insideGROWER

October 2015

CONTROLLED ENVIRONMENT AGRICULTURE





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LETTUCE Which
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hydroponic systems?



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Since sending out the first

issue of *Inside Grower* four years ago, we've maintained a focus on the cultivation of edible crops in controlled environments—and we'll continue to do so moving forward. Although it's rarely discussed in traditional horticulture, we all know that much of the same technology and techniques used in indoor production of tomatoes and leafy greens (and even ornamentals) are also used in the cultivation of cannabis, a.k.a. marijuana.

Whether you're morally for or against the use of cannabis products, it's one of the fastest-growing industries in the U.S. and it's increasing impact on the horticulture industry is undeniable. As more states legalize its cultivation for medicinal use (or even recreational use) and decriminalize its possession, the once-taboo crop isn't raising as many eyebrows. The so-called "green rush" is providing jobs for skilled growers and boosting business for greenhouse manufacturers and growing suppliers.

All that said, we decided to put cannabis cultivation in the spotlight for this issue's cover story. This isn't the

first time we've broken from the mold and pushed the boundaries of the traditional horticulture industry. In June 2011, *GrowerTalks* was the first trade publication in our industry to openly discuss cannabis—a feature story Managing Editor Jennifer Zurko won a prestigious national award for.

Four years later, cannabis cultivation is more widespread and the topic is less likely to ruffle as many feathers—we think.

Not knowing exactly where this story would take me, I set out with simply an open mind and a curiosity to explore the cannabis industry objectively and try to answer some questions I thought my readers would be curious about.

Naturally, I began my journey to learn more about the industry in Burlington, Vermont, the place I call home. Vermont has a small, but tightly regulated, medical cannabis program and it's possible the state legislature will legalize the recreational use of marijuana in 2016. I interviewed several growers and a dispensary owner here in Vermont and reached out to other growers, consultants and suppliers throughout the country. The result is a straightforward and unprejudiced look at some of the opportunities and challenges of cultivating cannabis in today's industry. Read all about it on page 10.

Of course, this issue of *Inside Grower* is also packed full of the practical information you've come to expect. You'll learn more about biocontrols for tomato plants (a.k.a. the "bug-eat-bug" approach); managing pythium in hydroponics; field lettuce varieties that also perform great in the green-

house; organic fertilizers and much more.

We hope you enjoy this publication of *Inside Grower*. As always, we welcome your questions and feedback.

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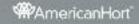
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ON THE COVER

As more states legalize its cultivation for medicinal use (or even recreational use) and decriminalize its possession, one of the fastest-growing industries in the United States isn't raising as many eyebrows, even in our traditionally morre conservative horticulture industry.

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Photo by Michael Tallman.

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Move Over Jell-O, Hospitals are Growing Veggies by the Acre

More and more hospitals, once known for their abundance of Jell-O flavors and soggy fries, are tearing out the deep fryers and partnering with local farms to give their cafeteria menus healthful makeovers. Some hospitals are even starting their own farms.

Jodi Helmer at civileats.com recently highlighted two hospitals that are farming in earnest, greenhouses and all.

Joining the staff of medical professionals at St. Joseph Mercy in Ypsilanti, Michigan, is Dan Bair, a full-time farmer. He manages about 25 acres of arable farmland (previously lawn) and three 30 ft. x 96 ft. hoophouses on the hospital's campus. All year round, Dan

and his farm volunteers grow fresh produce to sell at the hospital's farmers' market and to include in patient meals. You can visit their website at www.stjoesannarbor.org/thefarm.

At St. Luke's Hospital in Bethlehem, Pennsylvania, new moms are sent home from the hospital with a basket of fresh organic produce grown just outside on the hospital's own farm. Started last year, the farm doubled in

size this year, expanding to 10 acres and 30 varieties of fruits and vegetables.

St. Luke's partnered with the Rodale Institute to make their farming dreams come to fruition. The non-profit, organic farming gurus helped plan and design the farm, hire a farmer and manage operations.

Sounds great, right? Well, the unfortunate reality is that growing organic produce on a small on-site farm is more expensive for the hospitals than purchasing it through a food service supplier or sourcing it locally from other farms. According to Jodi's article, it took a \$125,000 of capital investment to start the farm at St. Luke's, and after two growing seasons, the farm is operating at a loss. They hope to break even in 2016.

Most Americans Could be Fed Entirely by Local Food

New research shows that more than 90% of Americans could be fed entirely by food grown or raised within 100 miles of their homes.

The research, led by University of California—Merced Professor Elliott Campbell, used farmland mapping data and land productivity information to compare the potential calorie production of existing farms to the population of American cities. Studying the farms and population within a local radius, they were able to determine what percentage of the population could be supported entirely by food grown locally.

The researchers found surprising potential in major coastal cities. For example, New York City could feed only 5% of its population within 50 miles, but could feed as much as 30% within 100 miles. The greater Los Angeles area could feed as much as 50% within 100 miles.

More people could eat entirely locally if they switched to a plant-based diet. For example, local food around San Diego can support 35% of the people based on the average U.S. diet, but as much as 51% of the population if people switched to plant-based diets.

The popularity of "farm to table" has skyrocketed in the past few years as people become more interested in supporting local farmers, but Elliot's research suggests that there's enough farmland that eating locally

doesn't have to be a passing fad. However, as his maps suggest, careful planning and policies are needed to protect farmland from suburbanization and development.

The research didn't specifically look at greenhouse farming as an option to grow more food locally, especially in urban areas.

You can find and purchase the full research paper in the June 2015 peer-reviewed publication Frontiers in Ecology and the Environment.



New York Greenhouse Project to Create 100 Labs for Kids by 2020

Started in 2008 by a small group of public school parents and educators, The Greenhouse Project continues to work towards their ambitious



goal of having 100 greenhouse project classrooms built by the year 2020.

Originally inspired by New York Sun Works Science Barge, the project's founders believe that urban farms on school rooftops in the New York City area can serve as highly influential classrooms.

To date, 26 greenhouse project classrooms have been created at local schools by the non-profit New York Sun Works. Fifteen more local schools will be getting greenhouse project classrooms during this school year. The program is aiming to have 100 built by 2020.

Most of the greenhouse project classrooms are built as traditional greenhouses to accommodate a hydroponic urban farm and environmental science laboratory. They typically include solar panels, hydroponic growing systems, a rainwater catchment system, a weather station and a vermicomposting station.

Grade school children grow food while learning hands-on about nutrition, water resource management, efficient land use, climate change, biodiversity, conservation, contamination, pollution, waste management and sustainable development. The laboratory operates as an integrated part of the school's curricula.

In addition to enhancing a school's science curriculum, the green-house laboratory greatly enriches arts and social studies by connecting nature to culture. Students learn the relationship between humans and the environment, and gain a greater appreciation of sustainable development and its direct relationship to cultural diversity.

Want to help support this effort to connect urban kids with green-

P. Allen Smith to Promote Sakata Vegetable Seed Brand

Sakata Seed America has announced a new partnership

between the company's Home Grown Vegetable division and P.Allen Smith Garden Home. Sakata

Home Grown is now the official vegetable seed brand of P.Allen Smith. Furthermore, P.Allen has identified a collection of Sakata varieties and branded it under the P.Allen Smith Home Grown Seed Collection.

P.Allen is an award-winning designer, gardener and lifestyle expert. His television programs, "Garden Home," "Garden to Table," and "Garden Style," air on hundreds of stations nationally.

"A return to the vegetable garden is a welcomed trend, which is good for the well-being of ourselves, families and communities," says P.Allen. "It may not be possible to grow an entire garden, but growing just a few things makes a difference."

Sakata Marketing Manager Alecia Troy says the company looks forward to the exposure P.Allen will bring to gardening and healthy eating with the P.Allen Smith Home Grown Seed Collection.

"Our partnership with P.Allen Smith is an exciting step toward connecting with consumers through education and passion," adds Alecia.

P.Allen Smith also has partnerships with Bonnie Plants, Proven Winners, Jobes Organics and Le Creuset. IC

LumiGrow Offers New Lighting Control System

LumiGrow, Inc., a California-based leader in greenhouse spectrum control systems, recently introduced what they're calling the most advanced lighting control system in horticulture.

It's called SmartPAR and it offers growers the same kind of control over the light environment as they have over most other parts of the greenhouse and indoor growing environments.

