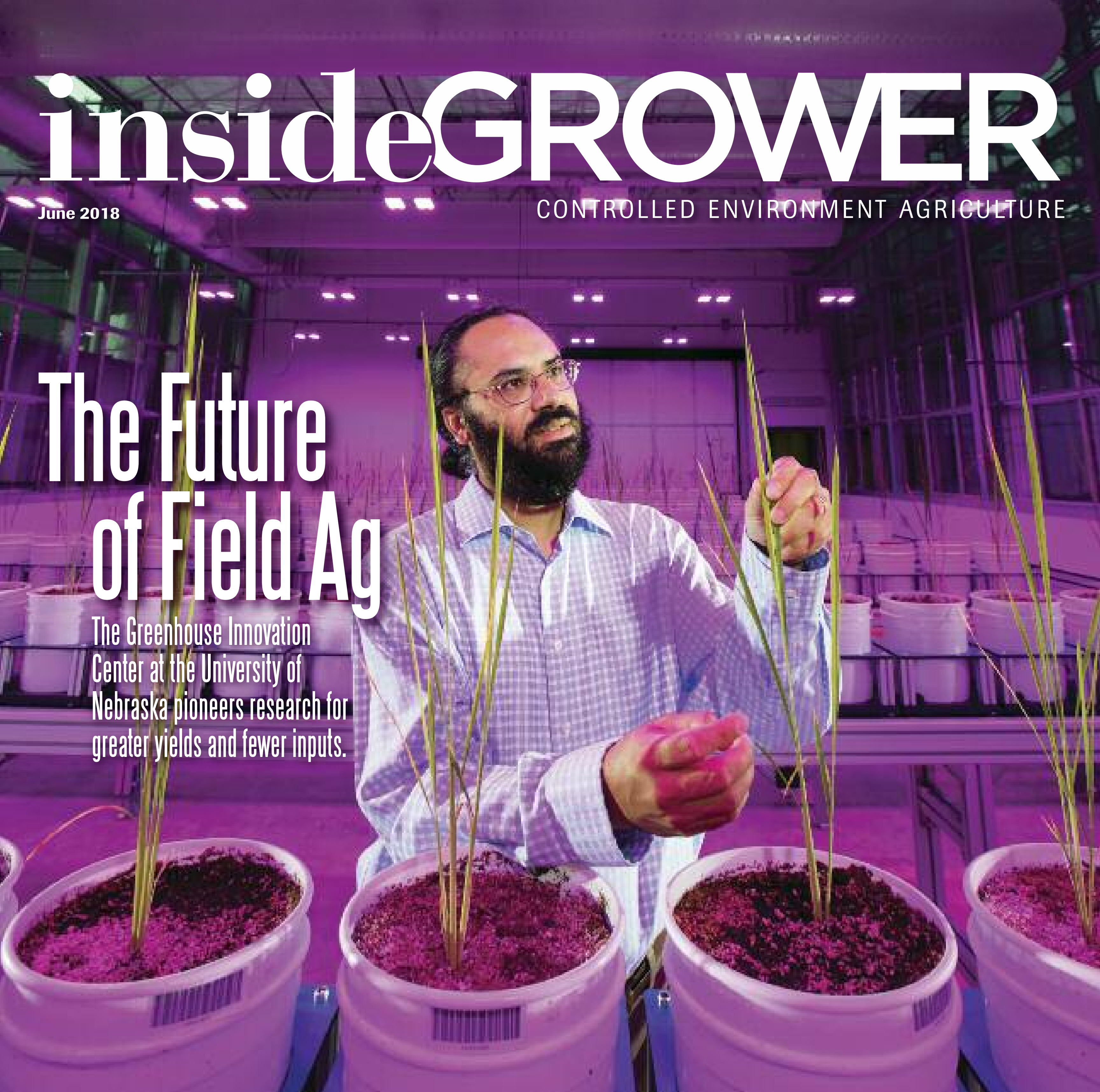
insideGROWER

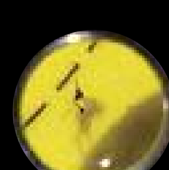
CONTROLLED ENVIRONMENT AGRICULTURE

June 2018



The Future of Field Ag

The Greenhouse Innovation Center at the University of Nebraska pioneers research for greater yields and fewer inputs.



The Many Applications of CEA

It's often my goal in this space to succinctly sum up the issue as a whole by pointing out its common threads. This issue was a bit more difficult than most because we're really all over the board this time with controlled environment ag. And then, it hit me: that's the common thread.

We've only really skimmed the surface in this supplement on the many ways in which we can use CEA, but it's a good representation of the idea that with a little creativity, it can serve multiple purposes.

Take, for example, its use for continued studies. Researchers at the University of Nebraska-Lincoln are using a brand-new Greenhouse Innovation Center to control the environment around field crops, which they are then studying with a High-Throughput Phenotyping System. It's a high-tech system that takes multiple images of the plants so they can better understand the plants' processes, eventually resulting in improved breeding and more finely tuned field practices. You can read more about this public/private partnership on page 12.

Need another example? How about CEA as it relates to urban centers? Duron Chavis, now the community engagement coordinator at the Lewis Ginter Botanical Garden, helped to bring an indoor farm to a historic YMCA building in Petersburg, Virginia, where fresh food can be grown for underserved communities, and area students can learn about agriculture and the culinary arts. Turn to page 14 for the full story by David Kuack.

Of course, cannabis is another area of CEA that's exploded over recent years. However, that explosive growth has come with some growing pains and one element of that is the fractured pesticide regulations coming from each state. As states come online with medical and/or recreational marijuana, their regulations often vary from other states (Canada is uniform throughout the country as it approaches legalized recreational cannabis). Some states say no pesticides at all, while others endorse pesticides with natural formulations, and yet others are fine with synthetic pesticides. Basically, they're all over the board. Our resident expert Dr. Brian Corr has broken down what you need to know about these regulations and has provided a very useful chart of pesticide active ingredients approved by state agencies. You can find that story starting on page 30. As always, though, double-check with your state regulators for formulation approval.

With CEA, understanding nutrition is of vital importance, as it can make or break your crop (and therefore your livelihood). In this issue, we have a couple of articles to keep you up-to-date on the latest in nutrition. First, on page 26, there's a high-level look at just how important nutrition is and author Joachim Nachmansohn dispels some myths and clarifies some misunderstandings about plant nutrition.

If you're a hydroponic grower, once you're done with Joachim's story, you can turn back to page 18 to learn about nutrient needs relative to certain types of basil and lettuce. In that story, David Kuack highlights new research from Tyler Baras (October 2016 *Inside Grower* cover story) on growing with organic and conventional fertilizers.

Whether it's research, education or good old-fashioned production going on under glass, there's always plenty to talk about when it comes to CEA.

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ON THE COVER

Dr. Harkamal Walia is one of several researchers working on phenotyping studies (here he's shown checking the progress of rice plants) at the Greenhouse Innovation Center on the campus of the University of Nebraska-Lincoln. Photo courtesy of the University of Nebraska-Lincoln.

DEPARTMENTS

FEATURES

CEA and Its Big Backers

It seems vertical farms are starting to trend among celebrities and billionaires. In the last several months, there have been multiple stories on vertical farms and their investors, and the names are very recognizable.

Out in Seattle, Amazon founder Jeff Bezos is a source of funding for a second location for Plenty, an indoor vertical farm operation that started in the Bay Area. The Seattle warehouse is 100,000 sq. ft. and is funded partially by DCM Ventures, along with funds that invest on behalf of Alphabet's Eric Schmidt and Bezos, according to a *Business Insider* story.

Meanwhile, Kimbal Musk, brother of Tesla and SpaceX founder Elon Musk, is working with entrepreneur Tobias Peggs at an old Pfizer plant in Brooklyn to grow leafy greens in shipping containers. The company, called Square Roots, secured more than $5 million in private funding and earned grants from the U.S. Department of Ag, according to a *New York Times* story. Kimbal, who has a background in the restaurant business, would like one in every major city to supply greens to local restaurants.

And now, Oracle cofounder Larry Ellison announced he'll launch a fully automated, indoor hydroponic greenhouse operation called Sensei on the Hawaiian island of Lanai (of which Larry owns 98%), according to a story in *Silicon Valley Business Journal*. The high-tech elements include Tesla solar power and reduced water usage. The story also notes: "The company lists three open positions on its website, notably a postdoctoral researcher who will be tasked with designing 'plant experiments and associated protocol and research methodology.' It adds: 'Travel to Hawaii will be required.'"

Just recently, AeroFarms—a vertical farm company that's been around since 2004— added a new round of funding that includes IKEA and celebrity chef David Chang as investors. David also will be joining the company's board of directors to help with "further culinary developments." IG

Food Hubs = Local Benefits

Recently released research from the University of Vermont (UVM) shows that food hubs are "serving a valuable service and providing another market outlet for suppliers. Even though volumes are small, suppliers find hubs to be worthwhile."

Associate Professor David Conner led the research efforts. "Increasing local food sales can bring a wide array of community development benefits. I think for local food to have a larger benefit to communities, it has to be more available where people shop and eat," he says. "It is important to move beyond direct markets to more mainstream outlets like grocery stores and cafeterias. Food hubs play a vital role in this. My goal was for food hubs to better understand farmers' perspectives so that hubs can serve farmers better."

According to the release on UVM's website, there are 20 food hubs around Vermont and 400 nationwide. These hubs act as sort of a middle man between typically smaller farmer suppliers and the customer, whether they're wholesalers, grocery stores, institutional or commercial food service entities.

UVM's complete study is published in the December 2017 issue of *Journal of Hunger and Environmental Nutrition*. IG

New Picking Robot

Robots are always going to make headlines, particularly when there are intense labor issues in an industry. The flexible robot with grippers is no exception to that. On Robot, the company that makes the robot gripper portion of the machine, recently highlighted the "cobot" in a video featuring one of Denmark's leading herb producers, Rosborg Greenhouses.

"We are constantly working to optimize the productivity and profitability of our processes by automating the monotonous, heavy tasks that employees would prefer to avoid anyway. Robot technology also helps us reduce the amount of overtime and temporary workers," says Henning Jørgensen, partner and operations manager, Rosborg Food Holding, in a release on On Robot's website.

The machine is made by Universal Robots and the grippers that allow the robot to gently handle the herb pots and packaging are made by On Robot.

"The two 'fingers' of the robot gripper have built-in intelligence and advanced technology that mimics the way humans instinctively use our sense of touch when we grab things to move them," according to the website.

"The automated packaging solution is so intuitive to use that staff without robot experience easily can switch the solution to packing other types of products by changing settings on the robotic arm's touch screen. The RG6 robot gripper's software is installed in the robotic arm in the same way as an app on a smartphone." Visit onrobot.com to learn more. IG

Combat Fruit Flies

Strawberry and tomato growers (and other berry growers, too): If you're battling *Drosophila suzukii*, check this out. Koppert Biological System's Fruit Fly Attractant has been named the most effective control of *D. suzukii*, according to a study by pcfruit, the Belgian center of excellence in fruit research.

The organization tested five different products and found Koppert's product to be the most effective lure for both males and females, allowing growers to "considerably reduce the level of infestation." Koppert recommends using the attractant with the Drososan trap to detect the presence of fruit flies and to continually monitor the situation, as well as combat the proliferation of the flies.

