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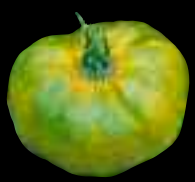
CONTROLLED ENVIRONMENT AGRICULTURE
February 2016

Does the Rooftop Model Work?

On the record with Gotham Greens' co-founder Viraj Puri, p. 10



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With the start of every New Year

comes speculation about the up-and-coming trends. Eating healthy, eating locally and enjoying big flavors are just a few of the movements motivating produce shoppers and restaurant goers in 2016. Paying attention to these trends can help vegetable growers better adapt to changes in our industry.

But that's not enough. Businesses also need to keep abreast of new regulations, technologies and cultivation techniques. We've got you covered. This issue of *Inside Grower* is packed with content covering some of the biggest trends in our industry. You'll get to know a few more businesses that are filling the ever-increasing demand for locally grown produce. We also discuss the new food safety regulations and several topics to help improve growing practices.

For our cover story, our writers hit the road to visit Gotham Greens' sprawling new rooftop greenhouse in Chicago (page 10). Gotham Greens is certainly one of the biggest trendsetters in the growing industry, now with four operational greenhouses in two major cities. Vertical farming is also a hot topic these days, so we sent another writer to visit Vertical Harvest, a three-story vertical hydroponic farm in the heart of downtown Jackson Hole, Wyoming. Read their story on page 22.

Marketing experts say it's not enough to just have a well-branded and delicious food product; consumers in 2016 want to know where their food comes from. Mighty Greens Farms, a small Illinois-based micro-green operation, has the compelling backstory. Check it out on page 26.

Food safety is another hot topic. Late last year, the U.S. Food and Drug Administration released the finalized rules of the Food Safety Modernization Act (FSMA). Many growers are scratching their heads trying to understand how these new regulations will impact their businesses. For a look at how the new food safety rules will affect greenhouse vegetable growers in particular, go to page 14.

Of course, this publication isn't just about news and stories. We're also here to spread science-based knowledge about growing techniques and practices. Learn the symptoms of common nutrient deficiencies in hydroponic lettuce on page 30; why buffering coir shouldn't be necessary on page 18; and how monitoring vapor-pressure deficit may be a more accurate measure to predict plant transpiration and water loss than relative humidity on page 28.

In the very first editor's letter I wrote, I shared with you that I'm the fourth generation in a family of horticulture and vegetable seed professionals, all of us finding our passions and our livelihoods in horticulture, but continually adapting to the times and redefining ourselves and our family's tradition in the industry.

Well, the time has come for me to redefine myself (again), and with mixed emotions, it involves stepping away from *Inside Grower*. I started editing the *Inside Grower* newsletter at the same time I started my PhD in Plant & Soil Science at the University of Vermont back in 2011. This industry and all the wonderful and friendly folks in it have been a great companion to me over the years, but now with the completion of my degree just months away, it's time for me to channel my full energy to new goals and ambitions. Of course, I'll always be in the green industry, one way or another, so I won't be hard to find. Keep on growing!

Annie White
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insideGROWER

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

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www.growertalks.com

BALL PUBLISHING

GrowerTalks (ISSN 0276-9433) is published monthly by Ball Publishing, PO Box 1660, West Chicago, Illinois 60186, United States. Subscriptions are free to qualified readers in the US. Subscription price for non-qualified readers is $35 per year US and Canada. All other foreign subscriptions must pay $99/year to receive/continue to receive *GrowerTalks* and *Green Profit*. *GrowerTalks* is a registered trademark of Ball Horticultural Company in the U.S. Periodicals postage paid at West Chicago, IL and at additional mailing offices. Postmaster: send address changes to *GrowerTalks* Magazine, PO Box 1660, West Chicago, Illinois 60186, United States.
Printed in the U.S.A.

GreenProfit Supplement Enclosed

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DEPARTMENTS

ON THE COVER

Viraj Puri, co-founder and CEO of Gotham Greens, talks about the challenges and success with building four rooftop urban greenhouses in five years. Turn to page 10 to learn more. Photo by Chris Beytes.

FEATURES

Photo credit: The Hernando Sun

Florida Prison Inmates Learn to Farm Hydroponically

In December, the staff at the Hernando County Detention Center in Brooksville, Florida, conducted a special media event to show off the jail's emerging hydroponics program. That's right—hydroponics program.

Monies from the Inmate Welfare Fund were used to help erect a small and simple hydroponic "greenhouse." The walls of the 24-ft. by 36-ft. structure are made of insect-resistant mesh, while the ceiling is made of semi-reflective aluminum net.

The greenhouse contains 14 floating lettuce beds and each bed holds 32 heads of lettuce for a total of 448 heads. They say the lettuce goes from seed to harvest in approximately 30 days, depending on weather conditions. The inmates are harvesting their first crops of leafy greens now.

The press release from the Sheriff says that hydroponic gardening at the detention center will actually reduce the cost of providing lettuce for meals from $1.03 per head of lettuce to $0.43. They hope to expand their hydroponic gardening program down the road to include other crops like peppers and cucumbers.

An Inside Look at Organics by the Numbers

Organic agriculture hasn't had a lot of numbers to quantify its growth. But now, with the release of the USDA National Agricultural Statistics Service (NASS) results of their 2014 Organic Survey, we have more than just 2008 and 2012 data to look at. This inventory of organic agriculture included those that are certified organic, those who produce less than $5,000 annually in sales and are exempt from certification, as well as those transitioning to organic.

It's a wealth of information, from the big picture to state-specific data. The headline from the USDA: U.S. organic farm sales in 2014 were up 72% from 2008 numbers.

Ever wondered how many organic growers are 100% organic versus those that just grow a portion of their products as organic? Turns out that about 58% of producers are 100% organic. The remaining growers grow organic for varying portions of their product offerings.

Google Expands Fresh Food Delivery

While local farmers' markets may be one growing trend, there's also increased interest in same-day delivery of fresh food via online services.

Google Express has been testing a new service that delivers fresh food and groceries in San Francisco, Los Angeles and New York. They're giving AmazonFresh, which offers a similar same-day service, some direct competition. The demand is proving to be there: Google just announced they plan to expand the service to Boston, Chicago and Washington, D.C.

With both Google Express and AmazonFresh, consumers pay a subscription fee that grants them "free" shipping with overnight or same-day delivery. AmazonFresh costs $299 per year (or you can pay extra fees for overnight and same-day shipping if you just have the $99 per year Amazon Prime service). Google Express is $95 per year or $10 a month.

Google has partnered with Whole Foods Market and Costco, as well as 1-800-Flowers, Vicente Foods in Los Angeles, Stop & Shop in Boston; Giant Food in D.C.; and Treasure Island Foods in Chicago, among others.

Women Take the Helm at Urban Farms

The gender gap in traditional rural farming is large and deeply rooted in a complexity of family customs and societal values. The statistics are indisputable. Fewer women own farmland than men and only 14% of farms in the U.S. have women farmers at the helm.

It's not for lack of interest in agriculture, however. According to statistics from the U.S. Department of Agriculture's Agriculture Census, women running agricultural businesses have tripled over the last several decades.

A recent article written by Trina Moyles and posted at modernfarmer.com discusses how urban farms could be the new frontier for female farmers. In a society where women are much less likely to inherit their family farms than their brothers, and purchasing new farmland on the real estate market is unaffordable for most, urban agriculture is a growing niche for women who want to farm.

Trina cited a 2014 article in *The New York Times* that interviewed 19 urban farms in New York City. Women led 15 of those farms.

Retractable Roof Greenhouses Increase Blueberry Yields in Mexico

In a recent newsletter from Cravo, the company shared research suggesting that using retractable roof greenhouses for blueberry production in Mexico could increase yields nearly 500%. That's right, 500% over field-grown berries in the same region. (Granted, Culiacan, Mexico, where the research was conducted, is not known for field blueberry production due to extreme summer heat.) The retractable greenhouses also provided for a 48% increase in brix (sugar content) in the Biloxi blueberries.

The small research project was conducted in cooperation with Fall Creek Farm and Nursery, Inc. at the Cravo Demonstration and Training Greenhouse in Culiacan.

Cravo said that when soil temperatures reached a scorching 147F (64C) one day in early June, the soil under the automated roof stayed at a friendlier 106F (41C). Leaf temperatures also remained lower under the automated roof. Both the indoor and outdoor plants flowered in February, but the plants under the structure bloomed for a second time in June.

Cravo says that growing blueberries in an automated retractable roof greenhouse can increase fruit quantity, size and brix. The trials are being expanded to include an additional three blueberry varieties.

Learn more from Cravo by visiting them at cravo.com.

New Bulletin on Biocontrol Agents for Greenhouse Pests

The diversity of biological agents available for greenhouse pest control in the U.S. can overwhelm growers new to the field of biological control. A new fact sheet from Michigan State University Extension and Kansas State University Extension offers a concise overview of the topic. The bulletin, which is available as a free download, provides information and photos about commercially available beneficial insects, their target pests and key facts about biocontrol agents.

The six-page fact sheet, titled "Commercially Available Biological Control Agents for Common Greenhouse Insect Pests," includes the beneficial insects that control Western flower thrips, whitefly, aphids, two-spotted spider mites, mealybugs and fungus gnats.