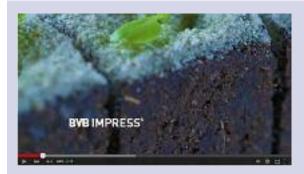
"We know our customers need every advantage they can get to maximize yields without increasing the size or expense of their operation," said Kevin Wells, CEO at LumiGrow. "The SmartPAR system is the next step in helping LumiGrow customers do just that."

The patented system's software and hardware work together to offer complete spectrum control, allowing growers to target plants with the kind of light they need when they need it.



LumiGrow says SmartPAR can be used to:

- Create separate lighting zones to differentiate production areas
- Remotely control the spectral output of zones to improve crop yield, productivity and energy efficiency
- Monitor the lighting system using real-time feedback for fixture maintenance and facility management
- Adjust light levels as needed when crop needs and available sunlight changes



New "Sticky Peat" from A.M.A. Plastics

A.M.A. Plastics, in partnership with BVB Substrates of The Netherlands, has a new product for North American growers. Called BVB Impress, it's described as a new version of "sticky peat" that's suitable for press block production and as a germination mix in plug trays.

"BVB Impress uses white peat with a mixture of other 100% organic materials

with no chemical additives, making it airier and more water absorbing for better roots; more dimensionally stable so it holds its shape; and importantly, much lighter for lower handling and transport cost," explains the company in a press release for the new product.

They say that BVB Impress is suitable for propagation of many crops in both greenhouse and field production. Crops include, but aren't limited to: lettuces, cabbage and other cole crops, cut flowers and herbs.

A.M.A. supplies propagation substrates, trays and equipment to a diversity of growers. They also offer wholesale distribution across the U.S. and Canada of hydroponic growing supplies for professional vegetable growers, including BVB Sublime Substrate, Stonewool, Coir, Tomato Clips and Truss Supports, Twines, CO2 Tubing, poly ground cover, picking shears, and turnkey Dry Hydroponics lettuce/leafy vegetable systems.

You can learn more about BVB Impress on A.M.A's YouTube Channel. [C]



Fresh Produce Reaching More Low-Income Families

A sharp increase in Supplemental Nutrition Assistance Program (SNAP) benefit redemptions through farmers and farmers markets suggests more fresh produce is reaching low-income families in the U.S.

SNAP participants spent \$18.8 million of their benefits (also known as "food stamps") last year at road-side farm stands, farmers markets and directly from local farmers. That's a six-fold increase since 2008. There are also eight times as many SNAP-authorized farmers now (over 6,400 vendors) than in 2008 (753 vendors). USDA provides free wireless equipment to qualifying farmers and farmers markets, enabling them to accept SNAP via electronic benefit transfers (EBT).

Additionally, in May, USDA announced the availability of \$3.3 million in Farmers Market SNAP Support Grants to help farmers markets serve SNAP participants.

USDA also recently awarded \$31.5 million in funding to local, state and national organizations to support

Philips Opens New High-Tech Farming Research Facility

Philips has opened a new state-of-the-art farming research facility at the High Tech Campus in Eindhoven, the Netherlands. At the GrowWise



Center, Philips will research customized LED light growth recipes to help indoor growers maximize their yields year-round.

The new facility, said to be one of the largest indoor farming research facilities in the world, aims to optimize growth recipes for leafy vegetables, strawberries and herbs. Philips says they're also interested in researching ways to grow more carbohydrate-rich crops indoors, such as wheat and potatoes.

The research center features four-layered mechanized planting racks in each of its eight climate-controlled rooms resulting in a total growing surface of about 2,500 sq. ft. Each growing layer at the facility is equipped with Philips GreenPower LED lighting, which can be customized for various lighting treatments. Philips says that LEDs are highly energy efficient and produce less heat, meaning they can be placed closer to plants for more uniform illumination.

Learn more about Philips' LEDs on their YouTube channel. [6]

Growtainer 2.0 More Productive, Efficient and Affordable

The new and improved Growtainer 2.0 will launch soon, according to



Glenn Behrman, president of GreenTech Agro. The Growtainer is a patent-pending growing system contained within a specially designed and modified insulated shipping

container. Developed for food production, horticulture or floriculture, the Growtainers offer efficient, climate-controlled environments for growing.

Growtainer 2.0 has been completely re-designed to be more affordable, more efficient and more productive, ultimately offering a faster return on investment. It comes with a moveable and adjustable proprietary Growrack system designed by GreenTech Agro and manufactured in Holland.

Glenn says that Growtainer 2.0 can produce two to three times as much produce compared to other container-based products in the market today. They're available in lengths of 40 ft. or 45 ft. and can be custom designed for any climate.

"GreenTech Agro is finally ready to talk to investors and choose two or three distributors," says Glenn. "I said at Indoor Ag [Conference in March 2015] that I wouldn't sell a Growtainer unless it was perfect. And version 2.0 is perfect."

For more information, visit www.growtainers.com or email

Six Fish Species for Commercial Aquaponics

It seems like Tilapia is the typical fish of choice to grow alongside plants in an aquaponic system, but are there other options? Indoor Ag, in conjunction with Aquaponics Consultant Sarah Taber, recently created an infographic comparing six fish species for commercial aquaponics.

Aquaponics is a food production system that combines growing veggies hydroponically with aquaculture (raising fish in tanks). Aquaponics uses a symbiotic environment to grow veggies and fish together. By-products of the fish serve as nutrients for the plants.

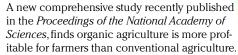
Traditionally a backyard or hobby pursuit, the commercial aquaponics industry is growing rapidly thanks to technology advances and demand for local sustainable food.

The six fish species reviewed in the infographic include tilapia, barramundi, sturgeon, hybrid striped bass, trout and Pacific salmon. The benefits, disadvantages and growth rates of each fish are discussed.



Sturgeon is one of the species that could be a strong contender for a commercial aquaponic system. Considered a sustainable alternative for swordfish, sturgeon grows quickly, has little competition in the market and it's optimum temperature is also optimum for plants. Its biggest disadvantage is it's not well recognized in the marketplace yet. ICE

Organic Agriculture More Profitable to Farmers



In spite of lower yields, the global study shows that the profit margins for organic agriculture were significantly greater than conventional agriculture.

Researchers from Washington State University conducted a review of 44 studies, spanning over 40 years, 55 crops and 14 countries on five continents. The authors say this is the first large-scale synthesis of the economic sustainability of organic farming compared to conventional farming.

The study found that the premiums paid to organic farmers ranged from 29% to 32% above conventional prices. Even with organic crop yields as much as 18% lower than conventional, the breakeven point for organic agriculture was a 5% to 7% premium.

Organic agriculture currently accounts for only 1% of cropland globally, but the study says that there's room for organic agriculture to expand and, with its environmental benefits, to contribute a larger share in feeding the world sustainably.

Read the full study at www.pnas.org/content/112/24/7611.abstract.



The U.S. is slated to see an impressive array of new or expanding greenhouse vegetable operations in the near future, according to Greenhouse Vegetable Consultant Gary Hickman. Gary says that over 670 acres of greenhouse vegetable production is in the planning stage or already under construction. This represents a 30% increase in total greenhouse vegetable production in the U.S.

Also according to Gary's data, Canada could see 98 new acres spread among three proposed projects and Mexico could see 111 new acres spread among four projects.

Details on all of these proposed projects, including the name of the company and Internet contact/information link, are available in Gary's June 2015 *North American Greenhouse Vegetable Producing Companies* publication. Also listed in the publication are over 730 current North American growers, with information

and contact links. The website, with ordering information for this publication, is available at www.cuestaroble.com. [6]



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Reader Service Number 202

Considering Cannabis

The science and practicality of growing CEA's trendiest crop.



Cultivation Manager Josh Drew tends to cannabis plants at Champlain Valley Dispensary's grow facility in South Burlington, Vermont. He wears Method 7 grow glasses, specially designed for working with a crop under HPS lighting.

by ANNIE WHITE, photos by Michael Tallman

It's one of the fastest-growing industries in the United States. Some people call the phenomena "the green rush" and those looking to cash in "ganjapreneurs." *TIME* magazine calls it "the highly divisive, curiously underfunded and strangely promising world of pot science."

Here, we'll simply call it cannabis cultivation. No puns. No ganja jargon. This is just an open-minded and objective look inside the industry of growing a unique plant—cannabis.

Whether you're morally for or against its widespread usage, from a strictly business standpoint, the cannabis growing market deserves some attention. ArcView, a cannabis industry research firm, predicts sales of legal marijuana will reach \$3.5 billion this year, up from \$2.7 billion in 2014 and \$1.55 billion in 2013.