Hannah Burrack, North Carolina State University, Bugwood.org

Find out more about the product at https://www.koppert.com/products. IG

lēf Farms Moves to Clamshell Packaging

The New England leafy greens grower lēf Farms recently converted to clamshell packaging due to strong consumer demand for the change. They previously used trendy black bags.

"There's no doubt that everyone loves our baby greens that, up until now, were available in distinctive black bags. Consumers expressed to us they were having difficulty finding our products in a consistent location within their local stores, as produce managers often placed them away from the traditional salad wall," notes lēf Sales & Marketing Manager Donald Grandmaison in a statement on the company's website. The new clamshell packaging is designed to better fit into store plan-o-grams so customers have an easier time finding the leafy green mixes.

"Within the baby greens space, our retailer partners indicated they were much more in favor of clamshells because they were easier to attractively stack, load, and restock product as compared to bags," Donald adds. "So, to us, putting our greens into clamshells made perfect sense."

Donald says customers also wanted more transparency in the packaging so they could see what's inside. The clamshells allow for 95% product visibility. lēf Farms also made sure the new packaging was eco-friendly. According to the company's statement, "Although its initial bags were recyclable, lēf's new clamshells are made of a much more commonly recycled material, food-grade PETE 1 (polyethylene terephthalate)—making them more easily recovered by most community programs."

lēf Farms is a hydroponic grower supplying leafy greens to grocery stores, restaurants, schools and food service locations around New England. IG

Converting to Cannabis?

There have been multiple stories within the last few months of greenhouse growers converting their acreage, some to leafy greens and others to cannabis. A recent story in Canada's *National Post* confirms that some long-time veg and leafy greens growers up north are making the conversion to cannabis for some of their ranges.

One of the biggest names is Village Farms, which produces greenhouse hydroponic tomatoes for North America. According to the story, "In June last year, the tomato, pepper and cucumber grower inked a joint venture with licensed producer Emerald Health Therapeutics. As part of the agreement, a massive greenhouse that was used for tomatoes in Delta, British Columbia, is being converted to cannabis production, with options to acquire two additional greenhouses."

The story quotes Village Farms Chief Executive Officer Michael DeGiglio as saying he expects "poaching" growers from veg and ornamentals to the cannabis industry to ramp up. He cautions, though, that while the profits might look good right now, they will level out after a period of turmoil.

"Cannabis will commoditize out like every other crop ... And one day when the supply is greater than the demand, things will recheck," he said. "And you can't afford to pay people more than the competitive salaries."

As more states in the U.S. come online with medical and/or recreational marijuana, it will be vitally important for ornamental and leafy greens growers to hire people with a passion to grow their crops. Often times (though it may take a while), you can train a grower in your specific discipline, but it's much harder to instill a passion if it isn't already there. IG

Philips to Install LEDs for UK Leafy Greens Grower

A Southern United Kingdom family-owned growing operation called Madestein UK recently settled upon Philips Lighting to install GreenPower LED toplighting for its lettuce and herbs greenhouse range. The grower, which supplies fresh lettuce and herbs to major food retailers, food service companies and wholesale markets in the UK, became convinced of the benefits after visiting other growers in the Netherlands and Finland who had adopted the LEDs.

"We are seeing a strong demand for UK-grown lettuce and herbs, so we've been exploring ways to raise our productivity. We were impressed with what we saw in our trials and confirmed those views with visits to growers in the Netherlands and Finland who are using LEDs to grow lettuce," says Jonathan Zwinkels of Madestein UK. "Our aim is to use LED grow lights to improve quality, reduce the impact of adverse weather conditions and improve the shelf life of our products."

"It's great to see how our network of growers are ambassadors across the entire globe," said Udo van Slooten, Business Leader Horticulture at Philips Lighting. "In this case, they were able to show how LEDs can help them speed up their crop cycles and grow more compact plants. That's the real value of working with people who are passionate about their professions."

The company has been investigating LED grow lights for a long period and carried out several LED trials at its site in Chichester from 2014 to 2017. The LEDs will be installed by Philips Lighting's Horti LED partner Cambridge HOK. IG

U.S. Veg Greenhouses Smaller by Comparison

Gary Hickman of Cuesta Roble Consulting sent the latest statistics he's compiled via U.S. government stats over the past five years on vegetable greenhouses across the country. It's interesting because he says the total number of greenhouse vegetable farms has increased by 115%, but the total area has only increased by 59%.

"More farms per area means the average farm size is now smaller than several years ago," he says. When it comes to the actual breakdown of greenhouse farm size, more than 8,000 of the farms are less than one-half an acre, while only 180 are over an acre or larger.

"As a comparison, in the Netherlands, the average greenhouse farm size is 9.1 acres, in Canada this average is 4.3 acres and in Australia, 3 acres per farm," Gary notes.

You can find complete data with reference sources available in his 2018 International Greenhouse Vegetable Statistics publication. Find out more at www.cuestaroble.com/statistics.htm. IG

Going Direct to Consumer

How important is it for growers to sell directly to consumers through CSAs, farmers markets and roadside stands? Turns out, it can be pretty important, according to a survey from the USDA's Economic Research Service.

They surveyed 4,826 households about their food acquisitions over a one-week period during the National Household Food Acquisition and Purchase Survey. Of those households, 231 bought from a farmers market or other direct-to-consumer (DTC) outlet. Of those 231 households that bought at a DTC outlet, 170 bought fruits and vegetables.

So here's the eye-opening statistic: The 170 households that bought fruits and veggies at the DTC spend an average of \$28.36, while the 3,388 households that bought fruits and veggies at non-DTC outlets only spent an average of \$16.53.

However, according to the survey, the average household buys fruits and veggies from a DTC outlet roughly 3.5 out of every 100 weeks, or one to two weeks each year. The challenge then becomes how we get consumers to more of these events where they can interact directly with the grower. And how can growers become more directly involved with interaction with the consumer? IG

Discontent Organic Growers Aim for Add-On Label

Photo courtesy of the Real Organic Project's Facebook page.

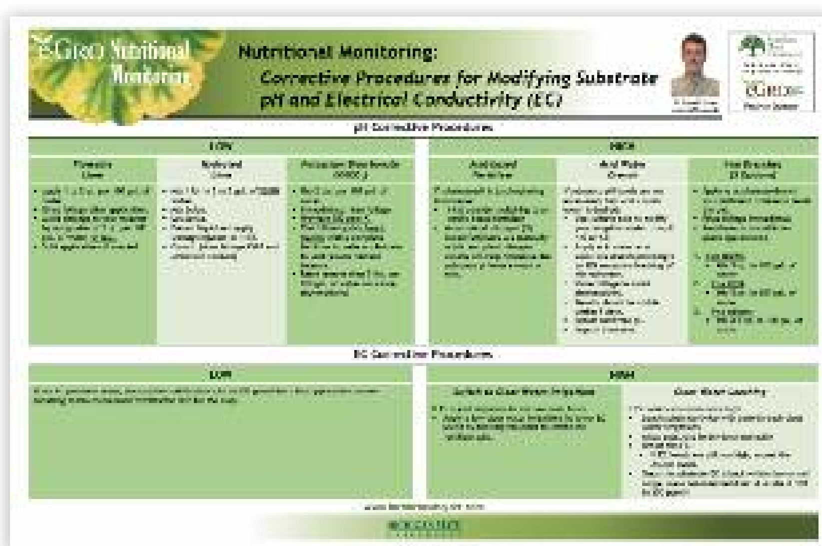
Remember the contentious National Organics Standards Board (NOSB) vote last November? The one where they voted to recommend prohibiting the organic certification of aeroponic production? The bigger deal to many was that another motion, which was to recommend prohibiting organic certification of hydroponic/aquaponic and container production, failed by one vote.

For many traditional organic growers who are devoted to the idea that organic is all about the soil, hydroponic growing doesn't fit into their definition of what organic means. And there was an outcry in November that led many to speculate that some would abandon the USDA organic program or at least pursue an additional label to set themselves apart.

Well, the speculation is over. A number of organic growers have organized and created the Real Organic Project. They say it will support a number of efforts, but they'll start with "the creation of a new 'add-on' label to represent the organic farming that we have always cared about. It will use USDA certification as a base, but it will have a small number of critical additional requirements." Those additional requirements are intended to rule out things such as hydroponics and certain confined animal operations.

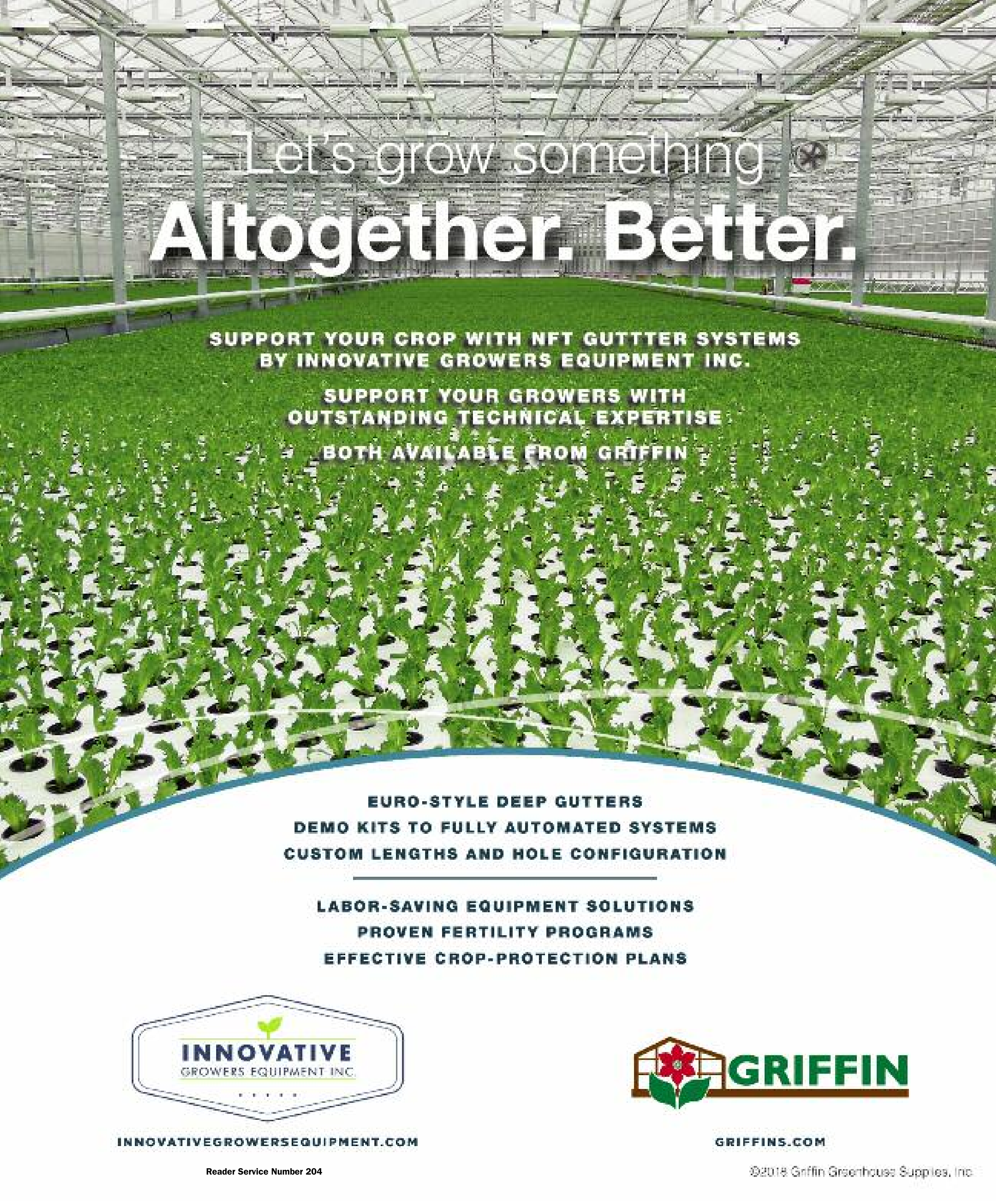
The Real Organic Project has a 15-member standards board, an 18-member advisory board (which includes four former and three current NOSB members) and an executive board.