The bulletin is free and can be downloaded off of the Floriculture Resources Page on the MSU Extension website at http://msue.anr.msu.edu.

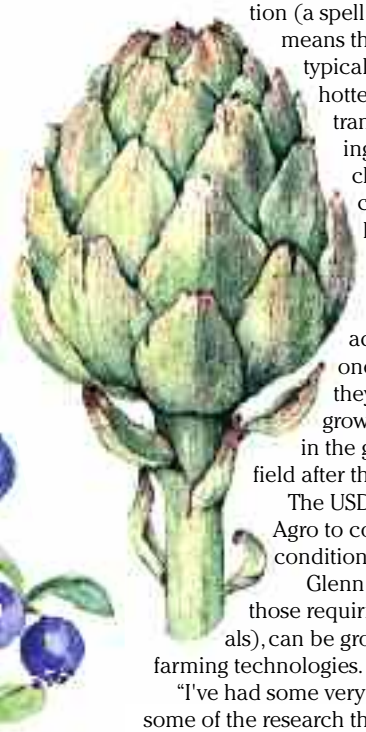
New Possibilities for Artichoke Farmers Using CEA Growtainers

The U.S. Department of Agriculture (USDA) recently handed out more than $113 million in program grants that will support production of fruits, vegetables, tree nuts and nursery crops, also known as "specialty crops."

Among the recipients are Texas A&M Agrilife Research Center and GreenTech Agro LLC, which plan to introduce new technologies in indoor farming to help improve and increase artichoke growing in Texas.

GreenTech Agro's Growtainer is a specially designed vertical indoor production environment housed in a modified insulated shipping container. Each Growtainer growth chamber is fully equipped with an HVAC system, LED lights and a hydroponic system for irrigation.

They say their initial trials starting artichokes in Growtainers showed striking improvements over greenhouse-grown transplants. We asked GreenTech Agro Founder Glenn Berhmann to explain more about how indoor farming techniques can help bring this profitable and typically California-grown crop to new regions.



Glenn explained that artichoke seedlings require vernalization (a spell of cool temperatures under 50F degrees.) This means that in places like Texas, artichoke seedlings are typically started in greenhouses in the summer at the hottest time of the year. About 60 days later, they're transplanted into the field for harvesting the following spring. Although necessary, this exposes the artichoke seedlings to some rough growing conditions—both high temperatures in the greenhouses and excessively low winter temperatures in the field.

Indoor farming to the rescue.

By replacing the existing control system and adding a refrigeration system for vernalization to one of the Growtainer growth chambers, Glenn says they can optimize growing conditions for both early growth and vernalization. Artichokes can be started in the growth chamber and go immediately into the field after the last spring frost for a late spring harvest.

The USDA grant will enable Texas A&M and GreenTech Agro to continue studying how they can optimize growth conditions in the Growtainers for artichoke production.

Glenn adds that he thinks many more crops, especially those requiring vernalization (including ornamental perennials), can be grown more effectively and efficiently using indoor farming technologies.

"I've had some very interesting, surprising and positive results on some of the research that I've done," adds Glenn. "I'm beginning to realize that I'm not selling a product, I'm helping to build an industry."

Learn more at www.growtainers.com.

All-America Selections (AAS) has launched a fun new endeavor to help the gardening industry promote AAS Edible Winners.

"These days, a love of gardening is directly related to a passion for cooking," explains AAS. "Tying the two together is a natural when marketing joys of cooking with fresh vegetables from the garden and farm market."

AAS engaged Jonathon Bardzik, a "culinary storyteller," entertainer and horticulture industry veteran, to produce their first series of five videos demonstrating cooking techniques with AAS-winning vegetables.

You can check out their videos on the AAS website at http://all-americaselections.org/index.cfm.

Garden retailers, mail order retailers and other garden supporters can download and use the videos free of charge on their websites or at special events. In addition to the videos, there are recipe cards available for printing and distribution.

AAS says they plan to promote the videos to consumers on social media starting in 2016 using the hashtag #Garden2Table.

Census Data Says Farm to School Program is a Good Thing

Preliminary data from a census looking at the U.S. Farm to School Grant Program suggests the program is offering numerous benefits to kids, farmers and the environment. The data suggests that a strong farm to school program can increase the number of students purchasing school breakfast and lunch, improve consumption of healthier foods at school and reduce plate waste.

Census data also indicates that schools purchased nearly $600 million worth of food locally during the 2013-2014 school year. That's a 55% increase over the 2011-2012 school year when the first census was conducted. This is good news for our industry. The program continues to create new marketing opportunities for fruit and veggie growers in their communities.

New Lettuce Trait Slows Discoloring

A vegetable breeder headquartered in the Netherlands has made news by introducing a new trait in its lettuce varieties that they say extends shelf life by two days as it slows down the discoloration process.

Rijk Zwaan, in De Lier, Netherlands, has nicknamed this trait KNOX. It goes without saying that such characteristics are sought-after in the supply chain. In a company press release, Rijk Zwaan's Convenience Manager Bauke van Lenteren pointed out that, "KNOX ensures you do not necessarily need low-oxygen packaging for lettuce; this allows for lower costs and more options when blending. This means getting rid of the negative smell that is characteristic of opening low-oxygen packaging."

The company, which has been working on this development for 10 years, is now rolling out about 10 varieties of lettuce that will all have the KNOX trait.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Exciting New Veggie Varieties Earn AAS Awards

A handful of new veggie varieties have earned spots on the winner podium at All-American Selections (AAS). Of the nine new AAS winners announced recently, six are edibles, including two peppers, two tomatoes, a white pumpkin and a strawberry.

Two tomatoes top the list as national winners for 2016. **Candyland Red** is the first currant-type tomato to earn an AAS award. The currant-type tomato is a bit smaller than a cherry-type, but packs big flavor into the dark red and sweet fruits. Candyland Red is bred by PanAmerican Seed Company.

STRAWBERRY DELIZZ

Chef's Choice Green tomatoes produce beautiful green-and-yellow-striped fruits throughout the season with "perfect" tomato texture. Bred by Seeds by Design, Inc., the plant is commended for its well-behaved form and disease resistance.

Two sweet Italian frying peppers are also national winners. Both are described as having outstanding flavor raw, cooked and fire-roasted. **Cornito Giallo** and **Escamillo** are both golden yellow and are bred by Johnny's Selected Seeds.

Super Moon is a winner for the Southeast and Great Lakes regions. It's the first white pumpkin to earn AAS accolades and is sure to spice up any fall décor. Super Moon is also bred by Seeds By Design, Inc.

Delizz is a national winner, described as a vigorous plant that produces sweet flavorful strawberries throughout the growing season. Bred by ABZ Seeds, the uniform habit and compact size of Delizz makes it a great choice for containers.

Learn more about these varieties and others at www.all-americaselections.org.

AAS WINNER

The Veggie Shortage/ Food Waste Connection

Our dismal vegetable consumption might have something to do with the American diet in general. But the USDA's newest food availability data (based on 2013) also shows that we don't even have enough vegetables available—even if folks wanted to actually eat their recommended daily servings. (FYI, that would be 2.5 cups of vegetables per day.) The USDA's Economic Research Service (ERS) says there are only about 1.7 cups per person available. So is it a case of low supply due to low demand? Or is it a case of low consumption due to low supply?

The ERS points out that U.S. consumers mainly eat a few mainstay veggies. Lettuce, potatoes and tomatoes compose 59% of vegetable availability (think French fries and ketchup). Nutritionists, of course, would love to see people eating a larger diversity of nutrient-dense vegetables.

As far as fresh vegetables go, in 2013, the farm weight available per capita of fresh vegetables was 184 pounds. The lowest it has ever been was 143 pounds in 1969. The highest was 204 pounds in 2004.

However, the amount of overall food waste may be the more startling fact facing the U.S. and it's one that officials are beginning to see as a threat to overall food security, as well as the country's natural resources. So much so that Agriculture Secretary Tom Vilsack and Environmental Protection Agency Administrator Gina McCarthy announced the United States' first-ever national food waste reduction goal, calling for a 50% reduction by 2030. They plan to partner with everyone from the private sector to state, local and tribal governments, as well as charitable organizations, to reduce the amount of food that gets dumped.

Fast fact: Approximately 31% of the U.S. food supply is wasted. That's about 133 billion pounds. Much of that happens at the retail and consumer level, after it leaves the growers' hands. But that's not to say there isn't room for improvement at the production level. Here's one inspiring story of how a nonprofit organization recovers food that would otherwise be left to rot from both farms and stores:

After the Harvest puts fruits and vegetables into the hands of people struggling with poverty and hunger in Missouri and Kansas. Growers can donate unsellable produce directly to the organization. But the interesting part is that After the Harvest also runs something called a Gleaning Network, working with local growers to provide labor to glean their fields and orchards post harvest. They then deliver the food to food pantries, soup kitchens, shelters and food banks.

They recently told *Food Tank* that they hope this gleaning process will work its way into agricultural practices throughout the Midwest.