Another report by a promarijuana research and advisory firm, Green Wave Advisors, says that if all 50 states and the federal government legalize cannabis, the annual sales for both medical and recreational marijuana could reach \$35 billion by the year 2020. To put that in perspective, the estimated annual sales of greenhouse tomatoes are \$400 million in the U.S.

As more states legalize its cultivation for medicinal use (or even recreational use) and decriminalize its possession, the once-taboo cannabis leaf isn't raising as many eyebrows, even in our traditionally more conservative horticulture industry.

The great legal conundrum

Even though cannabis was cultivated and used throughout the majority of U.S. history, the plant was designated as a Schedule I drug in 1970, meaning that it has high potential for abuse and addiction, has no medicinal value and possessing it could land you in prison. Other Schedule I drugs include heroin and LSD. (Schedule II drugs, which are described as having less abuse potential, include cocaine and methamphetamine.)

Nearly half of all states have re-evaluated marijuana's status as a dangerous substance. As of press time, 11 states have both a medical marijuana law and have decriminalized possession of small quantities. Eight additional states have medical marijuana laws and five additional states have eliminated jail time for possessing small amounts of marijuana. Four states (Colorado, Washington, Oregon and Alaska) have legalized marijuana use for adults-both recreational and medicinal. Recreational marijuana is taxed and regulated similar to alcohol in these states.

The problem is state laws don't trump federal law. It's still entirely within the scope of the federal Drug Enforcement Agency (DEA) to raid and prosecute marijuana growers, even if the growers are abiding by the laws of the state in which they operate. The unlawful distribution or possession with the intent to distribute marijuana is a federal felony. The possession of 1,000 plants

could theoretically put a grower behind bars for 10 years to life.

"We get up and go to work each day and sometimes it's easy to forget that what we're doing is still federally illegal," explained Shayne Lynn, executive director of a Vermont medical marijuana dispensary. (See case study on page 14.)

The DEA continues to conduct raids, even in states with legal medical and recreational marijuana programs, but in this legal tug-of-war over cannabis, it's believed the agency is yielding some ground. Growers who work closely with their state regulatory agencies to ensure compliance have less concern about a DEA raid than someone not in good standing with the state. The raids that make headlines typically stem from some kind of non-compliance (i.e., growing too many plants or illegally diverting irrigation water).

Of course, this legal conundrum creates an unusual landscape for running a business. Finding a bank willing to loan you money or an insurance agency willing to insure your crop and property is nearly impossible. Many businesses are forced to operate in cash only. According to a fact sheet from *Marijuana Business Daily*, less than 1% of financial institutions are willing to do business with the cannabis industry.

Cannabis science

To better understand cannabis cultivation, we turned to Ph.D. Plant Biologist and cannabis expert Monique McHenry.

Monique is also the executive director of one of the four licensed medical cannabis dispensaries in the state of Vermont. However, the operation maintains a strict "no talking to the press" policy, so when I sat down with Monique we strictly talked science—no business.

Originating in a small region in central Asia, cannabis is one of the oldest known cultivars. Its use is documented across 10,000 years of human civilization. Ironically, today, it's one of the least understood agricultural crops. Trialing and researching a Schedule I drug is complicated at the least, and at most, impossible.

Much of what we know today is thanks to a team of Israeli scientists, led by a young organic chemist named Raphael Mechoulam, who teased out the unidentified compounds in cannabis for the first time in the 1960s. They were the first to isolate tetrahydrocannabinol (THC), the psychoactive part of cannabis, which provides a "high" to users or a sense of mild euphoria and relaxation. It's just one of about 100 other cannabinoids chemical compounds that also provide relief to an array of symptoms including pain, anxiety nausea and inflammation. Different cannabis strains have different levels of cannabinoids, and frequently medical marijuana patients prefer strains with less THC.

Monique explains that different cultivation factors also affect cannabinoid production, including sex and maturity of the plant, length of daylight, ambient temperature, availability of nutrients and UV intensity. As cultivators strive to grow consistent medical-grade marijuana, it's important to understand how cultivation methods affect cannabinoid levels.

Learning and improving cultivation methods is uniquely

challenging for cannabis growers. They can't turn to the wealth of peer-reviewed journal articles or university extension production guides the way a tomato grower can. Frequently, they conduct their own research trials to evaluate different production methods.

Monique says the industry needs more research. Breeding programs are needed to develop strains that are mold resistant and pesticide research is also greatly needed. Several states require pesticide safety testing, but little is known about safe use of pesticides in cannabis.

Horticultural supply industry embraces cannabis

Five or 10 years ago, it may have been challenging to find trusted and experienced companies to help design, build, outfit and supply a cannabis-growing venture. But today, much of the traditional horticulture industry is involved, sometimes quietly, in the cannabis market.

Bernie Mantay, general manager of Biobest Canada and Biobest USA, says that working with cannabis growers is quickly becoming an important objective for the company. While they don't mention cannabis on their website, Bernie says they'll be promoting Biobest within the cannabis industry through alternate channels.

"I think, working together, there are excellent opportunities for both the cannabis industry and our industry," adds Bernie.

Chris Lundgren, national sales manager for Dosatron, says he's been regularly working with the cannabis industry for about two years. Chris notes that while cannabis growers are often behind the times on growing technologies, they are thirsty for knowledge.



The cannabis crop is monitored at Champlain Valley Dispensary's grow facility in South Burlington, Vermont.

Some companies work with cannabis growers, but prefer to keep it on the down low."We do not broadcast to the traditional industry that we are soliciting business from medical marijuana growers, but we do not hide it either," explains one U.S.based greenhouse manufacturer. "Most of our clients have asked and we tell them we have sold projects."

Other companies, such as greenhouse manufacturers Rough Brothers and GGS Structures, and environmental controls company Conviron, advertise openly to the cannabis industry through their websites.

GGS says their company has been helping cannabis growers for many years and has established an internal team of knowledgeable growers and managers for this purpose.

They only supply projects to states in the U.S. that have passed legislation allowing medical and/or recreational marijuana cultivation. (They also have projects in Canada, Jamaica, Israel and Uruguay.)

"Due to the amount of requests we receive from cultivators, we have to be vigilant that supply enquiries are compliant to state laws and regulations," explains Leigh Coulter, president of GGS.

SHS Griffin Greenhouse Supplies says they've launched a new marketing campaign to connect with the expanding cannabis market. They advertise in key cannabis industry publications, as well as attend industry trade shows. They say they're currently developing a website specific to the cannabis and CEA markets.

From traditional horticulture to cannabis culture

As more states are legalizing medical marijuana and licensing growing operations, some growers of ornamental and/or edible crops are wondering if they could be successful growing cannabis.

Leigh Coulter says that it's absolutely feasible to transition from ornamental/edible greenhouse crops to cannabis, but cautions that it's a significant change in business and should not be approached lightly.

"Cannabis is a very different business model from ornamentals and traditional greenhouse edibles," said Leigh. "Distribution, marketing, financing and regulatory issues are all different, so smart growers start with building a business plan for the new cannabis reality, then find a partner like GGS who can help put the whole package together: structure, mechanical, electrical, irrigation, computer control designed to optimize the cannabis crop environment."

Shane Hutto, owner of Horticultural Solutions—a Denver, Colorado-based cannabis consulting company—helps clients design, plan and implement growing operations. Before becoming a cannabis consultant, Shane served as a North American technical advisor for Grodan, a Netherlands-based manufacturer of hydroponic substrates.

Shane has helped growers of edible greenhouse crops retrofit their facilities (or expand them) to grow cannabis. "It's much easier for me to turn a hydroponic tomato grower into a cannabis grower than to turn an experienced cannabis grower into a tomato grower," explains Shane. "The principles are very similar, but most cannabis growers have never used the level of technology utilized in a modern tomato house."

Cannabis cultivation is

unique, explains Shane, in that it involves facets of multiple crops. Some aspects of the flowering plant require cultural practices similar to chrysanthemums. Other aspects, such as pruning and nutrition, are more similar to tomato growing.

Another consideration in entering the cannabis market is the crop's long-term profitability."I think the next five years will show astronomical growth, and a decade from now, I would expect a market

decrease and eventual leveling off," hypothesizes Shane. "In 10 years, I expect it will be a similar market to tomatoes—there will be slim margins and only the biggest and best will make worthwhile money."