We'll keep you posted on how their add-on label proceeds. In the meantime, you can see what they're up to at realorganicproject.org. IG



MSU Extension's Corrective Procedures for pH & EC

Getting the right pH and EC levels can be a battle, but now you have an extra tool for your fight. Michigan State University Extension has created some corrective procedures for fighting either high or low pH or electrical conductivity. There's also a downloadable poster you can print and hang if needed. Visit http://msue.anr.msu.edu to learn more. IG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Feeding the Future

Photo credit: University of Nebraska-Lincoln

Maize sits on the specially designed conveyor belt at the Greenhouse Innovation Center at the University of Nebraska-Lincoln.

The unique public-private partnership at the Greenhouse Innovation Center at the University of Nebraska-Lincoln is geared toward research that will pave the way for greater yields and fewer inputs for field agriculture.

by **JENNIFER POLANZ**

Simply put, the goal of agriculture is to feed people. On a global scale, to feed the world. It's a daunting task that grows more difficult by the day as the world's population balloons (estimates say 9.7 billion people will inhabit the Earth by 2050) and the climate continues to provoke drought, extreme weather events and other factors that impact field agriculture.

The University of Nebraska-Lincoln (UNL) is responding to those challenges through a unique blend of private and public enterprise that culminates in its Nebraska Innovation Campus (NIC), a 249-acre research and technology center that sits adjacent to the campus. The goal of the NIC is to connect private enterprise with public research and resources from all disciplines to facilitate new partnerships and create unique solutions to future problems related to food, water and fuel. In fact, it was just recognized in 2017 with the Emerging Research Park Award from the Association of University Research Parks for its efforts.

So where does controlled environment agriculture (CEA) come into play? After all, that's what we're about here at *Inside Grower.* Perhaps only a little ironically, the university has constructed the Greenhouse Innovation Center (GIC) as part of the NIC, a fully automated, 45,000-sq. ft. CEA facility designed to allow researchers and private companies the ability to control the environment as needed to study field crops.

Within those greenhouses, the university has installed a LemnaTec High-Throughput Phenotyping System that's rare among public institutions—most are owned by private breeding companies, not universities. The technology is available for university researchers, as well as private companies that would like to have the university conduct studies for them.

So let's take a step back and define the difference between phenotyping and genotyping. Plant genotyping is the study of a plant's genetic makeup—the DNA sequences that make it what it is.

"We can do a lot of detailed study on genetics already," says researcher Dr. Yufeng Ge, an advanced sensing systems engineer and assistant professor at UNL. "Those technologies are out there to do genotyping and sequencing on the genetic composition of the plants."

Phenotypes are the traits and characteristics of a plant as genes interact with the environment.

"We're trying to establish that connection between the genotypes and the phenotypes," Yufeng explains. "I think it will allow us to gain a lot of insight on basic rules and functions of plants. The hope is that we can really understand at a very fundamental level from genes to how the plant cells organize and function across various scales, all these processes … and use that knowledge to improve the plant in terms of yield and quality."

INSIDE THE GREENHOUSE

Researchers from multiple disciplines are using the resources at the GIC to study field crops like maize, sorghum, wheat, rice and even tomatoes. The phenotyping imaging system allows those researchers to get a truly inside look at these plants and it stands apart from even the private systems. To begin with, it's much taller than typical imaging systems.

"Our system is unique in the fact that it can grow full-sized corn plants about 2.5 meters tall (more than 8 ft. tall) or a really tall sorghum plant," says Amy Hilske, greenhouse director at the GIC.

The growing process is fully automated with conveyor belts that bring the plants through the imaging system daily. LED supplemental lighting, temperature and humidity control, and automated watering all run off the computerized controls, allowing researchers to crank up the heat and humidity or recreate drought-like conditions based on their needs.

The greenhouses themselves, like the rest of the innovation campus, are heated and cooled via a system that's similar to geothermal except it's using reclaimed, non-drinkable water from the nearby wastewater treatment plant. According to the university's website: "This award-winning, closed-loop system transfers thermal energy in underground piping to the entire campus. The investment in this source of alternative energy will ensure that NIC buildings operate 30% more efficiently than ones with standard equipment and will lower the risks associated with fluctuating commodity prices."

And while the greenhouses aren't set up for typical production (most are used only for research), Amy says the system is designed to reduce the amount of labor needed to grow the plants. In theory, you could plant a seed and leave it on the system for four months without touching it—barring, of course, any mechanical breakdowns.

THE RESEARCH

The phenotyping system brings the plant through a series of imaging sequences every day to allow researchers to collect vast amounts of data points. Prior to this system, the process occurred manually, Amy explains.

"In a traditional ag research situation in a greenhouse or in the field, a student would go out to the field with a ruler and measure the height of a plant," she says, adding that if they needed to measure leaf area, they had to remove the leaf, damaging the plant.

Dr. James Schnable, an assistant professor in the Center for Plant Science Innovation at UNL, says in the first project he worked on, they measured nutrient concentration in the leaves of sorghum and maize. This system allowed him to use the hyperspectral camera to measure those concentrations without destroying the plant. That research is designed to highlight the genes that are better at taking up nutrients, which will allow for more precision fertilization in the fields, saving farmers money and reduce fertilizer runoff.

Photo credit: University of Nebraska-Lincoln

Students (from left to right) Chenyong Miao, Qinnan (Bob) Yang, Zhikai Liang and Mallory Van Haute take a look at sorghum growing in the Greenhouse Innovation Center on the University of Nebraska-Lincoln campus.

James works heavily on the plant physiology side of the research and is now more focused on the architecture of the plants he's studying. The imaging system allows him to see how the plants are growing and changing to better understand which plants are performing well and why.

The automated system allows researchers to replicate various field scenarios, like drought stress at different times of the crop's life cycle, so they can study how the plant reacts. The problem in the field was trying to replicate this effectively. Now, they can weigh the plant and then add the same amount of water daily or change it up if they want to study how the plant reacts to reduced water rates.

"The nice thing with the controlled environment is we can replicate the exact same drought stress over and over again, and that allows us to focus in on specific genetic factors. Then we have a much more straightforward experiment we can put out in the field," James notes. "Because that really is the challenge—we want things that will translate to the field. GIC is really great for things above ground, but things controlled by root traits—obviously, roots in pots grown in controlled environment—are not nearly the same size as roots a corn plant would occupy in the field."

That's why the university also has a field phenotyping facility not far from the campus with a "spidercam" system, which consists of eight cables attached to a sensor platform that can take images while the plants are in the ground (the system is the same that universities use for televised college football games to get viewers closer to the action).

THE RESULTS

A handful of studies based on the imaging done at the GIC have been completed already and published, including the study of maize plant growth, water usage and leaf water content; the quantification of the chemical properties of maize and soybeans; and other imaging studies related to rice, maize and wheat.

What's great about the imaging being done at UNL, though, is that the data will remain there even after the plants die.

"It's going to be a continuous process—a lot of the researchers have been collaborating for three years already, but I feel we've just scratched the surface," Yufeng says, adding that researchers and students can label the images and later develop new algorithms for studying them. The imaging system generates a vast array of data sets that can continue to be studied.

So what good does it all do? Breeders can start to make choices when it comes to certain varieties that take up nutrients more efficiently or varieties that are more resistant to drought than others. It will speed up the selection process dramatically, hopefully, creating greater yields.

"The whole reason this exists is the state of Nebraska invested a lot of money in setting this up," James adds. "It would have been very hard to get this funded either using federal dollars or through university funds or any other source. The fact that we're doing all this cool stuff is because the state of Nebraska invested a lot in agriculture and that's something everyone I work with is really appreciative of." IG

Promoting the Benefits of Urban Greening

Duron Chavis, community engagement coordinator at the Lewis Ginter Botanical Garden, is helping the citizens of Richmond, Virginia, discover the benefits of plants.

by **DAVID KUACK**

Photos courtesy of Duron Chavis.

1 Duron Chavis, community engagement coordinator at the Lewis Ginter Botanical Garden in Richmond, Virginia. 2 & 3 Duron coordinates the recruitment and training of citizens throughout Richmond to become urban gardeners. 4 Duron helped set up an indoor farm in the Harding Street Urban Agriculture Center, which is a former YMCA recreational center in Petersburg, Virginia.

Duron Chavis has been involved with different aspects of urban agriculture for 15 years. In 2003, he helped start the Happily Natural Day. The annual event focuses on holistic health, cultural awareness and social change. Working with African-American farmers from rural parts of the state, Duron helped to initiate festival programs that were directly related to the topics of food and farming. It was during one of these programs that farmers said they didn't have the personnel and time to bring their food into urban centers.

"As a result of this discussion, I started working with the farmers," Duron said. "I did a pop-up farmers market. I worked as the farmers market manager for a project called the Richmond Noir Market, which opened in 2010. That project gave me a one-on-one opportunity to work with the farmers. We would set up a market stand on Saturdays and talk to people about producing their own food and the importance of being organic and not using pesticides."

Looking to expand his involvement with urban ag further, Duron continued his efforts to teach people the benefits of growing their own food in 2012 when he organized citizens in his Richmond neighborhood to start a community garden on a vacant piece of property. ▶


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Photos courtesy of Duron Chavis.

5 Urban gardeners trained at the Lewis Ginter Botanical Garden work with community members to plan, design, implement and sustain green spaces. 6 During a 12-week training program at the Lewis Ginter Botanical Garden, an emphasis is put on personal development so that urban gardeners can work with community residents.

"I gathered together people who were interested in community organization and told them that we should start a community garden," he said. "I said, let's start an urban ag project in the middle of the city to address some of the food access issues people were facing. There were about 20 people involved with the project."

The first garden was about 3,000 sq. ft. in which community volunteers built 20 4- by 6-ft. raised beds.

"I was able to get funding from different sources to support the project," Duron said. "I was out in the garden every weekend working with community members on different production practices and how to steward the garden."

Duron later began volunteering with a local non-profit called Renew Richmond in 2013. He worked with John Lewis, a certified prevention specialist/health education specialist with the Virginia Health Department, Division of Adolescent Health, to engage the community in the organization's urban farm efforts. The farm began on an acre of land John had acquired through a memorandum of understanding with a Jewish community center in the middle of Richmond. The project has since expanded to six urban ag sites and the produce grown is sold to local grocery stores, restaurants and community residents.

INDOOR FARMING BENEFITS LOCAL RESIDENTS

Because of the urban ag projects Duron was doing in Richmond, he attracted the attention of Virginia State University and extension specialist Marcus Comer, who was working on an indoor farm project in Petersburg, Virginia.