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Up on the Rooftop

Viraj Puri, Eric Haley and Jennifer Nelkin Frymark came up with an interesting concept of building a rooftop greenhouse in 2009, building Gotham Greens in Brooklyn, New York, in 2011. Now, five years and four locations later, we sit down with Viraj at their new Chicago facility to see how business is going, learn about some of the challenges they've faced and the future of Gotham Greens.

By Jennifer Zurko & Chris Beytes
Photos by Chris Beytes

So you're seven years old—what have you learned in that time?

The last seven years have been really interesting. What we have learned is that there's a very strong demand in the marketplace for high-quality, locally-grown produce. Local is one thing, but it must consistently be of high, reliable quality—that is most important. Consumers increasingly care about how the food is produced, where it's produced and who is producing it. I think a lot of mass market, commodity produce consumed, until now, has been kind of anonymous, co-packed product, maybe under a brand name, sometimes. But I think people are now understanding the supply chain better and really like the idea of having something locally produced, as it can be fresher, more nutritious and sustainable, and they can support local economies by making those purchasing decisions.

Secondly, we've learned that greenhouse growing is far from easy. I know that sounds very simplistic, but it's a very important lesson. There's a perception among industry outsiders that controlled environment agriculture means automatic crop production and that if one just raises enough capital and builds a high-tech greenhouse, the plants will grow themselves. As I'm sure your readers will agree, nothing could be further from the truth. Controlled environment agriculture requires a great

Photo courtesy of Gotham Greens.

degree of technical skill—a combination of engineering and horticultural techniques and dialed-in business operations. Despite this being controlled environment agriculture, there still are fluctuations in conditions that can disrupt yield throughout the year. You need a highly skilled team of growers to operate the facilities. And the margins are thin in this business and you need to be on your game. You need to have solid operations, very high quality control, very high food safety, a good marketing and sales team, good logistics—it takes a whole business to really thrive.

Where's Gotham Greens today versus where you expected to be or where you planned to be?

We're very proud to have built four greenhouse facilities over the past few years and across two cities. I think a lot of your readers will appreciate that it's hard to build greenhouse facilities from scratch. And we've taken a much more deliberate approach building one facility at a time before expanding too quickly—figure out our operations, get better at crop quality—it's given us a lot more confidence to now grow even more aggressively versus trying to be very aggressive out of the gate. We've had very much a one-foot-in-front-of-the-other approach, which I think has served us well. So, now given that we're no longer a startup—rather we're now a profitable, viable, medium-sized enterprise with over 125 employees—I see Gotham Greens growing more rapidly and aggressively in the coming years.

Are you already looking at the next location?

We are. Several locations. More in New York, more in Chicago, other markets on the East Coast, will have more Gotham Greens locations soon. Again, our approach has definitely been to put one foot in front of the other. But, yeah, our vision is to one day have a network of greenhouses all over the country that's growing high-quality, local produce to serve those markets.

So, you'll have multiple greenhouses in New York and Chicago, doing more but in the same area—it's seems inefficient because you have so much redundancy. Wouldn't it be better to have that one 10-acre greenhouse 10 miles west than ten 1-acre ones a little closer?

Absolutely. There's definitely economies of scale and operating efficiencies to be had by consolidating operations, but we want also to do innovative, cool projects that push the boundaries of conventional horticulture. So if someone at Gotham Greens wants to do a really cool greenhouse in downtown Chicago and it's only 40,000 sq. ft., we may do it if we think it's cool.

But certainly, putting on the straight business hat, it's an economies-of-scale business and, obviously, being consolidated and eliminating that redundancy and having just that one facility can have benefits. I think you'll see Gotham Greens build larger facilities in and around urban areas. and also build smaller, fun and exciting greenhouse projects because we want to push the envelope with horticulture, greenhouse growing and the locations we pick, the partners we pick and the community benefits [from that].

Convince us that this type of business isn't a flash in the pan, that you can make money.

Led by Jenn Nelkin Frymark, we've got the best greenhouse growing team around and they're supported by a solid corporate team. There are a lot of established greenhouse players and Gotham Greens is no different. Gotham Greens is an excellent grower. Period. We choose to bring our greenhouses in and around urban areas and we've located them on rooftops, which makes us different from established growers for sure. But at the heart of it, we're damn good growers and have earned a strong reputation. Our produce has been available in some of the leading retailers and restaurants for the past five years. We're no longer a start-up indoor ag player that is experimenting with commercially unproven technologies or systems or concepts. I put us in a very different bucket than a lot of those start-up companies involved in vertical farming and aquaponics. >>>

I do have respect for them. We're all part of this new breed of controlled environment agriculture, but in terms of our vendors, our growers, our practices, approach to our business, we liken ourselves a lot more to the older school, established greenhouse operators. I think what distinguishes us is A) we're bringing that production into an urban area; and B) we're winning customers with superior quality, hyper-local product. We lead with the quality of our products and not with the business concept.

We could build a million rooftop greenhouses, and people might buy our produce once or twice, but if the product tastes bad, no one's going to buy it again. So we are not touting the rooftop model or the world's largest this or the world's largest that, but really we're trying to lead with consistent and reliable premium-quality produce and I think that's evidenced by us being in business this long, our produce being available at top national retailers, Michelin-star restaurants sourcing it over and over again. The proof is in the pudding. So I think we definitely want to distinguish ourselves from this rapidly growing vertical farming, indoor, experimental, R&D-type growing sector. We're part of the new breed of CEA, but at the same time, we're an established greenhouse grower at this point.

How about vertical farms? What's your view of those?

I think they're very interesting conceptually. The adaptive re-use of real estate, application in diverse, extreme environments and the potential high crop yields are compelling. I haven't yet seen any examples of any truly being commercially viable and profitable, though, at least in North America yet. I think the big questions are about the lighting and climate control—can the lights really, truly produce the right spectrum that the plants need to grow well and can it be done consistently and reliably and, most importantly, cost effectively? And the climate control? I think the jury's still out.

Now, that being said, I think the lighting manufacturers have spent a lot of time and resources in the research in horticultural lighting, specifically LEDs, and they've come a long way the last couple of years. And I believe that they will play a much greater role in greenhouse lighting, supplemental lighting in the years to come, given the great progress they've made.

At Gotham Greens we too experiment with LEDs in our facilities—we use fixtures from at least five different manufacturers. But in our experience, the LED lighting, which is so critical to the viability of fully indoor vertical growing, is still not up to par with natural sunlight and more conventional supplemental greenhouse lighting. At least, that's what our research has demonstrated. We think the LED future is promising.

Bottom line is that I think vertical farming is an exciting area of innovation in agriculture, but still has to be proven. But I do have to respectfully disagree with claims that vertical farming, or even greenhouse agriculture for that matter, can somehow be the future of farming and replace more conventional types of farming. The crop selection simply doesn't allow for it to be a one-size-fits-all solution.

In the end, all they're trying to do is emulate what you've already got naturally through the sun and natural greenhouse ventilation. They're not necessarily going to get any better than what you have naturally.

I think the idea, though, is that if they can stack more plants and more plants, you can get a much greater yield per area. But the key is achieving the quality and the yield of the crops in all those different layers—are they that much better than doing it on a single layer?

For example, if I'm doing a single layer and I get 10 pounds per square foot and they've got 10 layers, but they're only getting a couple of pounds per square foot, then we've arrived at almost the same place and they've used a lot more energy and resources. If they can get consistently high yields from all layers, well then that's another story. But I don't know this for a fact because I don't know the inner workings of those operations. I do know some of the guys who've started those companies and I think they're cool and I think they're pioneering, innovative and smart. But, again, to answer your question, my thought is that the technology is still somewhat unproven and it's yet to be demonstrated to be successful on a commercial scale. Once it is, those players will be well positioned to do well. Perhaps Gotham Greens will also grow vertically one day once its proven to be viable.

What are the things you've learned about having a greenhouse on rooftop in a city that you didn't anticipate and has been a challenge?

Some of them we anticipated—like regulatory, permitting, infrastructure—but others not so much. But the challenges are obvious: there's logistical issues—you're contending with freight elevators and then it has to get into the loading dock and the truck and out the door. But that's just what you have to deal with being on a higher floor. The other thing that's obviously challenging is, when a facility is successful, we cannot expand upon that same footprint because you don't have the space. If we had a 2-acre greenhouse range on the ground and business was great and we wanted to expand, you could throw on a couple more bays. You can't do that on a rooftop.

Yeah, even if you could buy the rooftop across the street—which probably wouldn't work because it's not the right shape. How are you going to deal with that issue?

You've got to build a new facility. But I think fixating on the rooftop is also not necessarily the main thing we're about at Gotham Greens. The rooftop is symbolic of innovative, adaptive reuse of urban space, its underutilized real estate that allows us to be right in the heart of a city. But we want to be defined by what's happening inside the greenhouse, not whether it's on the ground or from the roof—that doesn't matter. If it's on the roof, great—it's unused real estate, it's a great talking point, it's a cool architectural project—but really, our focus is being a solid greenhouse grower.

It's not like we're fixated on the rooftop. It's allowed us to build greenhouses in cities, but it's challenging to do that. In New York City, you can't do it on the ground; the land is just not available or is prohibitively expensive. So this way, we've become this hyper-local brand. But, again, we try and let the produce define us and not the rooftop aspect.