If Shane's predictions are true, the next five years could be a unique time in controlled environment agriculture. The industry may see a surge of new growers, new-to-cannabis growers and a rush for cannabis information and technology.

GROWER PROFILE From Tomatoes to Cannabis

Chris Williams doesn't fit the physical stereotype of a marijuana grower. He isn't tattooed, pierced or even a little rough around the edges. He's friendly, professional and brings an impressive résumé of growing hydroponic greenhouse tomatoes to his job as cultivation manager at Champlain Valley Dispensary in Burlington, Vermont.

Chris, a Vermont native, became smitten with controlled environment agriculture when he was just 19 years old. He traveled north to Charleviox, Quebec, mentoring with the head grower at Serres LaCoste, a two-hectare greenhouse specializing in beefsteak tomatoes. After learning the ropes, Chris returned to Central Vermont to be the head grower at Vermont Hydroponic Produce.

After growing beefsteak and cluster tomatoes hydroponically in Vermont for six years, Chris wanted a new challenge. He went on to spend time as the head grower at BrightFarms' one-acre greenhouse in Yardley, Pennsylvania, and as an assistant grower with D'Vine Ripe in Australia, managing 66 acres of glasshouse tomatoes.

With his wife expecting their first child, Chris decided to return to the U.S. in early 2015. He considered returning to Vermont Hydroponic Produce, but was told, amiably, that he was too expensive for the small company. Despite having never grown cannabis and knowing very little about the plant itself, he reached out to the Champlain Valley Dispensary and soon he re-launched his career as a cannabis cultivator.

"As a grower, I've always looked for the next best thing. Cannabis is that thing now. It's the cutting edge," explained Chris, who is unabashed to talk about his leap from growing tomatoes to growing cannabis.

Chris says that while tomatoes and cannabis have different cultural needs, managing the growing environment is very similar. "I'm someone who thrives on data. I grow by numbers," he explains. "Consistency and uniformity are important in a tomato operation and are even more important growing medical cannabis." As medicine, each batch needs to be grown the same to achieve the consistent cannabinoid levels patients expect.

As for pay, Chris says that just like any other crop, wages reflect the scale of the operation. Right now, he's the cultivation manager



Cultivation Manager Chris Williams checks cannabis plants at Champlain Valley Dispensary's grow facility in South Burlington, Vermont.

for a small cannabis growing operation, but he's hopeful that as the company expands, so will his responsibilities, and so will his earning potential.

Now with a young family, safety is a consideration for Chris. As an employee, he does not own the cannabis crop, so in the unlikely event of a legal intervention, he would not be personally liable. Chris says he feels completely safe going to work each day and would even feel comfortable tending to a middle-of-the-night alarm, if need be. Multiple measures are in place to ensure the facility's security.

When asked what some of those security measures are, Chris quipped, "Well, we're here aren't we?" referring to the fact I was interviewing him in a public café and not at their growing facility. The facility is in an undisclosed location, somewhere in South Burlington, Vermont, intentionally in close proximity to the police department. Only people with official business (press do not qualify) are permitted to visit the facility and all visits must obtain prior approval from Vermont's Department of Safety, the agency overseeing medical marijuana operations in the state.

Chris said that his family, friends and former colleagues are supportive of his latest growing venture. He hasn't faced any criticism and he jokes that probably the most common response from people who know him is "we figured it was just a matter of time."



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CASE STUDY Champlain Valley Dispensary

Vermont has a small, but tightly regulated medical cannabis program, and it's possible the state legislature will legalize the recreational use of marijuana in 2016. The industry in Vermont is, of course, just a sliver of the cannabis boom that's happening in states like Colorado and California, but Vermont does offer a unique look at what operating a fully transparent growing operation in a tightly regulated state looks like.

Chris Williams and Josh Drew manage Champlain Valley Dispensary's 5,000 sq. ft. indoor grow facility—a small operation by most standards—but are currently expanding five-fold to a new location with 25,000 sq. ft. of indoor grow space, a laboratory, processing facility and outdoor space to add greenhouse production in the future.

Unlike Chris, cultivating cannabis has been 25-year-old Josh Drew's career goal since starting college as an environmental horticulture major at the University of Maine-Orono. Although the university didn't offer any training in cannabis cultivation, Josh took what he learned in his horticulture, sustainable agriculture and business classes and figured out how to apply it to the plant that fascinates him the most—cannabis. Josh has been managing and training the cultivation team at Champlain Valley Dispensary since 2013 and has developed many of the cultivation procedures and protocols.

To keep their two dispensaries in supply, they grow 52 weeks a year, on what they call a "perpetual grow" rotation. They grow between 30 and 40 cannabis strains, with an emphasis on 10 to 15 of their best sellers. All are grown hydroponically in coco media under 1,000-watt high-pressure sodium lighting. They're also trialing plasma lighting and LEDs.

As part of their integrated pest management program, they fight pests proactively with a well-rounded palette of beneficial insects. With good IPM and strict sanitary protocols, so far, they've never needed to use a pesticide.

Personal hygiene is important in the facility. The cultivation team wears facility-specific clothing, gloves and hairnets, and routinely wash their hands and step through disinfectant footbaths. Chris says the sanitary protocols are on par with what he's seen at other large-scale greenhouse vegetable growers, but he believes they keep their facilities cleaner than most cannabis growers.

Currently, they use a commercial water-soluble fertilizer, not specifically formulated for cannabis. Albeit expensive, they say it works great. As they expand, they plan to start mixing their own nutrients, allowing for more customization, and ultimately, saving money.

Every cannabis plant in their facility has a unique code and is tracked with the help of a computer program from cutting through harvest—a process that takes about two and a half to four months depending on the strain. This kind of tracking system is mandated by the state. It helps monitor the crop's consistency, which is important to patients, but it also makes it very difficult, if not impossible, for a plant or a portion of the harvest to go missing.

To work in the industry in Vermont, individuals must pass a state-mandated FBI background check. Folks with blemished records won't be hired. Josh says that members of their cultivation team don't necessarily need a college degree or even experience growing cannabis. Most importantly, they need to be attentive to

details, patient and willing to meticulously follow the company's sanitation and cultivation protocols.

"The biggest challenge with new employees is just getting rid of their bad habits," says Josh. "It can be hard for some people to understand that we don't always do things the way they're used to. We're growing medicine and our protocols are strict."

All "mother" plants (the source of cuttings) have to be donated to the facility by patients. Legally, that's the only option. Cannabis plants cannot cross state lines, and currently, there is no source of cannabis genetics in Vermont.

The business side of growing cannabis

Champlain Valley Dispensary's Executive Director Shayne Lynn looks like any other businessman you'd find walking down Church Street in Burlington.

About seven years ago, Shayne started following the medical marijuana movement in Vermont, attending meetings at the state house and advocating for its legalization. In short, his interest in the industry grew, eventually leading him to apply for (and receive) a license to grow and sell medical marijuana in 2012.

Banks loaning money to cannabis businesses are nearly unheard of, so Shayne secured "contributors," as he calls them, to invest in the nonprofit business he established. Two years after opening his dispensary door for the first time, he's grown from 80 to 800 patients and has so many people interested in investing, he can handpick the contributors he wants to work with.

Shayne feels fortunate to have found a couple of credit unions that were willing to work with his business. (In other states, many cannabis growers are cash-only businesses.) This was an important step in trying to be as transparent as possible. The bank tracks all of the money in and out of the business. There's nothing to

Protecting the company's physical assets has proven to be uniquely challenging. He's found that insurance companies are hesitant to work with cannabis businesses because it's a relatively new industry, there are still some uncertainties, and there just isn't enough data for insurance companies to feel safe hedging their bets. Shayne says he does have crop insurance, but he pays a lot for a very minimal policy.

Looking forward, Shayne plans to grow the business to provide more products to more patients. If the recreational use of marijuana is legalized in Vermont next year, a whole new market will open up, but so will the potential for new competition.

CANNABIS RESEARCH

Most universities are reluctant to affiliate themselves with the federally illegal plant, so research proposals remain shelved. However, the lab of Evolutionary Biologist Dr. Nolan Kane at the University of Colorado at Boulder is working on creating an ultra-high density genetic map of cannabis.