"I talked to Dr. Comer about my philosophy on entrepreneurial urban ag and the impact it had on the economy of the low-income community," Duron said. "We started working on an indoor farm in 2014."

The Harding Street Urban Agriculture Center is a former YMCA recreational center located in a residential neighborhood.

"The building is around 100 years old," said Duron. "Prior to becoming a YMCA, it was a performance hall that featured black entertainers like James Brown, Sam Cooke and Aretha Franklin who weren't able to perform at white venues."

Duron and Marcus removed the basketball floor and installed vertical towers, aeroponic tables, an aquaponics system and an ebb-and-flow system. They set up lighting rigs to hang lights, installed solar panels on the roof to power the lights inside the facility and modular climate control units for the different types of growing systems to control the light intensity, temperature and humidity. There's also a kitchen that was renovated into a culinary arts classroom.

Duron said some Richmond high school students are involved with a six-week program called Growing Up, which teaches students about culinary arts and urban agriculture. The urban ag center's kitchen has enabled high school students in Petersburg to also participate in this program. Students who graduate from the program become mentors for the next incoming class.

The urban ag center's kitchen enables Petersburg residents to also participate in culturally relevant cooking classes.

"On the second floor of the ag center are rooms where health and fitness classes are taught," Duron said. "There are also classes focused on urban agriculture and entrepreneurship."

They also installed another piece of equipment: a 10- by 12-ft. walk-in cooler. Duron said the cooler has allowed the ag center to become an aggregator of produce.

"Local farmers bring their fresh produce for sale and distribution," he explained. "What is grown at the urban farm in Richmond, which is about 30 miles away, is brought to Petersburg and then it's shipped out to wherever it needs to go."

Outside of the urban ag center is a micro-farm consisting of 5,000 sq. ft. of raised beds, along with a fruit orchard on another vacant lot.

"What can't be grown in the indoor farm can be grown outside," Duron said. "With the urban farm in Richmond and the facilities in Petersburg, it's possible to grow year-round."

Crops that have been grown inside the urban ag center include kale, mustard greens, basil, lettuce, Swiss chard, peppers, tomatoes, spinach and watercress.

"The focus is on growing what the people actually want to buy," said Duron. "For the local community, there is a staple group of products, including tomatoes, cabbage, peppers, collards, squash and cucumbers. The crops are chosen based on what the ag center's clientele is interested in buying.

"All of the food that is grown is sold. Even though this is a research center, part of the research is economic sustainability," he added. "The center's focus is community engagement and teaching the community so that its members can do these things for themselves. There is a balance that has to be met. The center's goal is to increase the number of end users who want to purchase the produce that is grown."

GROWING URBAN GROWERS

As community engagement coordinator at the Lewis Ginter Botanical Garden, Duron has now focused his activities on urban greening to "use plants in the urban environment for a multiple and a diverse number of purposes."

"Urban greening can address a number of issues, including public health, stormwater management, pollution, air quality, property values and food access," Duron said. "This involves using plants in the urban environment to create green spaces."

A green space could be an urban farm, a fruit orchard or a park. It's all connected to public green spaces, which could be related to food production as well as to ornamental plants, explained Duron, who also coordinates the recruitment and training of citizens throughout the city of Richmond to become urban gardeners.

"These urban gardeners work with community members to plan, design, implement and sustain green spaces," he said. "Last year, I implemented a 12-week training program for these urban gardeners who then serve as volunteer coordinators to work with community residents to maintain green spaces. The whole purpose is to build community connectivity to the green space in order to keep it sustainable."

He's also been involved with the development of a lot of green spaces, gardens, farms and orchards, which he says gives him an opportunity for him to "grow more growers." But not just people who have the skills to grow plants, but also to grow the community.

"It is really important to grow community while at the same time growing produce," Duron said. "What is more important are the relationships that are being built. We put an emphasis on the personal development that needs to take place in order for these urban gardeners to work with community residents."

The other part of Duron's responsibilities is to develop new partners for the botanic garden and to increase the garden's capacity to make social impacts in the region as an institution.

"I work with different organizations to try to develop new initiatives and deepen the garden's capacity to reach new audiences that may have not been reached before," he said. IG

For more: Duron Chavis, Lewis Ginter Botanical Garden, 1800 Lakeside Ave., Henrico, VA 23228; office (804) 262-9887; duronchavis@gmail.com; www.lewisginter.org. Information used in this article first appeared in Urban Ag News Issue 13 (http://urbanagnews.com/magazine/issue-13).

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Striving for Optimum

Growing vegetables in hydroponic production systems with organic or conventional fertilizers may be accomplished at lower nutrient levels.

by **DAVID KUACK**

Most growers who switch from producing edible crops with conventional production inputs to growing organically have a learning curve to overcome. And Tyler Baras has studied the differences between the two methods.

In a 12,000-sq. ft. greenhouse in Dallas, Texas, using four deep water culture ponds and a nutrient film technique system, Tyler trialed WISErganic 3-2-2 and Pre-Empt organic fertilizers. He studied the differences in growth using the organic fertilizers compared to crops grown with Hort Americas 9-7-37 hydroponic fertilizer with calcium nitrate and magnesium sulfate. All of the production systems were also incorporated with the commercial microbial inoculant TerraBella. Crops produced included Italian basil, and green butterhead and red butterhead lettuce.

WHAT'S OPTIMUM?

The deep-water culture production results Tyler got with WISErganic and Pre-Empt organic fertilizers were comparable to the crops grown with the conventional Hort Americas hydroponic fertilizer.

"We were able to achieve similar growth rates using WISErganic and Pre-Empt compared to the growth rates using the conventional salt fertilizer," he said. "As a result of the growth rates we achieved with the organic fertilizers, we started to question the nutrient recipes that have been recommended for hydroponic edible crop production."

Many of the traditional recipes for hydroponic production target a level of 200 parts per million nitrogen, provided primarily as nitrate and some ammonium. Tyler said he saw similar growth rates in organic fertilizer ponds that tested as low as 10 ppm nitrogen coming from nitrate and ammonium.

"It's possible there is nitrogen in the organic ponds that is not showing up in the lab test, which is generally used for conventional fertilizers," he explained. "But even if there are other forms of nitrogen, like amino acids, there are still very low levels of the primary forms of nitrogen, including nitrate and ammonium, used by plants."

The electrical conductivity (EC) level in the organic fertilizer ponds measured as low as 0.5 compared to 2.5 in the conventional fertilizer pond. Even with the difference in EC, the harvested crops were nearly identical in terms of production time and plant weight. The difference in measured EC may be due to the form of nutrients and not a reflection of true nutrient concentration. ▶

Photo courtesy of Tyler Baras.

Trials in Hort Americas' demonstration greenhouse compared the growth of butterhead lettuce and Italian basil using organic and conventional fertilizers in hydroponic production systems.


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Plugs grown in an organic fertilizer remained on the propagation bench one week longer than plugs receiving conventional fertilizer to ensure good root growth.

Photos courtesy of Tyler Baras.

Aging of the organic fertilizer solution can impact root growth. The root system (left) of butterhead lettuce grown in 9-month-old organic fertilizer solution compared to a root system in a 2-month-old organic fertilizer solution.

DIFFERENCES IN PROPAGATION TIMES

Tyler said one difference that occurred between the organic- and conventional-grown crops was the time in propagation.

"Even though the crops finished at the same time from transplant to harvest time, we kept the plants an extra week in the seedling stage for the organic fertilizer," he said. "We were running the seedlings for two weeks with the conventional fertilizer and about three weeks with the organic fertilizers."

Organic plugs were started one week earlier, but were transplanted on the same day as the conventional plugs. The seedlings were similar in size when they were transplanted into the ponds. After the organic and conventional plugs were placed into the ponds, their production time until harvest was the same.

"The plants came out of the ponds with nearly identical weights," Tyler said. "Overall, the seed-to-harvest time is faster with the conventional fertilizer, but this could be attributed to our ability to transplant the conventional plugs into the pond faster because the roots emerge from the plugs sooner."

Plants grown with the organic fertilizers also showed they could tolerate lower levels of other nutrients. With the conventional fertilizer, the nutrient solution may contain over 200 ppm potassium. In the organic fertilizer solutions, the potassium level was as low as 12 ppm.

Tyler found that macronutrient uptake for the plants, even when they were grown in a low-fertilizer concentration like 0.5 EC, were still able to pull what they needed out of the nutrient solution. For leaf sample analyses of butterhead lettuce and Italian basil grown in 0.5 EC organic fertilizer vs. 2.5 EC conventional fertilizer, most of the macronutrient levels in the leaves were very similar. Tyler said it appeared the plants were able to regulate the nutrient uptake to ensure they had what they needed.

NUTRIENT ACCUMULATION IN PONDS

Tyler said letting organic fertilizer solutions age in the ponds could have an impact on the availability of nutrients for some crops. The aging of the fertilizer solution may also have an impact on increasing the microbial population.

"There were definitely some differences in plant growth," he said. "With the first crops of butterhead lettuce grown with WISErganic and Pre-Empt organic fertilizers, they both grew beautiful heads of lettuce. However, WISErganic didn't produce the best-looking basil, while Pre-Empt produced great basil."

As Tyler and his team continued the trial with their second and third crops, the basil grown with WISErganic started doing much better. It showed that the organic solutions in the ponds may need to age until the nutrients reach adequate levels or convert to plant-available forms.

Tyler said similar results occurred in a 9-month-old Pre-Empt pond vs. a 2-month-old Pre-Empt pond.

"A lot of nutrients accumulated in the 9-month pond and approached the recommended nutrient levels that would be found in a conventional fertilizer system," he said. "Organic fertilizers like Pre-Empt don't contain a lot of magnesium. However, when the fertilizer is run in a pond system for nine months, the magnesium level rises and approaches what would be considered a conventional target level for magnesium."

Aging the fertilizer solution also had a positive impact on root growth.

"When we compared the roots in the 9-month vs. the 2-month solution, the roots in the 9-month solution looked much healthier," Tyler said. "The roots were very white, long and well-developed. There were also more roots on plants in the 9-month pond."

He said the root color was also significantly different between the two nutrient solutions. The roots in the 2-month solution looked healthy, but there was some browning. They lacked the crisp white color associated with healthy roots.

OPTIMUM pH LEVELS

Tyler was able to produce healthy crops in a pH range from as low as 4 up to 6.5. For hydroponic leafy greens, the recommended pH ranges from 5.5 to 6.5.

"Basil and butterhead lettuce grew very well in our organic systems at a pH of 4," he said. "I've heard of aquaponic growers growing these same crops at a pH up to 7 without any problems. Based on our trial results, some of the conventional recommendations for hydroponics for both pH and nutrient levels might need to be revisited."

Tyler said one of the issues he sees with some hydroponic growers is "helicopter parenting" the EC and pH.

"For instance, some growers feel that they need to be constantly watching the pH," he said. "They set up monitoring and dosing systems to keep the pH at a specific value like 5.8. It's possible the pH wouldn't even fluctuate that much. But the growers still invest in additional equipment they think is needed to keep the pH precise, even if the plants may do well outside this pH range. It's possible that the pH will naturally stay within an acceptable range, but growers instead add a dosing system to keep the pH under a very tight range."