That's a big marketing and PR tool for you, though. Would you sell as much if it was coming from 10 acres of greenhouse in New Jersey?

I don't think we would get as much press and media interest as we do, but I do think we would sell as much product, because at the end of the day, the produce buyers and chefs are buying Gotham Greens for the quality of the product, the customer service and getting a local product on the shelf.

How do you quantify that your product is "high quality"?

It tastes better than the competition. We do customer and consumer surveys. We get data from our buyers on what sells out in the stores. They report very little to no spoilage for our product. Produce is, obviously, very perishable. Most supermarkets factor into their P&L account loss of product, whether it's meat, seafood, dairy or produce. With our product, there's remarkably little spoilage, which I think is great evidence that the product sells well.

I think it's also evidenced by having the top chefs buy the product. The chef might buy it once because he read about it in a magazine, he might buy it a second time because there's a cool factor, but if he's not getting his product on time, whenever he needs his order and if it's not the perfect head of lettuce, he or she is going to stop buying it.

Why greens? Is it because they're easier and there's less competition than, say, tomatoes?

There are a lot of people who do great greenhouse tomatoes that are out there, so we saw a market opportunity in greens. We are doing some tomatoes in our New York locations. Ultimately, we want to have an offering across the board—things like cucumbers, peppers and strawberries, also.

Are you going to solve the food desert problem on Chicago's south side? Are you going to fix "broken agriculture," like all the indoor businesses say they're going to do?

Absolutely not. We don't have that kind of hubris. I think we can play a role in it, though. We announced a partnership with the Greater Chicago Food Depository and we donate a portion of our produce to those in need. In New York we work with a number of non-profits and food rescue organizations. But, no, that's not our mandate. But I do think we can contribute to addressing those issues.

Can an urban agriculture industry that just grows leafy greens and herbs and tomatoes and cucumbers solve the "broken agricultural system" or food security issues? No, but it can have a role to play in highly perishable greens and veggies that have to be shipped huge distances. Would it ever make up a majority of one's diet? No. Urban agriculture can't address staples like grains, dairy, protein, root vegetables, protein and tropical fruit.

But that being said, does that mean urban agriculture has no role to play? Absolutely not—urban agriculture has an important role to play and especially with highly perishable vegetables and greens and herbs that are often trucked or shipped thousands and thousands of miles. That doesn't make a lot of sense. There are also significant economic development, community development and educational opportunities that urban farming can foster.

So if you can farm in urban areas and you can do it well using fewer natural resources and produce high-quality product, produce jobs, create economic development opportunities and connect urban consumers with products that are grown closer to them, then I think that's great. And that's what we're focused on. We're not touting that we're going to revolutionize agriculture or be the complete future of farming—no, I bristle at that kind of talk. But can we be a large, established greenhouse player with greenhouse operations in and around all of the major cities across the country? Absolutely.

With more of these projects going up, what we see as a potential danger, is grocery stores and even chefs are going to be awash in locally grown products and they're just going to become commodities, just like the stuff coming in from Mexico or California.

I know that's certainly a possibility; just being locally grown is not going to be good enough. I think your product has to be able to speak for itself in terms of quality and price and customer service and I think that's what it's going to come to. I don't think you'll be able to sell the product forever just because it's locally grown.

More dangerously is consumers taking "locally grown" for granted, when they don't see them as anything special.

Perhaps. But at the end of the day, I think consumers are going to still be driven by quality, taste and value, so I think if local greenhouse operators can do that effectively, they'll be successful. But I don't think it's enough, to your point, to just tout that one's "local." I don't think that's going to be enough.

Have you looked at the food service market at all?

Yeah, we have. We've talked to a lot of food service operators who are very, very interested in local and differentiating themselves from their competition. I think they see the value in being able to market to consumers that this is a different product, not just a commodity product that's on their sandwich or in their grab-and-go salad.

I think it comes down to the enormous volumes that food service entails, which is a huge challenge for local operators. I think there's an infrastructure that's been built to support food service through commodity farming and a whole distribution network that's very entrenched. So even if certain buyers are excited to bring in a local product, they have to contend with the reality of the whole supply chain. McDonald's has, what 30,000 restaurants? Their secret sauce is being consistent across their operations, so even a 30/40-acre greenhouse is not going to be able to supply that. And let's be honest, food service—while the quality can be good—they pay commodity prices. And generally, what's grown in greenhouses tends to be sold more in retail.

A quick question on food safety—do you lose sleep when you hear about *E. coli* at Chipotle or listeria at Blue Bell?

Yes, there's a lot of concern. We take it seriously and have invested in food safety, in terms of resources, infrastructure, third-party auditing, compliance with the Food Safety Modernization Act. So that's something that we've paid a lot of attention to since we started and that's built into our standard operating procedures. But it's important. We're feeding people; we're providing a food product that they're feeding they're families and that's not something that we take lightly.

How much can you talk about brass tacks of the business side of Gotham Greens, like profitability?

I can't go into a lot of detail, being privately held. But what I can say is we're funded by professional investors. As any grower knows, greenhouses are capital intensive—especially building them in cities. We've raised a little over $30 million to date to build our facilities.

I can report that all four of our greenhouse facilities are profitable. But it's not easy to be profitable. IG

How Federal Food Safety Rules Will Affect You

Depending on the water source, irrigation method and type of fertilizers applied, the Food Safety Modernization Act could have a major impact on how greenhouse and controlled environment agriculture growers produce food crops.

by **DAVID KUACK**

On November 27, 2015, U.S. Food and Drug Administration released the finalized rules of the Food Safety Modernization Act (FSMA) in the Federal Register. The purpose of FSMA, according to an FDA press release, is to prevent foodborne illness "that, for the first time, establish enforceable safety standards for produce farms and makes importers accountable for verifying that imported food meets U.S. safety standards." FDA said FSMA's "final rules will help produce farmers and food importers take steps to prevent problems before they occur."

U.S. Centers for Disease Control and Prevention estimates 48 million people are sickened each year by foodborne pathogens. Of those people, about 128,000 are hospitalized and 3,000 die each year.

"The recent multi-state outbreak of Salmonella in imported cucumbers that has killed four Americans, hospitalized 157 and sickened hundreds more is exactly the kind of outbreak these rules can help prevent," said Michael Taylor, FDA deputy commissioner for foods and veterinary medicine. "The FDA is working with partners across the government and industry to prevent foodborne outbreaks. The rules will help better protect consumers from foodborne illness and strengthen their confidence that modern preventive practices are in place, no matter where in the world the food is produced."

The most recent multi-state outbreak of *E. coli* infections has been linked to Chipotle Mexican Grill Restaurants. Fifty-two cases in nine states have been reported so far. CDC's investigation is still ongoing to determine what specific food is linked to the illness.

As part of its efforts to minimize the risk of serious adverse health consequences or death from consumption of contaminated produce, FDA is establishing science-based minimum standards in the FSMA for the safe growing, harvesting, packing and holding of produce grown for human consumption.

WATER ISSUES

Phil Tocco, food safety educator at Michigan State University Extension in Jackson, Michigan, said one of the biggest issues that could impact greenhouse and CEA growers is water.

"FSMA's Produce Safety rule is going to

FSMA's Produce Safety rule's water-testing requirements will have a major impact on growers, depending on their water source and method of irrigation.

have a big impact on greenhouse growers and CEA growers," Phil said. "The growers who are really going to have to pay attention to this rule are the ones who are doing aquaponics with fish. Anytime any water, even if it is municipal water, comes into contact with anything animal-related, the water is considered agricultural water. The rule makes it very clear that fish are considered of animal origin. If water comes into contact with something of animal-origin or animals themselves, it must be considered untreated and is considered agricultural water. That water must be tested or treated in some way as to make it microbial safe. So growers who are doing aquaponics will have to put in some type of treatment system for the fish water used to fertilize if their fish water fertilizer water comes in contact with the plants."

Phil said there's an exception for plants being sub-irrigated with fish fertilizer water.

"If the water never comes into contact with the harvestable portion of the plants—for example, basil is being grown in a greenhouse and there is a tank of tilapia and the fertilizer water is circulated below the root zone so that the water never comes in contact with the upper portion of the plants. If anything that is being harvested never comes into contact with the water, it doesn't matter what condition that water is in because it's not considered agricultural water. However, if a grower took that same fish fertilizer water and applied it overhead, then he would have to treat the water.

"Most aquaponic growers that I'm aware of are using sub-irrigation, so there shouldn't be a problem with the water coming in contact with the edible portions of the plants. However, the one situation I am worried about is those growers who are producing crops like 'living' lettuce, where the roots are still attached to the plants. That may be an issue. Those lettuces are packaged with their roots attached, so the water they are grown in may come in contact with the harvestable portion of the plants."

Plants sub-irrigated in floating rafts that never come in contact with the irrigation water aren't considered to be growing in agricultural water, according to Food Safety Modernization Act rules.

WATER TESTING

Phil said the Produce Safety rule's water-testing requirements will have a major impact on growers depending on their water source and method of application.

"The rule will impact most growers who are drawing their irrigation water from wells and from surface water sources instead of using municipal water," he said. "A lot of greenhouse growers who are in urban areas use municipal water. Then there are growers who are out in the country and have their own wells.