"This will revolutionize cannabis breeding, bringing the genetic tools and resources up to the level of all but a handful of crops," says Nolan. The project will sequence two divergent lines, Cannabis sativa and Cannabis

indica, as well as 96 to 142 hybrids of those lines, to make a very high-quality genetic

Funding the research has proven trickier than studying, say, a tomato. Presumably for legal reasons, the University of Colorado does not accept money from the cannabis industry or people/companies explicitly representing the cannabis industry. So Nolan set up a nonprofit foundation and a bank account through a separate credit union, which can accept donations from all people and companies to help fund the research.





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Lettuce Tell You What to Grow

University of Arkansas researchers trialed 65 lettuce varieties to determine their potential for production in greenhouse hydroponic systems.

by DAVID KUACK

An increasing number of greenhouse ornamental plant growers are looking to expand into edible crops. There are also field vegetable growers who would like to expand their production to include crops in a protected or controlled environment. Some of the easier and faster crops for growers to try to produce in structures are lettuce and other leafy greens.

One of the issues these growers are facing is what varieties of lettuce can be grown in a greenhouse environment. Much of the commercial lettuce breeding is focused on outdoor field production. Growers looking to expand their lettuce offerings beyond commonly produced greenhouse varieties usually have to do their own trials, looking for field-bred and greenhouse-type varieties that can be adapted to a greenhouse environment.

EXPANDING GREENHOUSE VARIETIES

University of Arkansas horticulture professor Mike Evans said he's constantly receiving inquiries from growers about what lettuce varieties can be grown in greenhouses.

"At Cultivate' 14, we surveyed growers who participated in one of the greenhouse vegetable seminars about their educational and research needs," Mike said. "One of the growers' responses was the need for variety information.

"If you look at seed catalogs, most of the information describing lettuce varieties is based on field production, not greenhouse. So if a grower wanted to grow lettuce hydroponically in a greenhouse during the winter there's little information available. If a grower wanted to use nutrient film technique or deep flow floating systems in a greenhouse, there's basically little information on how lettuce varieties would do in these specific production systems. Most of the production information is field-based."

Mike said there's also a need for evaluating lettuce varieties for fall, winter and spring greenhouse production. He said these variety evaluations need to be done in different regions of the country to see how they perform under different climates.

LETTUCE VARIETY EVALUATIONS

University of Arkansas researchers selected 65 lettuce varieties for evaluation in greenhouse production systems. A nutrient film technique and deep flow floating system were used for the trials.

"Our goal with the variety trials was to generate better and more variety information, and to determine which varieties would work best in climates similar to ours," Mike said. "We especially wanted to be able to make variety recommendations across a production year. That is, varieties which work well in the fall, winter and spring.

"There are certain varieties that do well during winter, but as soon as the days start getting longer, the variety begins to bolt. Or a variety may do well in the fall and spring, but during the lowest light levels of winter, it has some type of production issue."

Mike said the information that's been collected is for lettuce varieties that perform well in a glass greenhouse in Arkansas.

"These varieties may not respond the same way in Michigan, Arizona, Florida and Texas," he said. "They also won't respond the same way in locations where the light and humidity levels are different. These trials are probably good recommendations for growers in climates similar to ours."

Lettuce varieties were grown from September through May. No

University of Arkansas researchers selected 65 lettuce varieties for evaluation in greenhouse production systems.



crops were grown in June, July and August. Four crops were produced during the fall to spring cycle.

"Some growers try to grow during the summer months by chilling the nutrient solution," Mike said. "We weren't set up for summer production. Having trialed 65 varieties, we will probably select 15 of the best-performing varieties to evaluate for summer performance. For the summer evaluations, we will have to use a different greenhouse set-up in order to chill the nutrient solution."

MEASURING GROWTH RATE

Mike said one of major growth parameters measured was biomass production or growth rate.

"The quicker the plants grow, the shorter the production cycle," he said. "Every day on the bench is cost to the grower. We looked at fresh weight and dry weight-two measures of growth. Some growers let lettuce grow for a specific amount of time. Other growers try to achieve a specific weight."

Mike said the lettuce crops were grown on a 42-day production cycle in both the NFT and deep-flow systems. At the end of the 42day cycle, the lettuce was harvested and measurements were taken.

"Sometimes if a variety is a fast grower, the lettuce might exceed the weight that a grower would want," Mike said. "That tells us this variety could have been grown in a much shorter period of time. Or a

A nutrient film technique (foreground) and deep flow floating system were used for the lettuce trials.



variety that didn't reach a minimum weight at the end of the 42-day cycle was considered a slow grower. Fresh and dry weights were used as a measure of how fast a variety can grow. How fast can a variety put on biomass? That is what growers are selling—biomass."

Mike said there were similarities in how varieties performed in the two production systems.

"If the varieties did poorly in NFT, they tended to perform similarly in deep flow, too," he said. "If a variety did well in NFT, odds were high that it did really well in deep flow."

IDENTIFYING DISORDERS

Mike said the two most common problems he hears about lettuce from growers are powdery mildew and tipburn.

"Ninety percent of the calls I receive are about these two problems," he said. "We rated the lettuce varieties we trialed for tipburn and powdery mildew. Powdery mildew in our region of the country is the disease that can often give growers fits. It can really wallop a lettuce crop. We also measured the incidence of tipburn, which can be a problem on a number of greens."

Mike said semi-heading and heading (butterhead) types seem to be more prone to tipburn.

"What happens is that, as these varieties start to form heads, there is an area of high humidity," he said. "There is this little microcli-

Lettuce varieties performed similarly in the two greenhouse production systems. If a variety did well in nutrient film technique, it performed similarly in the deep flow system.



mate of high humidity. If a grower is growing under real high humidity, has structures with poor air circulation or the nutrition levels aren't right, a calcium deficiency can occur. These can create a tipburn problem. We saw much less tipburn on varieties that tend to be loose-leaf types."

EVALUATING YEAR-ROUND PERFORMANCE

Having identified lettuce varieties that did well for fall through spring production, Mike is planning to select 15 to 20 of these varieties for a summer evalua-

"We want to take the best varieties from our trials and evaluate them during a summer production run," he said. "We will chill the nutrient solution to below 70F. We would also like to look at how these varieties perform without any chilling."

Mike wants to determine if marketable-size plants can be produced before bolting occurs.

"We are particularly interested in finding varieties that are highly resistant to bolting," he said. "We would like to identify lettuce varieties or other greens that would offer growers options for summer production. The ideal situation would be for growers to be able to grow these crops without having to make an investment in a chilling system. The ideal for a grower would be able to produce and market a crop that had enough size and weight before it bolts." [6]

For more, contact Mike Evans, University of Arkansas, Department of Horticulture at (479) 575-3179 or mrevans@uark.edu, http://hort.uark.edu/5459.php.

Some of the information presented in this article first appeared in the Hort Americas June 2015 Newsletter, http://www.hortamericas.com. The original article is available on the Hort Americas Blog, http://www.hortamericas.com/hort-americas-blog.html.

Top-Performing Lettuce Varieties The following lettuce varieties did well in the four greenhouse production trials conducted at the University of Arkansas. **OAK LEAF TYPES BUTTERHEAD TYPES Oscarde** Adriana **Panissee Deer Tongue** Rouxai **Nancy** Rex **ROMAINE TYPES Skyphos** (pictured) **Green Forest Red Rosie FANCY LEAF TYPES** Ridgeline Blackhawk Salvius Cavernet Truchas Dark Red Lollo Rossa **New Red Fire** Outredgeous **Red Sails** Ruby Sky

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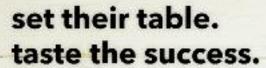




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Growing Greenhouse Tomatoes in Containers

A good way to jump into producing finished greenhouse vegetables from bedding plants is to grow tomatoes.

by NEIL MATTSON

Increased consumer demand for fresh, high-quality produce has led some bedding and potted plant greenhouses to consider vegetables for produce sales. Greenhouse operations are keen to put their facilities to use during their offseason. Doing so has the potential to increase their annual net revenue by growing another crop to help pay for fixed expenses (such as depreciation, property taxes, insurance, management salaries). Adding in vegetable crops during the off-season can also allow operations to keep labor employed year-round.

The first thing to consider with any new crop is the market channel that will be used to sell it. Some market channels include a retail store. farmer's markets, restaurants and local supermarket chains. Each grower must carefully scrutinize the costs of growing vegetables against their potential returns. Because this requires a lot of data on crop labor and input needs, as well as time to develop new markets, I've observed many bedding plant growers starting with veggies at a small-scale, exploratory basis.