In extreme cases, the over-maintenance of pH can lead to nutrient accumulations from acid or base additions. In organic systems, Tyler said he's seen toxicity issues with sodium accumulation when sodium bicarbonate is used as a base. In conventional systems, he's also seen toxicity issues with sulfur or phosphorous accumulation when sulfuric acid or phosphoric acid is used.

LIGHT LEVEL EFFECTS

One factor that Tyler said could affect the optimum pH and nutrient range is the light level.

"It might be the case that we were able to grow plants outside the traditional pH and EC range because we used light levels below the generally recommended target levels," he said. Due to facility limitations, Tyler and his team were only able to deliver 10 to 14 mol/m^2/day instead of the traditional 17 mol/m^2/day. If a grower is providing supplemental light, then the optimum pH and nutrient range may be different.

"With the organic trials we conducted, we weren't that far off from what most hydroponic growers are targeting for growth rates," said Tyler. "Thirty-five days is a target number for a lot of lettuce growers. We have done 35-day conventional crops. We wanted to be able to grow an organic crop in the same amount of time and we were very close." IG

For more: Hort Americas, (469) 532-2383; info@hortamericas.com; http://hortamericas.com.

Some of the information used in this article first appeared in the Hort Americas November 2017 News blog article [https://hortamericas.com/blog/news/what-are-the-optimum-nutrient-levels-for-hydroponic-edible-crops].

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Cannabis Media Crash Course

With many different formulations of growing media available, it can be a challenge for growers to choose the best blend to use. Understanding the composition, functions and intended use can make the selection process easier.

by **ED BLOODNICK & TROY BUECHEL**

What are the functions of growing media? Growing media provides a reservoir for water holding, a nutrient holding and exchange system, a zone for gaseous exchange for the plant root system and anchorage for plants roots. These physical characteristics of a growing medium are determined by the components used and the proportions in which they're blended together. What's important to remember is that the resulting physical characteristics don't equal the sum of the ingredients. Let's look at the components used in formulating growing media and the resulting characteristics.

COMPONENTS

Growing media components are either organic or inorganic. Organic components include peat moss, bark, coconut coir, humus, earth worm castings, wood fiber, etc. Inorganic components include perlite, pumice, vermiculite, sand, hydrogel, etc. Some of these components hold water on their surface; others hold water within their structure, while others hold very little, if any water, such as perlite. Keep in mind that a specific ingredient can vary in its water-holding capacity and physical structure, depending on its origin and how it's processed.

For example, peat moss can vary greatly in its source and structure, depending on how it's selected, harvested and processed. Light brown, fibrous peat moss has a porous structure and can hold up 16 times its weight in water. However, if this same peat moss is processed into fine particles, the water-holding capacity can be cut in half and the air porosity decreases dramatically.

PHYSICAL CHARACTERISTICS

There are various laboratory tests for physical characterization of growing media, however, the most common are bulk density (weight), water-holding capacity and air porosity.

Water-holding capacity is the volume percentage of water retained by a saturated growing medium after it drains. Air porosity is the volume percentage of pore space occupied by air after a saturated growing medium is drained. For the most part, packaged growing media have low bulk density, since the majority are made with a base of sphagnum peat moss and/or coir and have higher water-holding capacity.

Bark-based media are heavy-weight products that are suitable when high drainage and container stability are required. Growing media composed of these base ingredients typically have good air porosity in a range of 10% to 18% by volume.

CHEMICAL CHARACTERISTICS

Two important measurements for growing media are pH and EC (Electrical Conductivity). pH is a determination of how acidic or basic a substance or solution is. EC measures the ability of a growing medium solution to carry an electrical current and is an indication of the amount of nutrients and other salts that are available for crops to take up.

A combination EC and pH meter is used to measure these parameters of a growing medium sample.

For general-purpose growing media, the ideal pH range is between 5.2 to 6.2 with a target of 5.8 when wetting out (wet-out is the pH measurement after adding water to packaged growing medium).

Desirable EC for general-purpose growing media is between 1.0 to 2.0 mmhos/cm. For seed germination and rooting of cuttings, the desired pH range will be slightly lower, between 5.0 to 6.0, with a target wet-out at 5.6. This pH range is slightly lower, since pH can tend to rise during use from minimal fertilizer applications and water alkalinity of irrigation water from constant misting. Desirable EC for germination and propagation growing media is between 0.5 to 1.2 mmhos/cm.

Most commercial growing media are pH-adjusted with limestone and contain a balanced starter fertilizer to help plants acclimate after planting. It's generally recommended to begin fertilizer applications once new plant leaves begin to emerge and new roots develop. The amount of fertilizer and frequency of applications will vary based on the growing environment, stage of plant development, container size and frequency of watering.

Physical Properties of Growing Media Components

Component	Water Holding (% vol.)	Air Porosity (% vol.)	Bulk Density (lbs/ft^3)	Compaction (% vol.)
Sphagnum Peat	50-70	10-30	6-8	15
Peat Humus	50-60	5-15	10-15	10
Perlite	40-50	25-35	4-7	5
Vermiculite	30-55	25-45	4-9	20
C. Pine Bark	15-50	25-50	8-28	10
Top Soil	35-55	2-5	80-100	10
Sand	25-40	3-10	85-105	5
Styrofoam	10-20	40-50	1	15
Rockwool	50-90	20-40	3-5	20
Calcined Clay	50-60	15-25	40-60	5

Common organic components used in growing medium. Starting in the upper left, going clockwise, are bark, sphagnum peat moss and coir.

Common inorganic components used in growing medium. Starting in the upper left, going clockwise, are vermiculite, perlite and rice hulls.

Photos courtesy of Premier Tech Horticulture.

ACTIVE INGREDIENTS

There are several active ingredients that can be added to growing media to enhance plant growth or reduce incidence of root disease. Some active ingredients are available in preformulated media or they can be added during the crop cycle.

By far, mycorrhizae is the most popular active ingredient for cannabis. Mycorrhizae is a beneficial fungus that attaches to plant root systems and acquires nutrients and water for the plant so that plants grow healthier, faster and have more prolific flowering and fruiting. There are also active ingredients that reduce incidence of plant root disease. Active ingredients are a smart option when you want to limit the amount of chemical inputs during the crop cycle.

WATER ALKALINITY, GROWING MEDIA PH & FERTILIZER

We often receive questions about the pH of irrigation solution/water and the influence on growing medium pH. The truth is that water pH has little influence on the pH of the growing medium pH. It's the alkalinity of the irrigation water, fertilizers and the plant itself that influences pH of growing medium.

Table 1.

Water alkalinity (ppm $CaCO_3$)	Potential basicity of fertilizer (lbs. $CaCo_3$ per ton fertilizer)*	Potential acidity of fertilizer (lbs. $CaCo_3$ per ton fertilizer)*	Acid injection needed?
0-60	0-200	–	No
60-120	–	0-200	No
120-180	–	300-400	No
180-250	–	400-600	Maybe
250+	–	Adjust alkalinity with acid to range in first column. Apply suggested fertilizer.	Yes

*These ranges are only guidelines and assume fertilizer is applied as a constant feed at normal rates. Guidelines will vary based on the crop, stage of development, watering and feeding frequency.

Think of alkalinity as the amount of dissolved limestone in water—the higher the amount, the faster the pH climbs in the growing medium. While some growers use reverse osmosis (R.O.) to remove all elements from water, it's better to use water "as is" or blend with R.O. water.

Fertilizer influences pH of growing medium as well. All fertilizers are either potentially acidic or basic. The higher the potential acidity or basicity of a fertilizer, the greater the influence to move the pH of growing medium up or down. The alkalinity of the water needs to be taken into consideration when selecting a fertilizer (see Table 1). It's best to use complete water-soluble fertilizers that contain a balance of macro and micro nutrients.

WHEN TO IRRIGATE

Growers often ask: "When is the best time?" and "How frequently should I irrigate my crop?" This will depend on the growing medium selected, the size of the container, the stage of development of the crop and the growing environment.

The rule of thumb is to fully saturate growing medium at each watering with fertilizer solution to allow 10% to 15% leachate to run out of the bottom of each pot. Note the surface of a saturated, peat-based growing medium will be a dark brown to black. Once the surface dries to light brown or tan, it's about time to water again. To check, insert your index finger into the growing medium about an inch or so. If it's slightly moist, it's time to water the crop again.

It's best to irrigate early in the day to allow growing medium to dry out towards the evening. Thorough drying encourages root development and reduces stress that can make plants susceptible to root disease. IG

For more information, contact your supplier of growing media and fertilizer(s) for technical support and product use guidelines.

ED BLOODNICK is Director of Grower Services and Troy Buechel is a Horticulture Specialist–Mid-Atlantic U.S. for Premier Tech Horticulture.

Herbs & Pesticides Catch-22

Best practices to minimize pesticide use.

by **JOANNE LUTZ**

Herbs grown today can be used by consumers in several ways, including ornamental plants, for medicinal and culinary purposes, and for homemade items like potpourri. The idea that herbs are pest-free is a common consumer perception, but regrettably, not true.

Very few pesticides on the market are registered for use on all herbs, so scouting is essential for early detection of pests. The best way to manage pests is to emphasize Integrated Pest Management (IPM) practices. With proper planning and implementation, pest detection and establishing thresholds for action can be achieved.

INSECT CONTROL IMPLEMENTATION

Yellow sticky cards, placed vertically with one-third in the plant canopy, will attract flying insects, such as winged aphids, fungus gnats, shoreflies, thrips and whiteflies. The "beat test" can be used to dislodge pests from plants to provide an overview of pest presence. A hand lens or optivisor can be used to identify smaller insects not detectable on sticky cards, such as spider mites, soft scales or mealybugs.

Examine the undersides of the leaves and along leaf veins for presence of eggs or immature nymphs. Be observant of sticky substances on leaf surfaces, known as honeydew, that are secreted by aphids, mealybugs and soft-scale insects. Ants may also be present and will actually defend these colonies.

If you want to stay on top of pest problems, learn to recognize symptoms or signs of pest activity, as well as the presence of beneficial organisms. One symptom is evidence of activity, such as holes in a leaf or a wilting leaf. Another sign is evidence of an organism causing the damage, such as an aphid's shed skin or mycelium growing on a leaf surface.

Trap plants are used to lure pests away from the main plant during critical times. Trap crops can be placed around the perimeter of the crop to be protected or within the crop, depending on the pest to be trapped. Examples of trap crops includes nasturtium to attract aphids, basil and marigold to attract thrips, and chervil to attract slugs.

Companion plants—such as marigolds, sweet alyssum, cosmos and caraway—can also attract beneficial predator insects to aid in controlling pests. Biocontrol of insects and mites is becoming an increasingly popular way to manage these pests. (Contact your supplier for assistance in implementing a biocontrol plan for herbs.)

If chemical control is needed, choose soft or reduced-risk pesticides, referred to as biorational pesticides. Most herb growers look for products that are OMRI-certified and have zero-day or short pre-harvest intervals (PHI). Products like insecticidal soap, horticultural oil, neem/azadirachtin insect growth regulators and microbial products are labeled for use on herbs. Of course, it's the grower's responsibility to always read and follow the entire pesticide label, including checking to be sure the herb you wish to treat appears on the label.

Insecticidal soap and horticultural oils rely on thorough coverage for success. These products provide a quick knockdown, but have no residual control. Applications using soaps or oils should be made when conditions are good for drying (clear, sunny days) and air temperatures are between 40 to 80F (4 to 26C).

