18C)
Holding	40 to 50F (4 to 10C)	40 to 50F (4 to 10C)

Source: Proven Winners, 2017.

Table 2: Pot size to finish time.

Pot Size	Standard Growing Times	Quick Turn Growing Times
6 in.–gallon	8 to 10 weeks	4 to 6 weeks
10 to 12 in.–2 gal.	12 to 16 weeks	—
18 in.–3 gal.	16 to 20 weeks	2 to 16 weeks

Source: Proven Winners, 2017.

will result in chlorosis and stunting (Figure 3). To adjust the pH, lime can be added to raise the pH and acid to lower the pH. A PourThru method will help you monitor both the pH and EC and should be done at the beginning, middle and end of the production cycle. Fertilizers can also affect pH, as most mixed fertilizers are acidic. To avoid altering the pH through your fertilizer, choose a neutral-reacting fertilizer mix.

PLANT GROWTH REGULATORS

Given that goji is an edible, there are no PGRs that are labeled for use on plants for consumption. An alternative method to controlling growth is to use a fertilizer that's low in P and doesn't contain excess levels of ammoniacal-nitrogen, such as 13-2-13 Cal-Mag. Avoid fertilizers, such as 20-10-20 and 20-20-20, which can result in excessive growth.

Trouble shooting

DISEASE

Like any crop of economic production, the goji berry is not without its pests and diseases. Many of the common diseases and pests that afflict the *Solanaceous* family would likely be an issue for goji berry. The following diseases have been reported, but aren't typically observed in greenhouse production of goji berry plants: Alternaria leaf spot, Anthracnose leaf spot, Cercospora leaf spot and *Fusarium solani* root rot.

INSECTS

Thrips can be a pest on goji. Proper sanitation and scouting will help alert you to their presence. The sooner you identify this pest, the more effective any treatment will be. Using a spray program or beneficial insects is the best way to control thrips, although any spray program should take into consideration that the goji is an edible. The use of sticky traps to monitor the population is a good scouting practice.

Aphids can cause serious issues on goji (Figure 4). These insects will attack the newest growth and underside of the leaves resulting in distorted growth, and in some cases, death of the leaves and tips. Green Peach *(Myzus persicae)* aphids can be particularly problematic. When treating aphids, it's important to remember that the goji is an edible. Always ▶

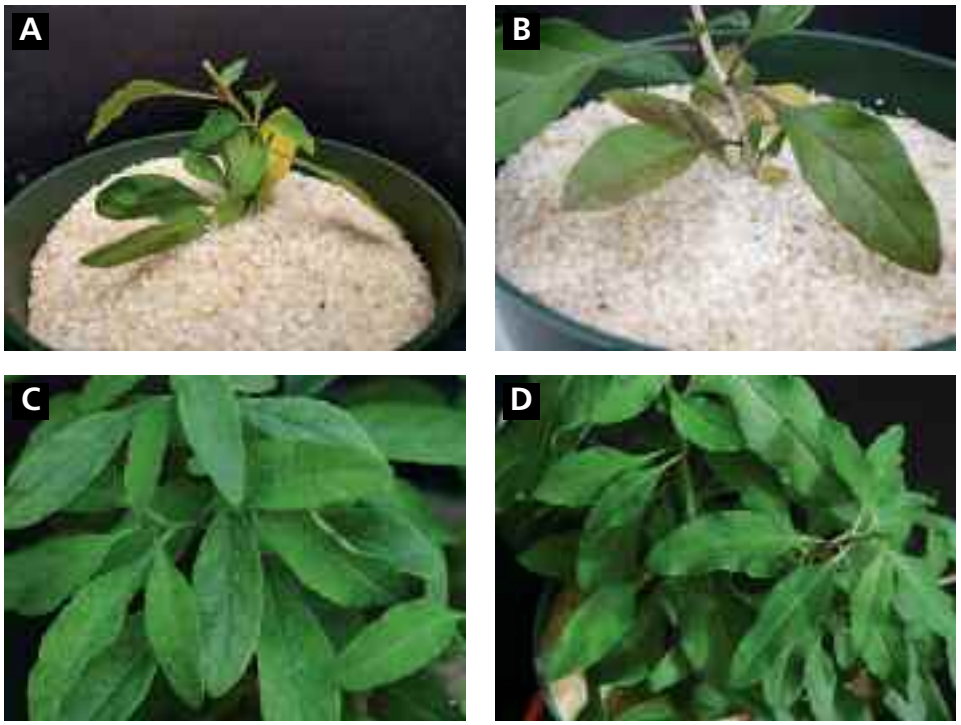

Figure 2. Nutrient deficiencies of goji. The figures above show nitrogen (A), phosphorus (B), manganese (C) and iron (D) in goji. These four nutrients are most likely to cause nutrient deficiency issues in goji, as they manifested early in deficiency trials.