SUMMER TOMATOES IN CONTAINERS

Fresh, vine-ripened tomatoes are a consumer favorite. Tomato plants have high light demand for decent yields, a minimum daily light integral (DLI) of 20 moles of photosyntheti-

cally active radiation per square meter per day (i.e., 20 mol/m²/day). To put this into perspective, suggested DLI requirements for highquality bedding plants are on the order of 10 to 12 mol/m²/day. For tomatoes, yield goes down by 1% for every 1% decrease in light. Therefore, year-round production requires supplemental light in much of the U.S. Because greenhouses are often idle from summer through early fall and have high natural light during this period, it's an ideal time to grow greenhouse tomatoes. Tomato plants are typically grown in rock wool slabs or containers, such as 3-gal. Dutch



Figure 1. Commercial greenhouse tomatoes growing in Dutch buckets (also known as "Bato" buckets).



Figure 2. The containers used in this study-Smart Pots-are a durable fabric container.

buckets (Figure 1) or 5- to 10-gal. round containers.

CORNELL TRIAL

We conducted a trial at Cornell University growing greenhouse tomatoes in a production system that could be adapted readily by bedding plant growers, using 5- to 10-gal. containers with potting mix and drip irrigation. We wished to determine the influence of container size on the fruit yield of greenhouse tomatoes growing in containers. The containers used in this study were Smart Pots, durable, soft-sided fabric containers often used in the nursery industry for root-pruning and aeration (Figure 2).

Seeds of Primo Red, a determinate large beef-steak tomato, were started by a commercial propagator on March 1. Seedlings were transplanted into square 3-in. pots. On April 15, we established our greenhouse trial—too early for a bedding plant grower-but we believe they could have transplanted and held at a higher density for some weeks until more greenhouse space was available. Seedlings were transplanted into Smart Pots with either a 5-, 7- or 10-gal. volume. The containers were filled with a peat/perlite-based substrate (Lambert LM-111). At this time, plants were placed in the greenhouse at a final spacing. Recommended plant spacing is 1 plant per 4 to 6 sq. ft. (Under low light, the

wider spacing is suggested.)

We chose a spacing of 1 plant per 5½ sq. ft. to give us ample space to get to each plant. From the center of each plant, they were spaced 20 in. apart between the plants within a row and 40 in. apart between rows. Plants were on a drip irrigation with two emitters per plant. Plants were placed in an older glass greenhouse with fan and pad cooling. No supplemental light was used. In late May, a light application of shading compound (about 30% shading) was applied to the exterior of the glass to help with temperature control. Our greenhouse temperature set points were 75/63F (23/17C) day/night temperature.

Tomato plants have higher demands for magnesium, potassium and calcium than traditional bedding and potted plants. Therefore, 25-lb. bags of "complete" water-soluble fertilizer used for potted flowering crops cannot typically be used as the sole fertilizer source. Besides our standard bedding plant fertilizer 21-5-20 (which contains micronutrients, but no calcium or magnesium), we added calcium nitrate, potassium nitrate and magnesium sulfate (Epsom salts). Calcium nitrate isn't compatible with 21-5-20 because a precipitate forms. Therefore, we used two stock tanks to prepare our fertilizers.

Because we had only one fertilizer injector, we alternated between the two stock solutions. During weekdays we used 150 ppm N from 21-5-20 plus 50 ppm magnesium from magnesium sulfate. During weekends, we switched stock tanks to deliver 150 ppm nitrogen from calcium nitrate and 100 ppm N from potassium nitrate. We monitored substrate electrical conductivity and pH weekly. When substrate pH was greater than 6.8 (optimum pH is 5.5 to 6.0), we switched to a more acidic fertilizer 21-7-7 in place of the 21-5-20 for a few days to bring pH back down. For a more in-depth article on fertilizer recipes for hydroponic fruiting crops and leafy greens, see "A Recipe for Hydroponic Success" in the January 2014 issue of Inside Grower.

Although the plants we used were determinate, they still grew several feet high, 6-ft. in our case, and needed to be trained to keep them upright. We suspended 9-gauge wire 7 ft. above each row and hung a spool of string from the wire to the base of each plant. Periodically, we used plastic clips to secure the stem below a strong leaf to the string, using clips about every foot of stem.

Early in the growing season, we removed lateral stems, or suckers, when they were 1 in. long. This encourages development of fruit instead of vegetative growth. About two months after transplanting in mid-June we let a few lateral stems grow on each plant, these provided fruit later in the season when the main stem had stopped producing. If an indeterminate variety of tomatoes is used, all suckers are typically removed. In addition, when indeterminate plants get taller, string is unwound from the spool and plants are leaned over and lowered so you can still reach the upper part of the plant. We removed older leaves up to the ripening fruit. This is important to promote good airflow to reduce disease incidence and to reduce habitat for insect pests. Regarding pollination, we didn't use a hand pollinator or bumblebees to aid in pollination of

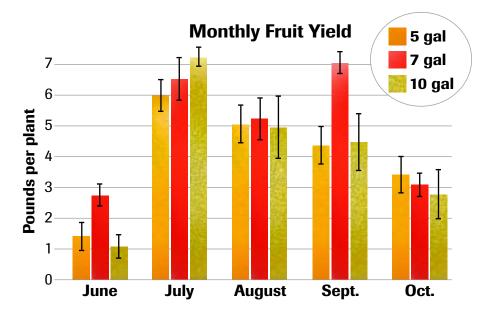
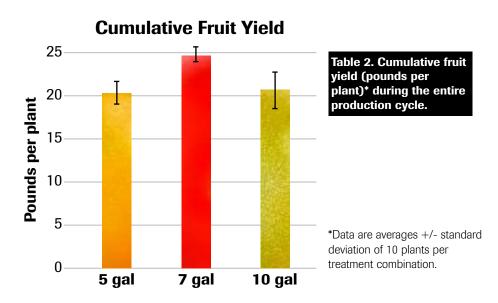


Table 1. Monthly fruit yield (pounds per plant)* in response to container size.



flowers; however, these methods are reported to improve fruit yields by about 20%. Fruits were harvested three times a week at the red stage (i.e., vine ripened).

Our first fruit were ready to harvest on June 4—about 7 weeks after transplanting (Tables 1 and 2). Plants yielded 1 to 2.5 lbs. of fruit in June. Peak harvest months were July, August and September, when plants produced about 6,5 and 4.5 lbs. per month, respectively (Table 1).

We concluded the trial at the end of October, as plants were yielding few marketable fruit by the end. Average fruit size was about 13 oz. for the first month and 9 oz. thereafter. We believe the decrease in fruit size is because later on there were many more fruits per plant to which the plant's energy had to be divided between. Interestingly we found that container volume of the Smart Pots significantly impacted plant yield. Cumulative plant yield over the entire crop season was greatest with the 7-gal. Smart Pots with an average of 24.5 lbs. per plant (Table 2). Plants in the 5- and 10-gal. containers produced about 20 lbs. of tomatoes per plant. We're unsure of the reason behind this, but we propose that the 5-gal. containers didn't hold quite enough water/nutrients for >>>

our fertilizer regime, while 10-gal. containers may have held too much, thereby keeping plants more vegetative and less reproductive.

Overall, our study shows Smart Pots could be successfully used to produce container tomatoes in the greenhouse. Our methods for container tomatoes can be readily adapted by bedding plant growers wishing to use summer greenhouse space. As with any new crop, growers should begin with small-scale trials to learn about the specific production system and determine if a profit can be made given their market and crop expenses.

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NEIL MATTSON, nsm47@cornell.edu, is Associate Professor and Greenhouse Extension Specialist at Cornell University. We thank High Caliper Growing, makers of Smart Pots, for funding this study.



Tomato plants from the Cornell trial (supplemental lights weren't used).



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From Football

A young go-getter turned his love for horticulture into a career with a strong future in hydroponics.

by ANNE-MARIE HARDIE

Managing a greenhouse operation may seem like a lofty feat for a 25-year-old, but that's exactly the type of challenge that RJ Malseed, Farm Manager of Vertically Local Farm, thrives on.

Growing up in Delaware, 14-year-old RJ had his first taste of horticulture at his local garden center, Always the Garden. It was here that RJ worked during his high school years, learning about gardening and growing in general. Inspired by the owner Tim Ross, RJ absorbed Tim's knowledge about horticulture, from backyard perennials to ornamentals.

"I took on an interest right away. Something about plants-specifically the veggies production and plants—caught my attention," said RJ. "I was hooked."