Insect growth regulators are often tank-mixed with other pesticides to help inhibit or interfere with part of an insect's life cycle. A common example allowed for greenhouse herbs would be azadirachtin—found in Molt-X, AzaGuard or Azatin O—for use on aphids, thrips and whitefly. Specifically, in aphid control, it works by preventing the molting process of the aphid, where the old skin is shed to allow a new one as the insect grows. These products do not control adult pests.

Microbial products can be a bacterium, such as DiPel, which specifically targets worm (lepidopteran) larvae. Grandevo PTO is another bacteria-based product, with broad activity against insects and mites. Fungal microbial insecticides that target many soft-body insects include BotaniGard, Mycotrol, BioCeres and Preferal/Ancora. Repeated applications are recommended along with a high-humidity requirement to aid in these fungal spores surviving while they germinate and penetrate into the insect's exoskeleton to cause insect mortality. Broader chemical control options include BotaniGard Maxx, Conserve (outside herbs only), Entrust SC and PyGanic 5.0.

DISEASE CONTROL IMPLEMENTATION

Disease control should be proactive rather than reactive. Knowledge of the disease pathogens most prevalent in herb production is a good place to start. The most common disease issues include Botrytis, powdery and downy mildew, Alternaria leaf spot, and damping-off diseases caused by Pythium or Rhizoctonia. Good cultural practices include avoiding high-density planting and extended leaf wetness while providing good air movement. Taken together, these steps reduce humidity, and therefore, foliar disease occurrence.

Scouting is just as important for diseases as it is for insects and mites. It's important to examine the root system for evidence of healthy, white roots. Biofungicides such as Rootshield, Cease, Companion and Triathlon BA applied as soil drenches aid in protecting roots against root pathogens and

1 Damping off in tomato seedlings.

2 Botrytis spores and stem canker on basil.

3 Examining a sticky card with a hand lens.

4 Brown-marmorated stinkbug eggs and hatching nymphs.

may also reduce the need for foliar fungicides. Damping off can cause seeds to fail to germinate or it may cause them to succumb to a stem canker that girdles the stem.

Visible spores may or not be present on leaf or stem surfaces. Botrytis will appear as fuzzy, gray-colored spores. Botrytis sporulation increases significantly during humid, overcast weather conditions. Biofungicides like Cease, Companion or Triathlon BA—as well as traditional fungicides such as Zero-Tol or Heritage—can be applied if symptoms are observed. Chemical control options include Affirm, Emblem/Spirato and Heritage.

Selecting herb varieties with disease resistance, especially to powdery and downy mildews, offers reliable protection while not compromising flavor or appearance.

Bacterial infections appear as water-soaked brown or black, greasy-looking spots, which may be surrounded by a yellow halo when they occur on the foliage. In some cases, bacteria may be carried in the seed coat, especially on vegetables. Purchasing treated seeds where available may help eradicate infections. Bacterial infections require the pathogen inoculum, a susceptible host plant and wet conditions. Bactericides required to treat bacterial infections are limited and labels must list the herb being treated. Camelot O and Phyton 35 are labeled for several herbs, but not all.

Increase plant defenses against foliar pathogens by using the microbial biofungicides Regalia PTO, Fosphite and Alude. Essential Organic 1-0-1 is a root and plant stimulator that contains multiple beneficial active ingredients, including kelp. Sil-Guard (0-2-5) contains potassium silicate to aid in strengthening plant cell walls and stem strength to aid in reducing stress to environmental conditions. IG

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Building a Strong Foundation

A high-level look into understanding how plant nutrition is vital to achieving a high-quality crop.

by **JOACHIM NACHMANSOHN**

It's very important to understand what nutrition actually accomplishes, which goes for all agri-inputs for that matter, including biostimulants. But it's perhaps even more important to understand what nutrition *isn't* doing.

Inputs cannot, in and of themselves, achieve anything in the crop. Every process and structure that's generated by the crop is due to the amazing "machinery"—meaning the structure and program code (DNA)—within each plant cell. Nothing else can achieve growth, fruiting and yield.

However, all of this machinery demands a lot of resources in order to fulfill its functions and that's where nutrients come into the picture.

THE FOUNDATIONAL APPROACH

There's an important principle to understand related to the functions of the plant nutrients that's often overlooked. To a large degree, this is due to the fact that nutrients often are coupled with properties in the plant—which by the way, is correct to a large degree.

However, the problem with this approach is that it's easy to miss the most elementary function of plant nutrients—that they're building blocks in the cells of the plants. If this isn't clear, all teachings on plant nutrition will be misunderstood.

The most elementary building blocks in plants are the carbon compounds obtained from the atmospheric CO_2 through the photosynthesis. The nutrients are specialized building blocks with properties that enable the different functions in the cell structure.

The analogy of building a house is very useful: the carbon can be likened to bricks, while the nutrients can be likened to special components such as pillars, roof beams and mortar, etc.

Furthermore, it isn't so relevant from a plant cultivation perspective with regard to exactly what function an individual nutrient fulfills. It's more about the effects and symptoms that arise from deficiency.

The first consequence that follows from nutrient deficiency is reduced growth. After that, different symptoms follow depending on what nutrient it concerns.

MYTHS AND SOME CLARIFICATIONS

A common misconception is that plant nutrients could generate something in the plant. There are several persistent myths that have arisen because of this. Allow me to illustrate this based on the three big nutrients: nitrogen, phosphorus and potassium.

Nitrogen is considered to favor growth. It's not hard to understand where the idea comes from, as nitrogen application often results in increased growth. But nitrogen has no mysterious property that can promote growth.

A plant nutrient cannot achieve anything more in a plant than a brick can do in a house-building project. The question is, therefore, whether the demand for nitrogen is saturated or not. If not, additional supply can be used for growth, but if it's saturated, it doesn't matter how much is added, it still won't lead to any increase in growth.

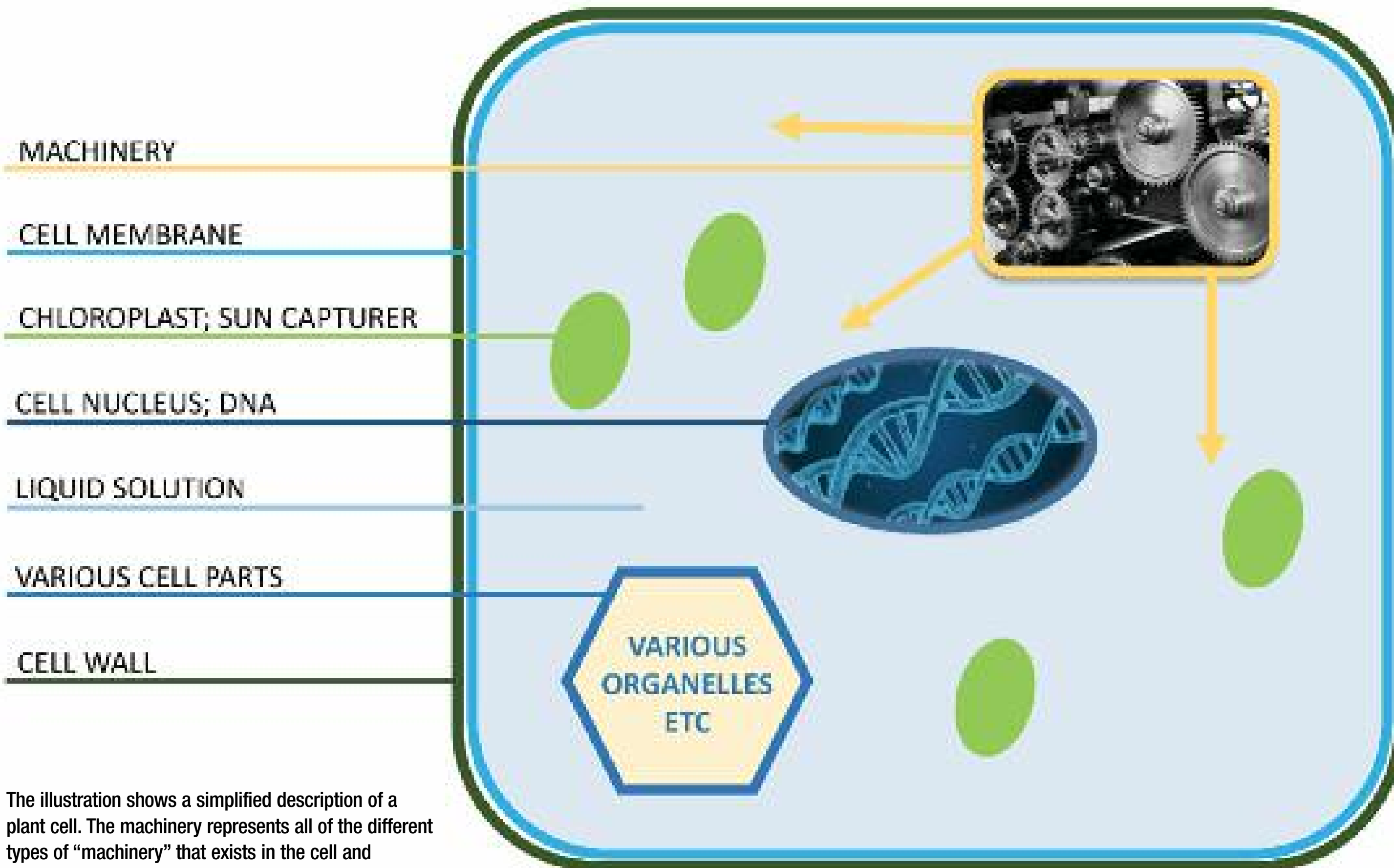
This is true for all nutrients, of course, and doesn't only apply to nitrogen. The principle of demand and saturation of a nutrient regulates not only growth, but all processes in the plant. Phosphorus is a good example, which is sometimes attributed with a particular ability to stimulate root development, and to promote flowering and fruiting.

But phosphorus has no unique ability to benefit these processes. The fact is that it's just the other way around—if phosphorus is supplied in a case of deficiency, it's the shoot that benefits and not the root.

The plant response to phosphorus limitation is similar to nitrogen; i.e., surplus of the photosynthesis resources will be

	Plant Nutrient	
Cell part	**Macro**	**Micro**
Machinery	N, P, Mg, Ca, S	Fe, Mn, B, Zn, Cu, Ni, Mo
Cell Membrane	P, Ca	
Chloroplast, Sun Capturer	N, Mg	
Cell Nucleus, Genome	N, P	
Liquid Solution	K	Cl
Cell Wall	Ca	B

The table shows where in the plant cell each nutrient respectively occurs. The categories of machinery and liquid solution have some overlap, but nutrients that occur in both are only mentioned in one of the categories.



The illustration shows a simplified description of a plant cell. The machinery represents all of the different types of "machinery" that exists in the cell and includes proteins. The cell membrane forms the boundary of the cell and regulates what comes in and out. The chloroplasts with their chlorophyll content are the cell's sun capturer. The nucleus contains primarily the plant's genome, DNA. The cell wall forms the skeleton of the plant and allows for an overpressure in the cell. The liquid solution is a central component of the cell, which should be regarded as a building block in the cell, even though it doesn't have a solid structure. The category of various cell parts is provided for illustrating only; there are other components in the cell as well. But these aren't necessary to understand the functions of the plant nutrients.

used for root development and the energy-intensive processes of flowering and fruiting.