Figure 3: This goji plant is stunted and exhibiting signs of interveinal chlorosis due to a high pH.

follow the label when applying any chemical. Natural predators can also be utilized to control aphids, as well as insecticidal soaps and some organic oils.

Spider mites can be problematic on goji. These insects are particularly difficult to control. Any chemical control must be labeled for edibles. Biological control can be utilized quite effectively for spider mites, although care should be taken that any sprays applied won't also kill your beneficials.

Fungus gnats also can be a pest on goji. These insects will eat the roots of the plants as larva and then the adults will emerge, mate and lay their eggs. The best control method for fungus gnats is cultural. Avoid overly moist substrate conditions and ensure there aren't rotting leaves or plant material in the pots. If populations become excessive, the use of yellow sticky traps is a good way to control and monitor these insects.

If growing goji in a nursery setting or if hardening the plants outdoors, birds can be an issue. Birds will eat the berries and may cause damage to the plants by eating the berries. Using row covers or shade tents will help reduce damage from birds.

Figure 4: Aphids can cause serious issues on goji.

Figure 5: Goji flowers are a vibrant purple to blue and attract bees.

Figure 6: Goji berries change color from green to yellow-orange to red.

Figure 7: Full cascading potted goji plant.

ENVIRONMENTAL

The goji is native to a temperate climate, and as such, excessive heat and cold are the greatest environmental stress concerns. Avoiding excess heat will ensure the plants don't become water stressed and drop their leaves. Temperatures over 80F (26C) should be avoided. Avoid excess cold, as this could result in frost damage to the roots, berries and foliage.

Blossom end rot can also be an issue with goji plants. This issue is brought about by a calcium shortage in the plant, which results in an undeveloped region of the fruit. This region will often be a site of infection and the end of the fruit will then rot on the plant. To avoid this situation, two steps can be taken. First, ensure the plant has adequate calcium during fruit initiation and maturation. This can be accomplished through a foliar spray or by supplementing calcium into your fertilizer mix. Second, if blossom end rot does occur, it's important to remove the dead and dying fruit, as this can become a source of disease and pests.

Fruiting & flowering considerations

FLOWERING

The goji plant will bloom anytime from late spring to mid-summer, depending on your location. In greenhouse operations, control over blooming time is much greater. Goji does require a vernalization period to bloom. You can hold the plants over the winter in a poly house outdoors with no heat, or for a speedier vernalization, control your temperatures at 40 to 50F (4 to 10C).

Flowers form on the new growth; goji will flower heavily. The flowers are a vibrant purple to blue and attract bees, which is an added marketing point (Figure 5). The flowers are self-pollinating and don't require the use of pollinators for fertilization to occur. After flowers open, frequent fertility checks (SME, PourThru, etc.) should be done to ensure adequate nutrient levels are maintained. A tissue sample can be submitted if desired for highly accurate fertility information.

FRUITING

After fruit fertilization, the flowers will fade and abscise. Shortly after abscission, green ovular berries will emerge. These berries will then change color from green to yellow-orange and finally to red (Figure 6). The goji is an extremely prolific bearer of fruit. The berries and natural cascading shape of the plant makes it a good container pot for large planters or accent piece (Figure 7).

It should be noted that the berries will change color before they're fully ripe, and consequently, a dark red coloration is a good indication of ripeness. The berries will ripen in the mid-summer through mid-fall. The berries are high in antioxidants and have a sweet flavor with earthy undertones.

The goji is a beautiful plant with many attractive characteristics. They bear heavily and have a natural cascading habit. These plants make excellent potted plants and will provide berries, attract bees and be a wonderful centerpiece in the garden.

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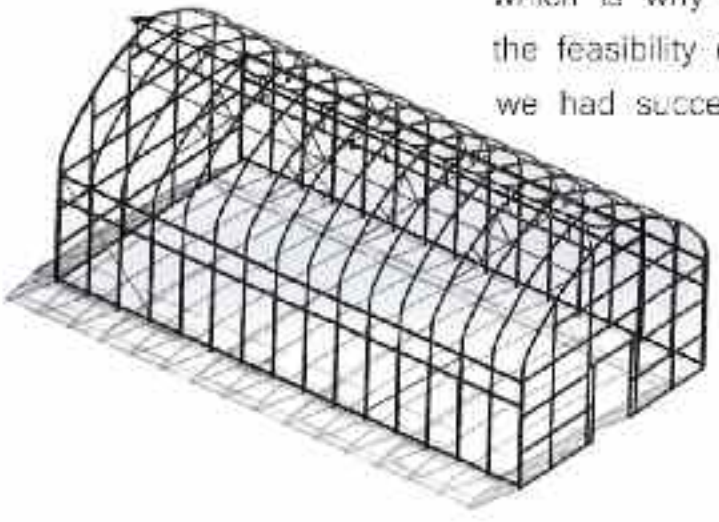

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