Recruited to Delaware Valley College on a football scholarship, RJ briefly contemplated majoring in sports management, but quickly returned to horticulture. Part of the learning criteria was an internship, which would offer the hands-on experience to supplement the in-class experience. RJ applied at Ford Hook Farm, a field trial farm run by Burpee Seed Company during his junior year. Here, manager Sharon Kaszan mentored him, teaching RJ about field productionincluding the value of crop rotation, disease and insect maintenance, and the impact of Mother Nature.

"Simply being on the farm and getting your hands dirty taught me more knowledge than any classroom," said RJ.

Jersey boy

One thing that RJ truly values is the knowledge that he learns from others, recognizing that it's these mentors that have helped shape where he is today.

Upon graduation with a degree in horticulture and greenhouse management, RJ had several job offers, including one from Burpee Seed. However, it was a phone call from Jerry Ambrogi, RJ's high school football coach and owner of Ambrogi Foods in Paulsboro, New Jersey, that truly captured RJ's attention. Jerry wanted to start a local farm that would sell directly to his distribution company and he was looking for an individual to help start and run the farm. RJ jumped on the opportunity.

It was 2012, but RJ's new career didn't begin on the farm—he began working directly for the distribution company. Here, RJ learned the needs of the customer, both in the type and quality of product that the clients were looking for and then sell. Knowledge that would help RJ become aware of the quality and type of produce that would be needed to appeal to the Ambrogi Foods distribution market. RJ was now ready to launch into developing the farm.

The farm project began in February 2013, when Jerry purchased a 7-acre old horse farm in Pilesgrove, New Jersey. "It didn't have electric or running water; the farm still had horses on the property at the time," RJ recalls. "Jerry said, 'Here's your farm. Make it

Together with the help of Mike Saggiomo, general manager of Ambrogi Foods, RJ began the transformation from horse farm to a greenhouse operation. The first few months were spent in full construction mode, from grading the land to running electricity and installing a well. The end project needed to be able to grow the microgreens and hydroponic lettuce that Jerry wanted for his company, so RJ and Mike built the facilities that would provide the optimal environment to grow these products.

The initial build included three greenhouses—two that were stand-alone hoophouses and one hydroponic greenhouse for the lettuce. The microgreens, which include arugula, cilantro, basil and a micromix, were grown in a four-level wood and chicken wire table with 20-row seedling flats. In October 2014, manager Marc Sammacicci joined the team, bringing with him his extensive greenhouse knowledge. Marc helped plan and complete the new expansion, which including shifting the micro greenhouse to hydroponics, eliminating soil and peat moss.

"We started the houses in 2014 and ever since then we've been expanding," said RJ. "I just finished an expansion on my hydroponic greenhouse and I'm hoping to do my microgreens in hydroponic production as well."

Converting to a hydroponic system for the microgreens would increase profitability, shared RJ, primarily because they no longer have to rely on using peat moss, which had become a major expense. In addition, it frees up space to experiment with other things like growing tomatoes inside the greenhouse year-

"I would love to make our whole farm hydroponic. That's kind of the goal down the road," said RJ.

Learning hydroponics

Despite not having a formal hydroponic education, RJ became his own teacher, seeking out resources online and learning hands on.

"I didn't think of doing hydroponics full scale until I had the opportunity to work with Jerry and help them with it," said RJ. "I did have a bit of trouble in the beginning when we started the farm; it didn't run as smoothly as it could. But after some hands-on trials and tribulations, we learned what works."

One of RJ's first crops of hydroponic lettuce had pythium. It was through this negative experience that RJ not only learned how to treat the problem, but found ways to prevent the issue from occurring in the future. They were able to save 60% of the crop.

"I learned from that day on to change the water in the source tank every 10 to 14 days to keep proper oxygen levels in the water for good root development," said RJ.



Thoughts on Using Organic Fertilizers for Greenhouse Plants

Growing organic? Here are your best choices.

by DOUGLAS COX

For a number of years, I've studied the use of organic fertilizers for growing commercial greenhouse crops. To start, I chose to evaluate fertilizers that could be mixed and applied using methods familiar to growers using traditional water-soluble or granular slow-release chemical fertilizers.

Right now.I recommend Nature's Source 3-1-1 liquid fertilizer and Sustane 8-4-4 granular slowrelease fertilizer. Both of these are readily available, cost effective, OMRI-certified and have good label directions for greenhouses. I've also evaluated or am currently trialing other organic fertilizers and these are listed with comments in the table accompanying this article.

Two liquid fertilizers that may have promise one day are Bombardier 8-0-0 and Espartan 2.0-3.03-2.6 manufactured by Kimitec in Spain. At this time, these have limited availability, are rather expensive and the labels aren't written for greenhouses. Nature's Source, Bombardier and Espartan are plant extract fertilizers and Sustane is made from poultry wastes.

My work has led me to recommend using different organic fertilizers in combination rather than relying on one fertilizer. I suggest using Nature's Source and Sustane together to take advantages of each fertilizer's strengths. This would be done by incorporating Sustane in the growing medium at planting and then fertilizing on a regular basis with Nature's Source, starting about four weeks after planting. Combinations should be considered regardless of what brands or types of organic fertilizer are being used.

Here are some more important specific recommendations on how to use organic fertilizers to grow greenhouse plants:

1. Mixing and application. The fish fertilizers and plant extract fertilizers are sold as concentrates and they must be diluted in water to be safe for plants. Nature's Source. Bombardier and Espartan have a pleasant "beery" aroma as concentrates, but within seven days of being mixed with water, they "spoil" and develop very unpleasant odors. The odor, however, is not as bad as fish fertilizer. The nutrient value of spoiled fertilizer is unknown and the colonies of bacteria that develop may plug irrigation lines, so diluted fertilizer solution should be used as soon as possible after

Fish fertilizer has the thickest and least consistent solution and should be agitated before mixing with water. Bombardier and Espartan concentrates are "syrupy," but mix well with water. Nature's Source is the thinnest concentrate, and it mixes well with water and can pass fertilizer injectors.

Sustane is a granular fertilizer that would be mixed with the growing medium before planting. It's the easiest organic nutrient source to use in combination with the liquid types.

2. Fertilizer analysis. Some organic fertilizers supply only one or two of the NPK elements. An example is Bombardier, which is 8-0-0, so a grower using Bombardier would have to use other fertilizer(s) to supply P and K. I recommend Sustane, which has an 8-4-4 analysis or some other complete NPK granular organic fertilizer.

Organic Fertilizers Evaluated or Currently Under Trial at UMass Stockbridge School

Fertilizer	Туре	Analysis	Comments		
Neptune's Harvest Organic Fish fertilizer	Liquid emulsion	3-1-5	Fish fertilizer has been widely used as organic fertilizer for many years. The emulsion needs to be mixed well to give a consistent material for dilution and application. Once mixed with water, it spoils and develops a bad odor. Mix fresh and use immediately. Leaf chlorosis, probably due to ammonium toxicity, is common. OMRI listed.		
Plant Natural alfalfa pellets	Pellet	5-1-2	Alfalfa is a legume and, therefore, is rich in nitrogen. The pellets are often used as animal feed and are similar in size and shape to wood pellets used in pellet stoves. Pellets supported the plants for about 40 days and then were exhausted of nutrients. Also, they swell when water is added, greatly increasing the volume of medium in a pot. Limited potential for this fertilizer.		
Kimitec Bombardier	Liquid	8-0-0	Bombardier is a plant extract fertilizer made from fermented sugar beet molasses. It works well with Sustane, which supplies the absent P and K. Some plants develop interveinal chlorosis due to ammonium toxicity. Chlorosis is lessened or eliminated by combining with Sustane. Dilute solutions spoil within 10 days.		
Kimitec Espartan	Liquid	2.0-3.03- 2.6	Espartan is a plant extract fertilizer made from fermented sugar beet molasses. Some plants develop interveinal chlorosis due to ammonium toxicity and growth medium EC is rather high. Chlorosis and EC are lessened or eliminated by combining with Sustane. Dilute solutions spoil within 10 days.		
Sustane	Granular	8-4-4	Granular slow-release fertilizer made from turkey litter, feather meal and potassium sulfate. Release time is 45 days, but nutrients may run out a little sooner. Excellent fertilizer to combine with liquid organics, especially those with no phosphorus or potassium. OMRI listed.		
Nature's Source	Liquid	3-1-1	Despite the low nutrient analysis, Nature's Source is currently the best liquid organic fertilizer. It's made from oilseed extract. Container has dilution rates expressed in familiar terms for greenhouse growers. I've seen no foliar chlorosis yet with this fertilizer. Nature's Source is widely available and a great improvement over its predecessor Pinnacle. OMRI listed.		
Verdanta Eco Vita	Granular	7-5-10	I'm currently testing this granular slow-release fertilizer. It has a release rate of 100 days. The granules are composed of bone meal, soybean meal, cocoa shell meal, feather meal, and fermented sugar cane and sugar beet molasses. I see potential for this one. Available from SHS Griffin. OMRI listed.		
Verdanta PL-2	Liquid	2-0-6	I'm currently testing this fertilizer made from fermented sugar cane and sugar beet molasses. It should be a good supplement to use in combination with other organic fertilizers low in N or K. Available from SHS Griffin. OMRI listed.		
Ferti-Nitro Plus	Soluble powder	13.6-0-0	I'm currently testing this fertilizer as a supplement to use in combination with other organic fertilizers low in N. It's made from hydrolyzed soybean protein and is soluble. Google this one on the web. OMRI listed.		