"The rule tries to distinguish between a direct water application, where the water touches the harvestable portion of the plant, and an indirect application, where the water does *not* come into direct contact with the harvestable portion [of the] plant. FDA also wants growers to consider the risk of the water source, with municipal water being generally the safest source, and well water somewhat riskier. So depending on a grower's practices and water source, they influence the risk."

Phil said FDA wants growers to know what's in their water.

"Generally speaking, if a grower is going to be drawing from surface water, there is going to be a requirement that he test that surface water five times a year as close to harvest as he can, but before harvest," he said. "All five water samples cannot be taken on the same day and the samples need to be spread out as close to harvest as practicable."

FERTILIZER ISSUES

Phil said another area that could impact greenhouse and CEA growers is the type of fertilizer they're using.

"If a grower is using an animal-derived organic fertilizer, such as bone meal, blood meal or fish meal, it needs to be treated," he said. "Any fertilizer that is animal-derived needs to be treated, preferably by the person or company that is selling it, so that the microbial activity is reduced.

"If growers can't buy bone meal or blood meal because of the rule's requirements, the companies manufacturing these products are going to have to fix the problems so the >>>

growers can buy them again. Growers may have to find alternative fertilizer sources. The rule has made it clear that plant-derived compounds are exempt and don't fall under the scope of this rule."

Phil said growers who are using compost teas may also have to make some adjustments.

"Compost tea products are all over the board," he said. "Some people have taken composted manure and put it in water and let it sit for a couple days. Then they have used that to fertilize their plants. There are some people who use raw manure and do the same thing.

"For compost tea, if the compost itself is microbial treated and the water being used is microbial treated, then the tea can be applied. However, no types of additives like molasses can be added to the compost tea. Even if the molasses is considered safe, it has the potential to spike the microbial activity to the point where there could be a problem. Just like in the case of the water source, none of these are simple situations. That's probably the worst part of this rule—the changes and nuances are so fine."

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

Under FSMA rules, growers who are drawing from surface water are going to be required to test that surface water five times a year as close to harvest as possible.

Photo courtesy of Phil Tocco.

For more: Phil Tocco, Michigan State University Extension; (517) 788-4292, Ext. 6; tocco@msu.edu; http://msue.anr.msu.edu/experts/phillip_tocco.

Produce Safety Alliance, http://www.producesafetyalliance.cornell.edu.

National Good Agricultural Practices Program, http://www.gaps.cornell.edu.

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Bye-Bye Buffering

Proper processing of coir to lower its natural high salts level should eliminate the need to buffer it with calcium nitrate.

by **DAVID KUACK**

Coconut coir has been studied as a component of soilless growing media for over 20 years. Coir is produced primarily in Sri Lanka, India, Philippines, Indonesia, Mexico, Costa Rica and Guyana.

Coir has become a major component of both greenhouse vegetable and container crop production. It can be used by itself in grow bags, slabs and propagation cubes, or it can be used in growing mixes with other components like sphagnum peat, perlite and bark.

CLEANING UP COIR PROCESSING

Dr. Hugh Poole, international agricultural consultant, said coconut coir is initially high in sodium, potassium and chloride salts.

"Where the coconut coir originates from can have an impact on the salt levels," Hugh said. "Growers should assume that all coconuts have high salt levels. These salts are relatively soluble and are not totally bound by the coir, so they are easily leached. Most coir producers use rainwater for most of the year to remove the salts.

"If the EC [electrical conductivity] level is below 1.0 milliSiemens per centimeter [mS/cm], growers should not have to leach the coir. In most cases, the coir producers have already leached the coir for the growers. It should be ready to use. If the salts level is high, then the coir producer has not done its job. A producer should be able to provide growers with the coir's EC value, its pH value and other information, including percent moisture, as well."

Dr. James Altland, a research horticulturist at the USDA-Agricultural Research Service Application Technology Research Unit in Wooster, Ohio, said substrate manufacturers have worked to improve the processing of coir to ensure they're manufacturing a consistently standard product.

"In the past, coir wasn't always processed properly and the salt levels were sometimes too high," James said. "My impression is that the processing has been cleaned up. The media companies that are importing the coir and putting their names on it have taken measures to clean up the processing. They've standardized how coir is handled so growers can have confidence in the products they are buying. The concerns with high sodium levels were legitimate 20 years ago, but they aren't anymore, especially if the coir is coming from a reputable importer or substrate company."

TEST COIR BEFORE PLANTING

Hugh advises growers using coir to test for soluble salts before it's combined with other mix components and before any plants are placed in the coir.

"If the level of salts is low, then a grower doesn't need to worry about sodium, potassium and chloride," Hugh said. "Many growers say the soluble salts level should be less than 1.0 mS/cm; others say the salts level should be less than 0.5 mS/cm. It really comes down to how the coir is going to be used. If Ellepots are going to be filled with coco peat for young seedling production, then the soluble salts level should be around 0.5 mS/cm. Test results will vary depending on the testing protocol [saturated media extract, 2:1 or others], but the values should be low to moderate for the procedure used."

USDA-ARS research horticulturist Dr. James Altland said substrate manufacturers have worked to improve the processing of coir to ensure they're manufacturing a consistently standard product.

Dr. James Altland said if the coir is processed and packaged correctly, buffering with calcium nitrate isn't going to alleviate any problems.

James said whether a grower is producing an ornamental or food crop shouldn't make a difference when it comes to soluble salts level. He said the smaller the plants growers are producing, the more sensitive they'll be to substrate salt concentrations and pH.

"Whether the crop is begonias, peppers or microgreens, if growers are producing small plugs, the soluble salts level should be similar," said James. "In most cases, an EC level of 1 mS/cm or less is satisfactory."

Hugh said if coir is being blended with sphagnum peat, perlite or some other growing mix components, and plants are being transplanted into containers, the coir soluble salts level can be higher.

"I have seen EC values as high as 3 to 6 mS/cm," he said. "In these instances, unless the coir is being diluted with a lot of other mix components, growers would certainly want to leach the coir before it is used.

"If growers have to deal with a growing mix component with an EC level that is always bouncing around, it is going to be very challenging for those growers from crop to crop and from year to year," he said.

BUFFERING COIR

Hugh said some growers are asking suppliers to buffer their coir with calcium nitrate.

"These growers think that the cation exchange sites are loaded with potassium and sodium ions and if the coir isn't buffered with calcium nitrate then their crops may suffer a calcium or magnesium deficiency," he said. "These types of deficiency problems are more commonly encountered with hydroponic systems. If a substrate is being used, then this usually isn't a concern.

"Most of the coir's exchange sites are tied up with sodium and potassium. These ions are readily replaced by calcium. If calcium is applied, much of that calcium is going to be tied up in the exchange capacity taking out sodium and potassium. Therefore, calcium is not in the substrate solution for utilization by the plants. There is a lag before the cation exchange capacity can be fully charged with calcium, potassium and magnesium. If a grower isn't cognizant of this lag and doesn't address it, it can cause deficiency problems. When 50 ppm calcium is incorporated in the fertilizer solution, the leachate may only contain 10 ppm calcium. Not that the plants utilized the other 40 ppm. Much of that 40 ppm was tied up at the exchange sites and will be available later."

AVOIDING DEFICIENCY PROBLEMS

Hugh said if the coir's EC level is initially low and growers apply a Cal-Mag fertilizer at the beginning of a crop, there shouldn't be deficiency problems. He said growers using reverse osmosis water, in which there is no calcium or magnesium, should make adjustments in fertility, especially if they're producing a fast-growing crop. Although no deficiency problems might occur, Poole said growers should be diligent in monitoring fertility levels.

"Once the cation exchange sites are charged with calcium and magnesium, then there is free exchange and there shouldn't be any problems," he said. "In the first two to four weeks, growers should probably start out with higher calcium and magnesium levels if they're growing with coir. They should try to favor calcium and magnesium absorption at the exchange sites. This is a precautionary step."

James said if the coir is processed and packaged correctly, buffering with calcium nitrate isn't going to alleviate any problem.

"If the coir is buffered with calcium nitrate, then there is some level of nitrate going into that coir and that may result in an initial positive growth response," James said. "The nitrate is not going to have any effect on sodium concentration.

"Buffering with calcium nitrate is going to have a very short-term effect. There might be an initial positive response from the nitrate, but not a great response. How a grower is going to fertilize during the first week of production is going to have far greater influence on the plants than whatever was added to the coir to buffer it."

REVIEW WATER, FERTILIZER ANALYSES

Hugh said growers who are using coir and are planning to use a 20-10-20 fertilizer need to be aware that this fertilizer doesn't contain any calcium, magnesium or sulfur.

"The growers are going to have to add these nutrients," he said. "If growers are using coir, they have to recognize that the exchange sites need to be filled or charged with calcium and magnesium before there starts to be a free exchange of nutrients back and forth.

"With coir, where the exchange sites are filled with sodium and potassium, the only way of removing these ions is by reducing them with leaching with water or by overcompensating with calcium and magnesium."

Hugh said initially the natural salts found in coir must be leached with water. The remaining salts will be exchanged with calcium and magnesium by a buffering treatment or with elevated levels in the fertility program. He said buffering isn't an option for organic growers.