The third myth is that potassium would be beneficial for plants preparing for cold-dormancy periods (which is something that would be relevant for tree nurseries in a later production stage). But there's nothing in potassium itself that would strengthen the plant before the winter.

The misconception may be due to the fact that potassium is important for the carbohydrate production, as potassium regulates photosynthesis. If a deficiency of potassium occurs later in the season, the carbohydrate resources will be depleted, which would be problematic for the winter dormancy, as sugar deficiency would lead to impairing the plant's ability to protect itself from sub-zero temperatures and frost.

But this isn't unique to potassium; it applies to all nutrients that regulate photosynthesis.

Sometimes, it's important to know the factors and mechanism behind different phenomena. I have no doubt that several of the misconceptions above are based on observations from trials in commercial production, but there's a risk with assuming too much in empirical trial-and-error-based set-ups. A mechanistic understanding in combination with applied research trials is necessary in order to achieve universally applicable knowledge.

DON'T FORGET THE RATIOS

The ratios in between the nutrients determine how the plant will respond to the supply of a specific nutrient. This is also an important factor in explaining some of the misconceptions mentioned above.

The mutual proportions in between the nutrients greatly influences how a plant assimilates nutrients, which in turn has a major effect on the physiology of the plant, from the growth rate and the distribution of carbon from photosynthesis to the various parts of the plant, to a variety of other processes and behaviors in the plant.

So if the absolute demand for a specific nutrient increases, the need for all other nutrients increases with the same proportions. This is because the new structures that are formed are very similar to each other in terms of nutritional composition. In the house-building analogy, every single cell would represent a house in itself, and therefore, every house initially needs the same raw materials, in virtually the same proportions.

Nutritional deficiencies may be due to an absolute lack of a certain nutrient in the soil. This means that the growth will stop when the plant's own nutrient storage is consumed and then the plant will become impaired and eventually die.

However, it's often the case that nutritional deficiency is due to a nutrient not being available in a sufficiently high proportion in relation to the nutrients that are available.

A CORRECT FERTILIZER MANAGEMENT REGIME

So how should we summarize this knowledge in terms of fertilizer management? First of all, we shouldn't obsess about one particular nutrient; plants need all 14 essential nutrients all the time and we must ensure that they're constantly available to the crop.

Secondly, we need to think in term of ratios when we supply them. Instead of asking how much the crop needs of each particular nutrient, it makes more sense to ask how the ratios should look like in reference to the nutrients that are in the highest demand—and that's usually nitrogen.

This varies somewhat between species and growth stages, but in general, there's not that much nitrogen, so it can be fine-tuned based on knowledge of the specific crop. The exact amount of nitrogen will be determined either by experience or research.

Final point here is that fertilizer management is a lot about ensuring the supply and preventing deficiency. If we return to the house-building analogy, we want to make sure that all workers have the correct and sufficient materials to perpetually build the house with maximum efficiency. When the supply is governed correctly, the nitrogen input will serve as the driver for growth and development, and it becomes quite simple to keep everything at the right level.

RAMIFICATIONS FOR GREENHOUSE SYSTEMS

Greenhouse production usually offers a lot of control over the process of supplying inputs over time. Therefore, it's recommended to utilize fertigation and provide all nutrients throughout the season. Another option is to use control-release fertilizers and be careful to irrigate accurately.

It doesn't have to be a complicated process to fertilize correctly. Regardless of the exact method, it should be fairly simple to manage fertilizer applications and ensure a sustainable and accurate supply, which both optimizes the production and is good for the environment. This will be much more likely if we have a correct understanding of plant nutrition and fertilizers.

JOACHIM NACHMANSOHN works internationally as a fertilizer and soil and water management expert. Through his company, Nachmansohn Consulting & Co., he, among other things, works with spreading accurate knowledge and skills on how to improve fertilizer use. His unique specialty is Demand-Driven Fertilization. He can be reached at consulting@joachimnachmansohn.com or visit www.joachimnachmansohn.com.

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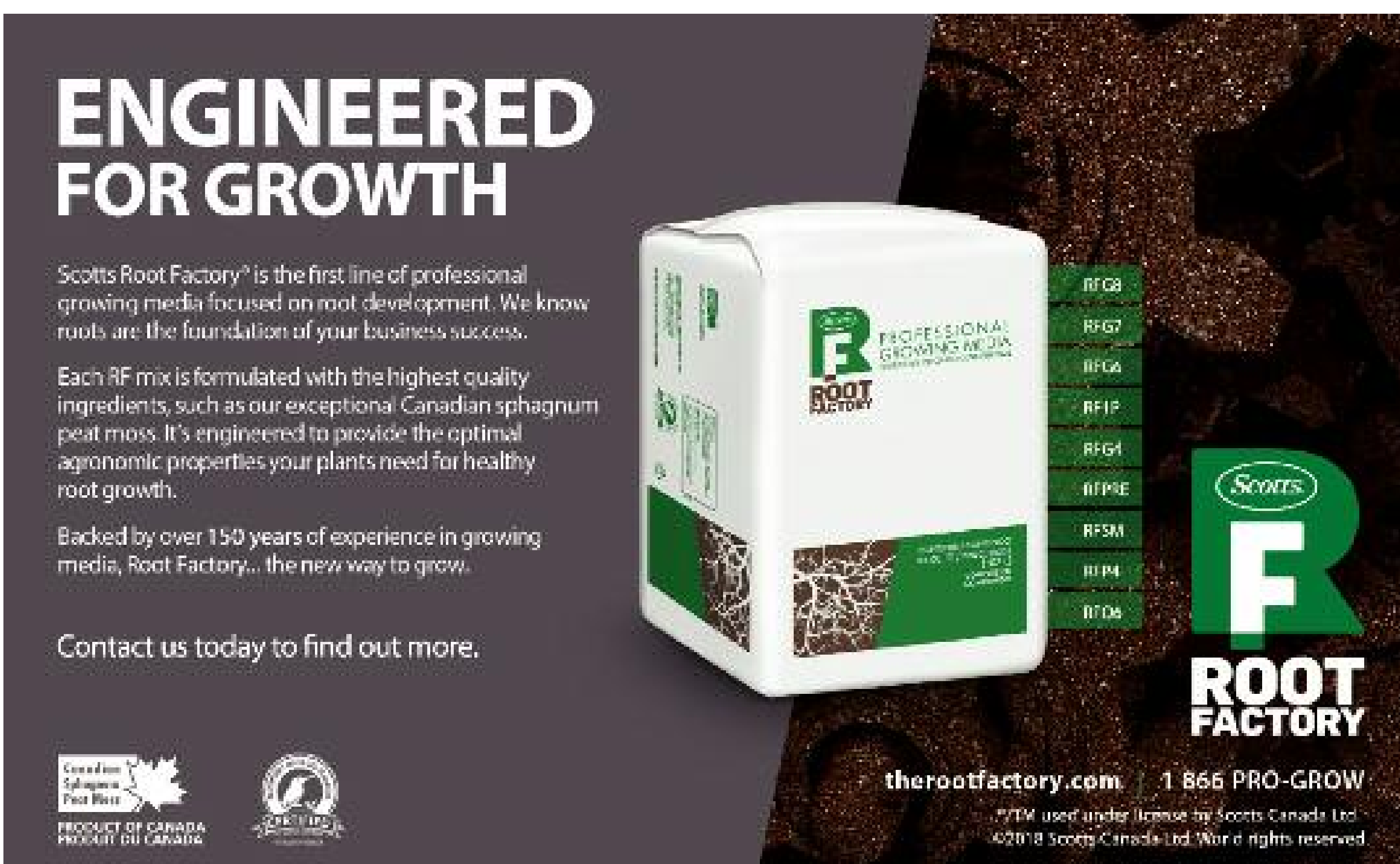

Reader Service Number 212

Look to the Law

Before you spray that pesticide, make sure you're not doing something illegal.

by **DR. BRIAN CORR**

Cannabis, like any cultivated crop, is subject to insects, mites, fungi or bacteria. Compared to some crops, cannabis pest problems are minimal, but controlling pests on cannabis has one significant challenge not found with other crops—limited registered pest-control products.

Horticulture and agriculture professionals have heard throughout their careers "the label is the law," meaning pesticide labels are the specific and final word on how a pesticide can be used. Health Canada and the Environmental Protection Agency (EPA) in the U.S. are "the law"—the agencies that regulate pesticide use.

Health Canada has issued a short list of specific pesticides allowed for use on cannabis production in Canada (see Table 1). However in the U.S., the EPA will not issue registration for pesticides used to produce cannabis (other than for industrial hemp).

In the U.S., states with laws allowing for state-legal production of cannabis have dealt with the lack of EPA-registered pesticides in different ways. In general, the approaches fall into one of several categories.

One approach is to develop a list of pesticides approved by the state, typically by the state Department of Agriculture. Sometimes the state also establishes testing requirements for pesticide residue. Some states (e.g., Nevada) are liberal in allowing synthetic pesticides, while others (e.g., Pennsylvania) restrict approved pesticides primarily to natural products. (See Table 2 for active ingredients approved for use in eight states.)

Table 1: Pest control products approved by the Pest Control Products Act (PCPA) and approved by Health Canada for use on production of cannabis in Canada.

FORMULATION NAME	ACTIVE INGREDIENT(S)
Actinovate SP	*Streptomyces lydicus* WYEC 108
Agrotek Ascend Vaporized Sulphur	Sulphur/sulfur
Bio-Ceres G WP	*Beauveria bassiana* Strain ANT-03
Bioprotec Caf	*Bacillus thuringiensis* ssp. *kurstaki* Strain HD-1
Bioprotec Plus	*Bacillus thuringiensis* ssp. *kurstaki* Strain EVB-113-19
Botanigard 22 WP	*Beauveria bassiana* Strain GHA
Botanigard ES	*Beauveria bassiana* Strain GHA
Cyclone	Citric acid, Lactic acid
Doktor Doom Formula 420 Professional Use 3-in-1	Canola oil
Influence LC	Garlic
Kopa Insecticidal Soap	Potassium salts of fatty acids
Lacto-San	Lactic acid, Citric acid
MilStop Foliar Fungicide	Potassium bicarbonate
Neudosan Commercial	Potassium salts of fatty acids
Opal Insecticidal Soap	Potassium salts of fatty acids
Prestop	*Gliocladium catenulatum* Strain J1446
RootshieldWP Biological Fungicide	*Trichoderma harzianum* Rifai Strain KRL-AG2
Rootshield HC Biological Fungicide Wettable Powder	*Trichoderma harzianum* Rifai Strain KRL-AG2
Sirocco	Potassium bicarbonate
Vegol Crop Oil	Canola oil

Some states declare that no pesticides may be used on cannabis. Delaware regulations state very succinctly "use of pesticides is prohibited."

Some states take a middle ground. Maryland has simply said pesticides must be applied "in keeping with state and federal guidelines" with no further comment, which leads to various interpretations.

In some cases, the state says nothing regarding what is or is not allowed. For example, Arizona regulations simply require reporting of "all chemical additives, including nonorganic pesticides, herbicides and fertilizers used" without giving guidance on what can or cannot be used.