"If coir is washed well and its EC is >>>

International agricultural consultant Dr. Hugh Poole said if coir is properly washed and its electrical conductivity is below 0.5 mS/cm or lower, then the coir shouldn't have to be buffered for most crops.

below 0.5 mS/cm or lower, then the coir shouldn't have to be buffered for most crops. If calcium nitrate is used to buffer the coir, magnesium has to be provided as well."

James said he expects most growers would prefer to control the nitrogen levels.

"It would be better for growers to apply calcium nitrate so that they have more control over the amount that is added to the substrate," he said. "If I have a substrate and I have to fertilize, I want to know what I need to do, as opposed to wondering what is already in the substrate and how 'hot' it is. How much nitrogen is already in the substrate? You can't have the nitrate level too high, especially if you are producing vegetable crops."

Hugh recommends growers should review both their water analysis and their fertilizer analysis to know what nutrients they're applying and to confirm nutrient levels.

"Young plants and bare-root plants are more sensitive to high salts than to short-term nutrient imbalances," he said. "Long-term crops should be monitored using tissue analyses to optimize plant nutrition and crop productivity."

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

Dr. Hugh Poole recommends growers should review both their water analysis and their fertilizer analysis to know what nutrients they're applying and to confirm nutrient levels.

Photos courtesy of Riococo (http://riococo.com)

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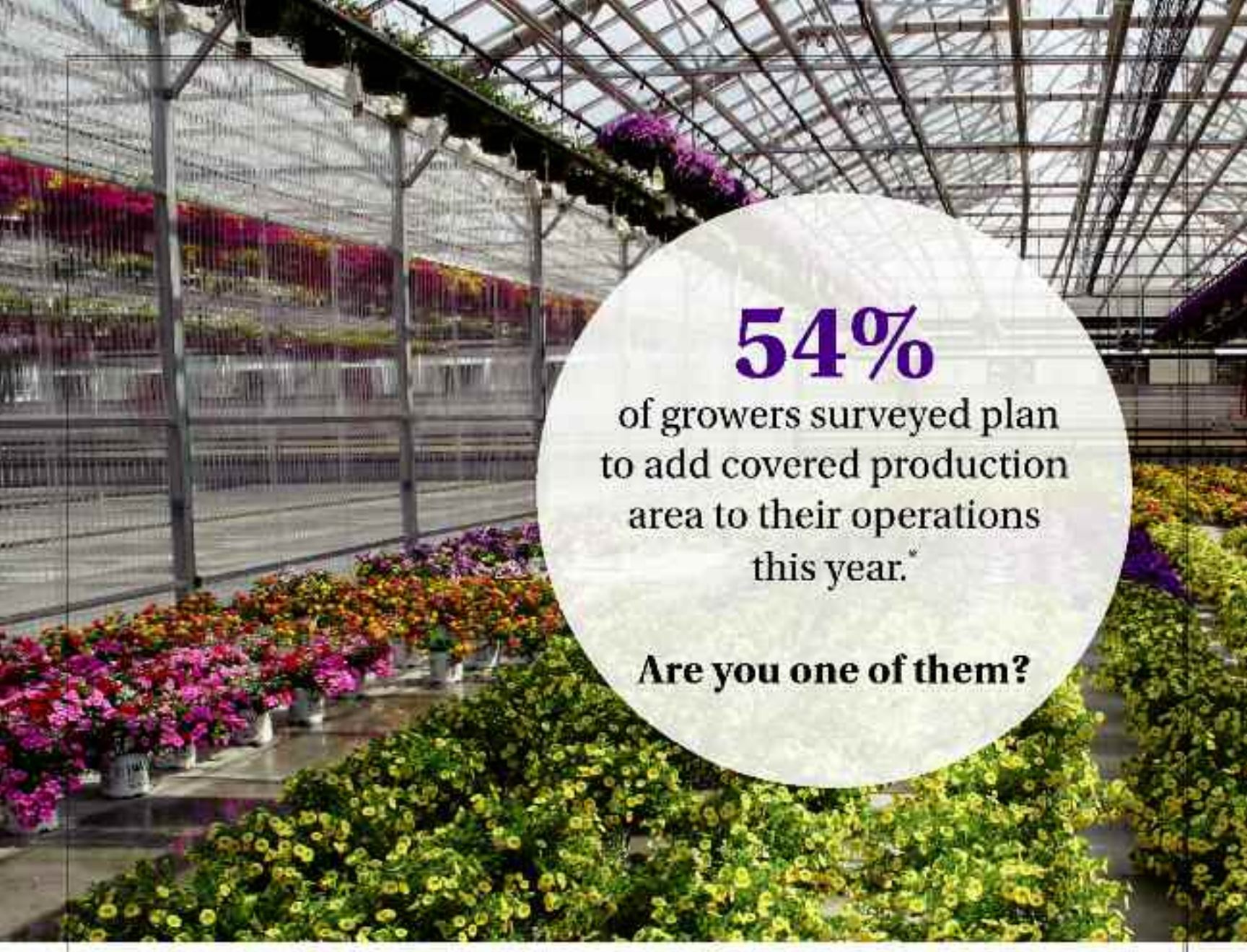
Some of the information presented in this article first appeared in the July 2015 "News from Hort Americas!" e-newsletter, http://www.hortamericas.com.



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Aiming High with 3 Stories

A vertical greenhouse with a social mission.

Story & photos by
JENNIFER DUFFIELD WHITE

It took six years, a lofty vision for a tiny sliver of vacant ground and a whole lot of collaboration, but Vertical Harvest co-founders Penny McBride and Nona Yehia have put a ground-breaking three-story greenhouse on the side of a parking garage in downtown Jackson Hole, Wyoming.

What might be more impressive is that they didn't set out to build a flashy hydroponic greenhouse; they just wanted to grow good, local food and provide employment to people with developmental disabilities. Along the way, it also became a project about education, engineering and balance.

The three-story, $3.7 million glass structure is state of the art, sun drenched and faces south, looking out onto the slopes of the local Snow King ski area. Before the glass was even installed, the media had hyped up this three-story greenhouse as the design of the urban future. We visited them in November, a few months before the construction was complete, to get a look for ourselves and learn what it was really about.

"It's been an evolution of people coming together at the right time," says Nona.

Penny, who grew up on a farm, had studied sustainable community systems, including agricultural systems. Meanwhile, there was Nona, a local architect whose firm, E/Ye Design, was focused on sustainable design. She also has a brother with developmental disabilities. The two began to envision a place where it all came together.

STORY 1: A FULLY INTEGRATED WORKPLACE

Unemployment among employable developmentally disabled Wyoming residents is a staggering 78%. Vertical Harvest is giving some of those people a new place to work. For the last two years, without a greenhouse to work in yet, Vertical Harvest has been educating a group of 20 trainees on how to take care of the plants and harvest them so they'll be ready to enter the greenhouse this winter.

"One of the amazing things is that the impact on our employees is already apparent," says Nona of their experience so far. "It's really flipping the perception on what these individuals can do. They can be trainees and leaders."

Penny is quick to point out how much their new employees are teaching them about the value of people. "It's also what they bring to the table," she says.

The workers with developmental disabilities will each be on a customized employment plan, meaning they'll work hours based on their desire and their skills—anywhere from four to 40 hours a week. A part-time employment facilitator is in charge of training and managing the employees, as well as working with programs that support them.

Vertical Harvest's production will be in experienced hands. They recently hired Timothy Schutz as their director of production. He comes with a background in hydroponic growing and tomato production.

STORY 2: ENGINEERING

"We didn't start out to build a three-story greenhouse," says Penny. They just wanted to grow as much food as they could in a small space (real estate in Jackson is some of the most expensive in the country), extend the growing short season and hire a workforce that would really benefit from working in the greenhouse.

So an innovative three-story design is what they ended up with. The city had a vacant 30 ft. by 100 ft. lot on the side of a new parking garage—not much room for a hoop house, but they got creative and looked to Dickson Despommier's ideas about vertical farming. "We put down what we thought was possible," says Penny.

But they also knew it needed to please the eye. In Nona's world, architecture is more than just a building. And in Jackson Hole, she points out, "you have to be careful in a town that has a lot of great aesthetic value." While many urban agriculture operations grow in warehouse spaces, Vertical Harvest knew that wasn't ideal for their employees. "We wanted a really beautiful place for them to work in," explains Nona.

It was Thomas Larssen, of Larssen Ltd. Greenhouse Engineering, who brought the project from a vision to reality. "He wasn't afraid," says Nona. "He took what we had and distilled it into something realistic."

Vertical Harvest broke ground in November 2014, and as we went to press, they were within a week of planting their first crops. Dutch workers installed the plant carousels, which create a moving wall of plants that extends from the first floor up into the second story and will constantly rotate, allowing for light distribution, as well as a single harvesting area where plants come to the workers. Between the carousels and the efficient design, Vertical Harvest calculates that the system turns a 4,500 sq. ft. footprint into an 18,000 sq. ft. growing area.

A hydronic heating system provides insurance against the long winters at 6,000 ft. (and it helps keep the roof clear of snow). And all of it, still, despite all the setbacks and hard work, seems to enchant Penny and Nona, who call it, "a lovely and elegant way to grow."

The three-tier system features three microclimates:

Floor 1: The ground floor is the coolest and includes a production area, a separate living wall (for demonstration only) that the public will be able to visit, as well as educational space and a small retail store that will function like a year-round farmers market, selling their produce and food from other local producers. They have LEDs on floors one and two for supplemental lighting. >>>

Vertical Harvest's three-story greenhouse being built onto the south side of a parking garage in downtown Jackson Hole, Wyoming. The building was designed not only for growing, but to fit into the discerning aesthetics of the community.

Program Director Penny McBride (left) and Managing Partner Nona Yehia on the third floor of the greenhouse.

Floor 2: Slightly warmer, the second floor is designated for lettuce, herbs and microgreens. It also has a few of the lower-light areas in the construction, so they placed a germination chamber, a seeding area and propagation tables on this floor, as well.

Floor 3: With a glass roof above, the third floor will be the warmest section and is, therefore, the tomato floor. It features HPS lights (and some really great views).

The plant carousel system rotates both vertically along the outside windows, as well as horizontally within the production area, giving plants access to both natural and artificial light.

STORY 3: THE BUSINESS MODEL

"We're a for-profit business with a non-profit soul," is how Nona and Penny like to explain their LC3 or Bcorp status as a low-profit business. The hybrid status allows them to stay true to their social purpose while still maintaining some of the legal and tax flexibility of a traditional LLC.

Vertical Harvest is purposeful in inviting the community into their space—for education, for art and to buy produce, but they still plan for the majority of their predicted 100,000 lbs. of annual produce to be sold wholesale. They have pre-sold 95% of their crops to the local hospital, grocery stores and restaurants. The remaining 5% will be distributed via their retail space and community programs.

The co-founders admit that this is a learning project. "It's about what's possible," says Penny.

They say they're constantly aware of the potential for the social aspect or the business aspect to cannibalize the other and that they need to balance both to fulfill their mission.

They're already getting calls from people wanting to learn more about vertical growing and to build similar systems. And they hope Vertical Harvest will push that intersection of urban growing, more diverse crops and social awareness.

"We don't want this to be a one-off," says Nona.

Time will tell how the multi-story greenhouse works. But for now, Vertical Harvest's biggest accomplishment is showing what can be done with partnerships and a strong sense of mission. And we might add, a willingness to build outside the box.

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The Quest for

To escape an unsavory circumstance, one young man finds his calling in growing vegetables.

by **ANNE-MARIE HARDIE**

Passionate, hard working and resilient are three words that describe Carlos Palomares, owner of Mighty Greens. During his seven-year journey in horticulture, Carlos continually adjusted and adapted his skill set to become the business owner that he is today. It's this ability to adapt that enabled Carlos to escape his life in Las Vegas and seek out a brighter future in Illinois.

Born in Mexico, Carlos' father moved his family to Las Vegas so that he could work at a local farm. Although a positive move for his family, life in Las Vegas presented some challenges for Carlos.

"I got in trouble and fell into some bad experiences," said Carlos. "I knew that this wasn't where or what I wanted to be, and so in early 2008, I decided to move to the farthest place I could move to from Las Vegas."

Desperate to get away, Carlos called his godfather, Victor Ahumada, in Illinois and asked if he could help him find a new start. Victor welcomed him with open arms, providing both a home and an offer of a job at a local organic vegetable farm, Heritage Prairie Farm.

Without any specific career in mind, Carlos decided to try out farming on a part-time basis. To his surprise, he discovered that he not only liked working with plants, but believed that horticulture held the key to his future.

"There was something special there; it connected me with the soil," says Carlos. "It was so therapeutic to be growing things organically, without any help from chemicals or big machines."

It was at Heritage Prairie Farm that Carlos built a strong growing foundation, delving into organic vegetables and microgreens. Although microgreens were only a small portion of Heritage Prairie Farm, Carlos saw potential in this sector of the industry, believing that this could be the core of his future livelihood.

"I knew that microgreens was going to be our backbone," says Carlos. "It was something you could do in a heated greenhouse year round and it's profitable."

To further his education, Carlos left Heritage Prairie Farm to work as a manager of an emerging microgreen farm in Kansas City, Missouri. Carlos' knowledge grew, paving the way to start his own operation. And so in September 2014, Carlos and his wife Katie moved back to Illinois and began their own microgreen operation aptly named Mighty Greens Farm in the rural town of Elburn.

Although it's just been over a year, the response has been phenomenal, allowing Carlos to add essential equipment and double the size of the greenhouse.

"Our community is interested in eating fresh, local greens. It's something that we can do year round," says Carlos. "The bigger greenhouse has allowed us to continue to grow without running out of space."

As part of his operation, Carlos has incorporated the practices of Elliot Coleman, author of "Four Season Farm," including adding two moveable structures in the spring and fall to expand Mighty Greens' production.

"These structures allow us to bring other items to market other than just microgreens," says Carlos. "They are not stationary, but they move from plot to plot."

Being able to have fresh produce year round has driven Carlos to investigate the potential of winter harvests.

"I eat every single day of the year," says Carlos. "One of my dreams is to have a greenhouse that I can continue growing all year round. It not only fulfills my passion, but will permit me to continue feeding those people that love having local food and supporting local growers."

Over the past year, Carlos has learned that the key to success is to provide the crops with their optimal environment. He urges growers to pay attention to how the plants are responding and to adjust your operation accordingly.

"The biggest thing that I learned is that even though they are just plants, and may not seem to be alive, they communicate to us, said Carlos. "You can see their reaction to certain environments in the greenhouse."

A natural businessman, Carlos is continually looking at both new markets and ways to increase overall profitability. One of the biggest impacts to Mighty Greens production was the consistent use of the germination chamber. After experimenting with a variety of struc-

Something Better

tures, Mighty Greens opted for a fully insulated box, sealed and maintained at a steady temperature of 75F (23C). Using heated water, the steam adds the additional humidity that the microgreens thrive off of. Arugula and radishes are two of the fastest germinating seeds, leaving the chamber fully germinated.

Despite it being labor intensive, Mighty Greens has opted to put every plant through the germination chamber for a maximum of 72 hours. Although some seeds won't germinate, Carlos has found that the process still reduces the overall germination time.

"Some farmers would argue, 'Just be patient.' We could do that; we could leave our trays under our benches to germinate," says Carlos. "But then we would have our greenhouse full of trays waiting for them to germinate. We prefer to go through the trouble of using the germination chamber than just having the trays waiting around."

As an added bonus, the fast turn-around time seems to reduce the amount of pests and disease. "Our germination helps with insect management," says Carlos. "A bug simply doesn't have the time to settle on certain crops."

Although not an organically certified farm, Carlos is constantly researching alternative methods to cope with insects. Currently, Mighty Greens is pairing greens to repel insects—in particular radishes and onions.

With over a year under his belt, Carlos feels he has the tools in place for the continued growth of Mighty Greens. His hope for the future is to continue to move forward branching into bigger markets, more restaurants, and eventually, wholesale.

1 Carlos Palomares and his wife Katie started Mighty Greens Farm in Elburn, Illinois, which grows microgreens and organic vegetables for local restaurants and community.

2 One of the biggest impacts to Mighty Greens production was the consistent use of the germination chamber.

3 Carlos incorporated the practices of Elliot Coleman, author of "Four Season Farm," by adding two moveable structures in the spring and fall to expand Mighty Greens' production.

4 Carlos plants peas with his 3-year-old son Henry.

ANNE-MARIE HARDIE is a freelance writer/speaker from Barrie, Ontario, and part of the third generation of the family-owned garden center/wholesale business Bradford Greenhouses in Barrie/Bradford, Ontario.

VPD vs. Relative Humidity

Vapor-pressure deficit is independent of temperature and is a more accurate measure to predict plant transpiration and water loss than relative humidity.

by **HEIDI WOLLAEGER** *&* **ERIK RUNKLE**

Greenhouse ornamental and vegetable growers manage many environmental factors in their greenhouses—sometimes including humidity. Air with a high relative humidity, greater than 85%, can provide an environment conducive for fungal pathogens because the water lost through the stomata is slowly lost to the air and, therefore, remains on the leaves.

While relative humidity is the most common way growers express the air's saturation with water, it's not the best measurement to accurately predict plant transpiration or water loss. Why?

Relative humidity refers to the amount of water vapor in the air versus what it can hold. The amount of water that air can hold varies with temperature; warmer air has a greater water-holding capacity than cooler air. The water-holding capacity of air approximately doubles with every 20F-degree increase in temperature. Therefore, air that is at 80F (26C) can hold twice the amount of water compared with 60F (15C).

Instead of relative humidity, the more accurate way to express the driving force of water loss from a leaf is vapor pressure deficit (VPD). Its value is independent of temperature. VPD is the difference between the amount of moisture in the air and how much moisture the air could potentially hold when it's saturated. It's often measured in pounds per square inch (psi) or kilopascal (kPa). A high VPD (greater than 1.0 kPa) means that the air can still hold a large amount of water. Therefore, there's a fairly large gradient between plants (nearly saturated with water) and the air, enabling the plants to transpire and, over time, dry out. A low VPD indicates the air is near saturation. A VPD of zero means the air is 100% saturated and thus plants cannot transpire effectively.