Oftentimes, even when regulations have been written, they need interpretation. For example, a section of the Illinois regulations states: "No application of pesticides shall be made after the vegetative stage of growth of the cannabis plant." However "vegetative stage of growth" simply means there are no buds or flowers. In practice, this is typically being interpreted as two weeks after the initiation of short days. However, another might interpret the end of the vegetative stage as when the first buds are visible. The message to take from this is cannabis growers in each state must work closely with regulatory officials.

Pesticide regulations are in place for good reason. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) enables the EPA to establish regulations for safe usage of pesticides, so the environment, applicators and end users of products are protected. Since cannabis is eventually consumed, it makes sense to be careful about what is applied. Studies have shown that as much as 69% of pesticide residues in cannabis can be

Table 2: Pesticide active ingredients approved by state agencies for use on cannabis production.
(NOTE: Colorado, Oregon and Washington do not approve all formulations of an active ingredient. Always check with state regulators for approved formulations.)

ACTIVE INGREDIENT	CA	CO	IL	MI	NV	OR	PA	WA
1 Napthaleneacetic Acid (NAA)						X		
Acequinocyl					X			
Ammonium salts				X				
Ammonium salts of phosphorous acid		X				X		
Ammonium soaps of higher fatty acids						X		X
Ammonium nonanoate		X						
Auxin		X						
Azadirachtin	X	X	X	X	X	X	X	X
Bacillus amyloliquefaciens Strain D747	X	X	X	X	X	X	X	X
Bacillus licheniformis					X			
Bacillus megaterium					X			
Bacillus pumilus (various strains)		X	X	X	X	X	X	X
Bacillus subtilis (various strains)		X	X	X	X	X	X	X
Bacillus thuringiensis ssp. *aizawai*		X	X		X	X	X	X
Bacillus thuringiensis ssp. *galleriae*								X
Bacillus thuringiensis ssp. *israelensis*	X		X	X		X		X
Bacillus thuringiensis ssp. *kurstaki* (various strains)	X	X	X	X		X		X
Beauveria bassiana (various strains)	X	X	X	X	X	X		X
Bifenazate					X			
Burkholderia sp Strain A396	X	X		X	X			X
Canola Oil		X	X			X	X	X
Capric Acid		X		X		X		
Caprylic Acid		X		X		X		
Capsaicin	X	X		X	X	X	X	X
Castor Oil*	X	X		X	X	X	X	X
Cedar Oil		X					X	
Chitosan						X		
Chlorine dioxide			X					
Chromobacterium Sub Strain PRAA4-1		X	X	X	X	X	X	X
Cinnamon*	X	X	X	X	X		X	
Cinnamon oil*	X	X	X	X	X	X	X	X
Citric acid*	X	X	X	X	X	X	X	X
Citronella Oil		X	X			X		
Citronellol								X
Clarified Hydrophobic Extract of Neem oil		X	X			X	X	X
Cloves*	X	X		X	X		X	
Clove Oil*	X	X	X	X	X	X	X	X
Complex Polymeric Polyhydroxy Acids		X				X		X
Copper octanoate		X	X		X	X	X	X
Copper oxychloride					X			
Copper hydroxide					X			
Corn gluten meal*					X			
Corn oil*	X	X	X		X	X	X	X
Cornmint oil						X		
Cottonseed oil*	X	X	X	X	X	X	X	X
Cytokinins		X	X			X	X	X
Cyfluthrin and beta-cyfluthrin					X			
Diatomaceous earth		X	X			X	X	X
Dimethomorph					X			
Etoxazole					X			
Eugenol				X	X			
Farnesol			X	X		X		X
Fenhexamid				X	X			
Flonicamid					X			
Fludioxonil					X			
Garlic*	X	X	X	X	X	X	X	X
Garlic oil*	X	X	X	X	X	X	X	X
Geraniol*	X	X	X	X	X	X	X	X
Geranium oil		X			X		X	
Gibberellic acid (or gibberellins)		X				X	X	X
Gliocladium virens G-21	X		X	X		X		X
Gs-Omega/Kappa-Hxtx-Hv1a		X				X		
Harpin Protein		X				X	X	X
Helicoverpa armigera nucleopolyhedrovirus Strain BV-0003		X						
Homobrassinolide						X		
Hydrogen peroxide (or dioxide)		X	X		X	X	X	X
IBA (Indole-3-Butyric Acid)		X	X			X	X	X
Imidacloprid					X			
Iron phosphate	X		X			X		X
Isaria fumosorosea	X	X	X	X		X		X
Jojoba oil			X			X		
Kaolin		X	X		X	X	X	X
Lauryl sulfate*					X			X
Lemongrass oil		X			X	X	X	X
Linseed oil*		X			X	X		
Malic acid		X			X			
Metarhizium anisopliae Strain F52			X		X	X		
Mineral oil/horticulture oil		X	X	X	X	X	X	
Mint*					X			
Mint oil*					X	X		X
Mono-and Di-Potassium salts of phosphorus acid		X	X	X	X	X	X	X
Monopotassium Phosphate		X	X				X	X
Myclobutanil					X			
Myrothecium verrucaria dried Ferm. Solids/Slbs		X	X			X	X	X
Neem oil/Cold Pressed	X	X	X	X	X	X	X	X
Nerolidol			X	X		X		X
Oregano oil			X					
Paecilomyces fumosoroseus (Isaria fumosorosea)				X	X			
Paraffinic oil				X	X			
Pentachloronitrobenzene (quintozene)					X			
Peppermint*	X	X	X	X	X			
Peppermint oil*	X	X		X	X	X	X	X
Peroxyacetic acid		X	X		X	X	X	X
Petroleum Distillate	X		X			X		X

continued

Table 2 continued

ACTIVE INGREDIENT	CA	CO	IL	MI	NV	OR	PA	WA
2-Phenethyl propionate (2-phenylethyl propionate)					X			
Piperonyl butoxide		X	X		X	X		X
Potassium bicarbonate	X	X	X	X	X	X		X
Potassium laurate		X	X				X	
Potassium salts of fatty acids (insecticidal soap)	X	X		X	X	X	X	X
Potassium silicate	X	X		X	X	X		X
Potassium sorbate*	X	X	X	X	X	X	X	
Pyrethrins		X	X		X	X	X	X
Pythium oligandrum DV 74			X					
Reynoutria sachalinensis	X	X	X	X	X	X		X
Rhamnolipid Biosurfactant		X						X
Rosemary*	X	X	X	X	X		X	X
Rosemary oil*	X	X	X	X	X	X	X	X
S-Abscisic Acid								X
Sesame*	X	X	X	X	X	X		
Sesame oil*	X	X	X	X	X	X	X	X
Sodium bicarbonate	X			X				
Sodium carbonate peroxyhydrate					X			
Sodium chloride*		X			X			X
Silicon dioxide			X					
Sodium ferric EDTA		X	X			X	X	X
Sodium lauryl sulfate*		X			X		X	X
Sorbitol octanoate			X					
Sodium salts of phosphorous acid		X				X		
Soybean oil*	X	X	X	X	X	X	X	X
Spinetoram					X			
Spinosad					X			
Spirotetramat					X			
Streptomyces griseoviridis Strain K61		X	X		X	X		X
Streptomyces lydicus WYEC 108			X	X	X	X		X
Sucrose octanoate (esters)				X	X	X		
Sulfur	X	X	X	X	X	X		X
Thiamethoxam					X			
Thyme*		X	X	X	X		X	X
Thyme oil*	X	X	X	X	X	X	X	X
Trichoderma asperellum Strain ICC 012		X	X	X		X	X	X
Trichoderma gamsii Strain ICC 080		X	X	X		X		X
Trichoderma hamatum Isolate 382						X		X
Trichoderma harzianum Rifai Strain KRL-AG2	X		X	X	X	X		X
Trichoderma reesei					X			
Trichoderma virens Strain G-41			X		X	X		X
Trifloxystrobin					X			
Ulocladium oudemansii					X			
White pepper*				X	X		X	
Zinc metal strips					X			

NOTES:
- *ALWAYS* check with state regulators to determine what is approved.
- Not all strains of biological controls are allowed in each state.
- There's some overlap in compounds based on variable naming (e.g., "auxin" in CO and "NAA" in OR and various salts of phosphorus acid).

*Products on the Minimum Risk Pesticide list (25b) allowed for use on food.

transferred to the user in smoke. Pesticide residues can become more toxic on burning or become concentrated in extracts.

Pesticides registered by the EPA for use on food crops are extensively tested, so applications will not result in pesticide residues in excess of amounts determined to be safe. Although no pesticides are tested for use on cannabis, some pesticide active ingredients have been determined to be generally exempt from residue tolerances because of their safety.

One category of pesticides often allowed for use in cannabis production are pesticides classified as "25(b)" minimum risk pesticides. These are compounds the EPA has determined have little or no risk to human health or the environment. Examples of 25(b) pesticides are those with herbal or spice extracts as the active ingredient (clove oil, thyme oil, etc.) or materials typically used as food items (corn or soybean oil). Pesticides that contain only 25(b) listed active ingredients and approved inert ingredients are exempt from EPA registration. The EPA has specifically stated: "Pesticides that are exempt from federal registration requirements under section 25(b) are not prohibited from use on cannabis" (although some states require registration of 25(b) products before sale).

One important note: There is misunderstanding regarding the use of pest-control products certified for use in organic production. Simply because a product can be used in organic production does not necessarily mean it can be used in cannabis production. For example, rotenone is a pesticide derived from the roots of tropical plants that's approved (with restrictions) by the Organic Materials Review Institute (OMRI). However, it's not exempt from tolerance restrictions on food crops and isn't approved by any state for use on cannabis.

One pest control method is clearly allowable—biological control of insects and mites using predatory insects, mites or nematodes. Used with exclusion and good environmental control, many cannabis growers avoid the need for pesticide use.

In summary, nothing in this article overrides local regulations. Cannabis growers must develop a good relationship with the regulators in their state and listen to them for guidance on interpretation of pesticide regulations and always follow their interpretation of the regulations to the letter. IG

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

New Products JUNE 2018

Argus Controls Systems Ltd.
Omni sensors were developed to resolve many issues relating to the measurement of the most common climate parameters used in horticultural production. Along with state-of-the-art high accuracy temperature and humidity measurement systems, the Omni Sensor V4 is the first of its kind to include models that incorporate PAR light readings and CO_2 measurement. **Reader Service Number 220**

Berger
OMRI-listed OM2 Seed Germination is a fine grade plug mix that insures a perfect contact with the seed or stem and maintains optimal moisture for uniform germination and rapid rooting. It's perfectly balanced water-to-air ratio allows rapid root-ball development. Specifically designed for seed germination in small-cell trays or paper pots, the OM2 is a flexible and forgiving substrate that provides peerless uniformity.
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PanAmerican Seed
This first all-kale SimplySalad multi-pellet seed is an attractive mix of textures and colors. Kale Storm multi-pellets are a well-balanced mix of purple, green and blue kale varieties. Easy to grow with very quick crop times and only one pellet needed per cell. Grows well in hydroponic systems for long-term harvest. Height/spread can reach up to 24 in.
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GrowSpan Series 2000 Greenhouses can be the commercial grower's solution to bedding plants, modernized vegetable production, hydroponic production and more. With widths available from 20 to 50 ft., the Series 2000 can be used for a wide range of growing operations. If you're looking for specific sizing and accessories, a Growers Supply greenhouse specialist can help design the ideal structure for your application. **Reader Service Number 225**

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