Growers should aim to have fairly low VPD—for example 0.3 kPa when rooting cuttings in greenhouses. This will reduce the drying of young plants, thereby reducing the frequency of misting and watering required to keep plants hydrated. However, Michigan State University Extension recommends maintaining a greater VPD (greater than 0.5 kPa) in greenhouses while finishing plants, especially when there's a dense plant canopy. Plants will be able to transpire, cool themselves and be less stressed while the environment is less conducive to disease.

While relative humidity is the most common way growers express the air's saturation with water, it's not the best measurement to accurately predict plant transpiration or water loss.

Too dry of an environment can cause problems for greenhouse vegetable growers.

When temperature is increased by 15F increments and relative humidity stays the same, vapor pressure deficit varies from 0.55 kPa to 1.45 kPa.

Temperature	Relative humidity	Vapor pressure deficit
60F (15C)	70%	0.55 kPa
75F (24C)	70%	0.90 kPa
90F (32C)	70%	1.45 kPa

When temperature is increased by 15F increments and vapor pressure deficit stays the same, the relative humidity varies from approximately 22% to 71%.

Temperature	Relative humidity	Vapor pressure deficit
60F (15C)	22%	1.38 kPa
75F (24C)	41%	1.38 kPa
90F (32C)	71%	1.38 kPa

Greenhouse vegetable growers harvesting fruits should be aware that one study,"Vapor Pressure Deficit (VPD) Effects on the Physiology and Yield of Greenhouse Tomato," reported that a VPD of 0.8 kPa during the day and night increased photosynthetic rates and tomato fruit yields compared to plants grown with a VPD of 0.5 kPa. Too dry of an environment can also cause problems. For example, another study,"High Vapor Pressure Deficit Influences Growth, Transpiration and Quality of Tomato Fruits," showed that a very high VPD of 2.2 kPa could cause plant stress and fruit cracking in tomatoes.

HEIDI WOLLAEGER is with the Michigan State University Extension and **ERIK RUNKLE** is a professor in Michigan State's Department of Horticulture.

Symptoms of Common Nutrient Deficiencies in Hydroponic Lettuce

As with insects, diligence is key to spotting when your lettuce is lacking certain nutrients.

by **NEIL MATTSON & TANYA MERRILL**

Managing the nutrient solution of hydroponic crops can be much more challenging than container-grown crops because: 1) hydroponic solutions are often captured and reused, which can, over time, lead to deficiencies of some elements and excess of others; and 2) pH changes much more quickly in hydroponics than in container-grown plants.

Hydroponic growers should monitor nutrient solution pH and EC daily, as well as periodically have their nutrient solution tested by a laboratory to make sure nutrient supply meets plant needs. Monitoring plants to look for visual symptoms is another tool that can be used to detect nutrient deficiencies. Lettuce is one of the most commonly grown hydroponic vegetables. Currently, there are few resources in the literature regarding photographs and descriptions of common nutrient disorders in hydroponic lettuce. Therefore, the objective of this study was to grow butterhead lettuce in nutrient solutions deficient of individual macro- and micro-nutrients to document visual symptoms of nutrient deficiencies.

MATERIALS AND METHODS

Pelleted Flandria lettuce seeds were sown in 1-in. (200-cell) rockwool cubes that were previously soaked in reverse osmosis water for five minutes and then drained and soaked and drained in a Sonneveld's nutrient solution for lettuce (Mattson and Peters, 2014). Seedlings were placed in a greenhouse at 68 to 72F (20 to 22C) with ambient light and hand watered daily (or as needed) with the Sonneveld's nutrient solution.

Fourteen to 20 days after seeding the lettuce seedlings in rockwool, they were placed in the lid of 1-gal. buckets filled with the Sonneveld's solution and with an airline from an aquarium pump with an airstone on each end. There was one plant per bucket. After the plants had been established in hydroponics for one week, the nutrient solutions for each bucket were replaced with either a control solution prepared in reverse osmosis water (Table 1) or the control solution minus one nutrient element of interest (-N, -P, -K, etc.). Every other day, reverse osmosis water was used to raise the solution level in each container back to 1 gal. Every week, the nutrient solution in each container was completely replaced with new solution.

Plants were monitored every week and visible symptoms of nutrient deficiency (with reference to the control plants) were noted. There was one plant for each nutrient deficiency condition; the experiment was repeated over time for a total of three replications.

◀ **Nitrogen (N)**—Nitrogen deficiency initially resulted in lighter green color, which proceeded to uniform chlorosis (yellowing) of older leaves. Reduced growth was noticeable within the first two weeks of exposure to the deficient conditions. Severe chlorosis of older leaves was observed after three weeks of deficient conditions.

◀ **Phosphorus (P)**—Phosphorous-deficient plants (right) were shorter and exhibited more reduced growth compared with control plants (left), evident within two weeks of deficiency. Leaf margins of older leaves exhibited chlorotic regions followed by necrotic spots present after four weeks of deficiency.

▲ **Potassium (K)**—Potassium deficiency initially resulted in small necrotic spots on margins of old leaves, which advanced to larger necrotic regions as the deficiency continued. By the fourth week of deficient conditions, large scattered necrotic regions had developed on mature leaves and leaves began to curl downward.

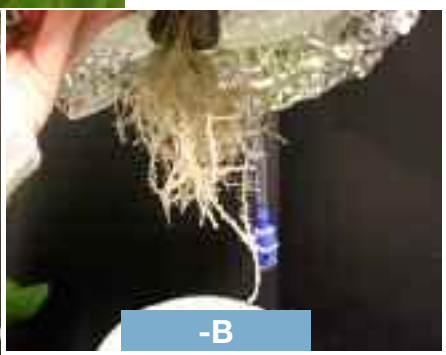
▲ **Calcium (Ca)**—Within the first week of exposure to the calcium-deficient solution, there were numerous scattered necrotic spots on young leaves, and marginal necrosis and distortion of the youngest leaves. The growing tip was completely dead by the third week. Symptoms were much more dramatic than leaf tipburn, which typically occurs when there's enough calcium in the nutrient solution, but environmental conditions (high humidity, rapid growth) don't allow enough calcium to reach the growing point and new leaves.

▲ **Magnesium (Mg)**—About 10 days after deficient conditions, mature leaves exhibited light interveinal chlorosis, and shortly thereafter, marginal necrosis was visible. After three weeks of magnesium-deficient conditions, all lower leaves exhibited severe interveinal chlorosis, as well as marginal necrosis and some scattered necrotic spots along the leaf blade.

▲ **Sulfur (S)**—Within 10 days of sulfur deficiency, plants exhibited uniform chlorosis across the entire leaf blade. While the whole plant was affected, chlorosis was most pronounced on recently mature leaves and newer growth. After four weeks of deficient conditions, the entire plant was uniformly chlorotic and plant size was much reduced to control plants.

◀ **Iron (Fe)**—Iron deficiency resulted in interveinal chlorosis of new growth within 10 days of exposure to deficient conditions. By the third week, similar symptoms became more advanced on the plant and were presented on recently mature and younger leaves.

◀ **Boron (B)**—Early symptoms of B deficiency included distorted new growth with slight marginal necrosis and leaves cupping upward. As symptoms advanced, the growing point became crowded with new leaves that weren't properly unfolding/expanding. The root system was much smaller than control plants with short primary roots.



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DISCUSSION

The timeline for development of symptoms may vary based on your environmental conditions. Many nutrient disorders are similar in appearance, therefore, laboratory analysis of leaves is necessary to verify symptoms (Table 2).

Periodic laboratory nutrient solution analysis is an important proactive tool to detect nutrient disorders earlier than when visible symptoms appear on the plant. In many cases, nutrient deficiencies may be due to environmental causes rather than to lack of nutrients in the fertilizer solution. For example, calcium deficiency, (i.e., tipburn of lettuce) occurs at high relatively humidity and light, and temperature conditions that favor fast plant growth.

NEIL MATTSON (nsm47@cornell.edu) is Associate Professor and Greenhouse Extension Specialist and **TANYA MERRILL** is a former undergraduate at Cornell University.

Table 1. Control nutrient solution used during the experimental period. Single elements were removed to impose the nutrient deficiencies.

Element	Name	ppm
N	Nitrogen	210
P	Phosphorus	31
K	Potassium	235
Ca	Calcium	200
Mg	Magnesium	49
S	Sulfur	64
Fe	Iron	4.0
Mn	Manganese	0.5
Zn	Zinc	0.1
B	Boron	0.5
Cu	Copper	0.10
Mo	Molybdenum	0.01

Table 2. Average tissue analysis range of healthy greenhouse butterhead lettuce. Tissue samples taken from most recently mature leaves. (From H.A. Mills and J. Benton Jones, Jr. 1996. Plant Analysis Handbook II. Micro-Macro Publishing, Inc.)

Macronutrients (%)		Micronutrients (ppm)	
N	4.20 to 5.60	Fe	168 to 223
P	0.62 to 0.77	Mn	55 to 110
K	7.82 to 13.68	B	32 to 43
Ca	0.80 to 1.20	Cu	6 to 16
Mg	0.24 to 0.73	Zn	33 to 196
S	0.26 to 0.32	Mo	0.29 to 0.58

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