3. Nutrient disorders. Plants may develop an overall light green or yellowed color caused by a general nutrient deficiency or, more likely, just N deficiency. For example, if Sustane is used alone, the symptoms might occur about 45 days after planting, the end of its release time. This can be prevented by applying an organic liquid fertilizer supplement about 30 days after planting.

Interveinal chlorosis sometimes occurs about halfway through crop time if plants are fertilized with some liquid organic fertilizers alone starting at planting. This chlorosis is most likely caused by an accumulation of too much ammonium-nitrogen in the plant, so-called "ammonium toxicity." Most greenhouse crops do best with a combination of ammonium and nitrate nitrogen. Unfortunately, organic fertilizers generally don't contain nitrate-nitrogen. The best approach is to rely on Sustane as the sole source of nutrients for the first month after planting and

then start applying Nature's Source or another liquid organic fertilizer.

4. Organic fertilizer effects on growth medium soluble salts

(EC). Sustane is a slow-release fertilizer and its use results in low EC, and potentially a deficient level after 45 days. As for the liquid organics, at the same N level. the lowest EC results from Nature's Source (similar to chemical fertilizer) and then Bombardier. Espartan results in an EC significantly higher than the other liquid organic fertilizers, which might be an aggravating factor in ammonium toxicity. In short, from the standpoint of EC, Nature's Source is the best.

5. Overcome reduced size caused by organic fertilizers.

Many growers who've used organic fertilizers have observed size reductions compared to what they're used to with chemical fertilizers. Some growers say "raise the rate (ppm)" of organics to compensate. If you've done this and it works, carry on! Otherwise, give it a try starting with increases of 20% at a time. Increasing the rate in 20% increments is likely to be partially successful. but because of a nutrient

imbalance, ammonium toxicity or some unknown factor, results may be disappointing or worse.

6. Plant species-specific responses. It seems that plants may respond differently to organic fertilizers. At this point in the development of organic fertilizers for commercial greenhouse use, use them with caution on plants you know have exacting nutrient requirements or those prone to foliar chlorosis. Fertilizers should always be tried first on a small number of plants.

7. Best uses. The fertilizers discussed in this article are probably best for short-term crops of less than six weeks duration when en-

Ammonium toxicity on petunia with high levels of some watersoluble organic fertilizers

> vironmental conditions are most favorable for plant growth (e.g., April to September). Bedding plants, herbs and vegetable transplants are good candidates for trying organics. Assuming the plants are of good quality and color, reduce or stop using the fertilizer within a week or two of planned marketing. This practice will reduce the chance of ammonium toxicity symptoms. [G

DOUGLAS COX is Associate Professor of Greenhouse Horticulture at the Stockbridge School of Agriculture for the University of Massachusetts in Amherst, Massachusetts.

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Biocontrols for Tomato Plants

The best parasitic weapons to use to defend your tomato crops.

by SCOTT CREARY

Across the country, tomato growers are shifting their pest management strategies to incorporate biological controls into the mix. Reasons for adopting a more "bugeat-bug" approach vary from protecting the health of their family and workers, maintaining the vigor of bumblebee pollinators or maximizing the market value for their crop by ensuring their fruit is grown in an environmentally responsible way. And avoiding the sweaty mess of spray gear in the summer is an added bonus. Regardless of the rationale, bios can be used easily, cheaply and effectively with a few phone calls, in addition to a thorough scouting regimen.

Most growers, thankfully, only encounter one or two of the pests that can decimate tomatoes in hoop houses or greenhouses. They likely lock horns with these same critters perennially and there's always the possibility of developing new pest problems. That's what makes a grower's life interesting, anyway. Roughly speaking, the key pests of tomatoes are aphids, thrips, spider mites and whiteflies, which commonly rear their ugly little heads in the same order. There are no guarantees with pest control, so it's a loose chronology. But before we go into too much detail about ways of killing them, a brief interlude about sanitation.

We're all tired of hearing about the importance of sanitation and I really don't want to beat a dead horse. That said, the severity of your pest problems this year is tied to the amount of pests you've carried over from last year. Aphids and whitefly persist often at undetectable levels on weeds and greens, spider mites stay dormant on debris and structures and thrips live everywhere—on weeds inside and near the structure or in the soil. In addition to simply cleaning your hoop houses and greenhouses, consider solarizing them, too. Simply close everything



up between crops and let the sun bake the house for a week or so. That'll kill many of the pests that were hanging out on your previous crops. And if you were growing any winter crops, chances are those pests are aphids.

ADIEU TO APHIDS

For aphid control, Aphidius parasites are your first responders; call your biocontrol supplier at the first sign of aphids. Aphidius are little wasps that lay their eggs inside young aphids. Those aphids continue to live and grow for another six to 10 days, after which they swell into a golden brown, papery aphid "mummy." Seeing as the most common aphids encountered on tomatoes are green peach and potato aphids, the two parasites involved here are Aphidius colemani and A. ervi, attacking the former and the latter aphids, respectively. The 2-mm-long A. colemani completes its life cycle in two weeks, while the 4-mm A. ervi takes a week longer. Though they develop more slowly than their aphid hosts, one female wasp can kill hundreds of aphids.

Judson Reid, the Senior Extension Agent with Cornell University's Vegetable Program, suggests, "Once temperatures are dependably above the 40s (F), I like to release a mix of [Aphidius] parasites."

Aphid parasite mixes are more expensive than those targeting a certain species, but Judson says, "We lose too

much time trying to get the aphids identified." But with a good shot from a smartphone camera, some savvy growers can get an ID the same day. Aphid parasites are shipped inside their mummies, so keep the vial closed until you see that some wasps have emerged. Release at least one wasp per 10 sq. ft. weekly or biweekly (depending on temperature and aphid population) three times. As with many winged bios, these wasps are attracted to bright lights and should be released at dusk.

By April and May, the aphid midge Aphidoletes aphidimyza is a useful compliment to the slower-acting parasites. Released at a rate of one to 10 midges per 10 sq. ft. for three consecutive weeks, the midges can bring even established aphid populations under control. Not surprisingly, the more aphids you have, the more midges you should plan on releasing. If your aphids are under control by June, usually enough predators will join the party from outside to keep cool weather-loving aphids under wraps until frost. Of course, the warm season brings plenty of its own challenges.

TA-TA TO THRIPS

With warmer temperatures, the life cycles of other pests, like thrips, speed up, allowing even low populations to explode seemingly overnight. But don't worry they've got a bug for that. According to Judson, "I would suggest people start with *cucumeris* and treat transplants in the propagation house rather than after planting out. It's inexpensive enough to use preventatively and it's likely to provide sustained control."

Judson goes on to say, "Two releases of cucumeris have been enough to knock our thrips population down to undetectable."

Cucumeris are predatory mites that arrive amongst wheat bran, which hosts a prey mite that the cucumeris eat until they disperse onto plants. These predators aren't picky eaters, but they eat newly-hatched thrips—the only thrips life stage small enough for the little mites to tackle. When thrips hatchlings are scarce, cucumeris will munch on pollen, broad mites and spider mite eggs, allowing predators to establish long-term. You'll want to release them at least twice at two-week intervals. Once sprinkled onto the foliage, the mites disperse out of the bran on their own. To make things even easier, Judson offers, "Start by treating the transplants in the propagation house before planting out."

To be on the safe side, you can release rove beetles (Dalotia coriaria) or the predatory mite, Stratiolaelaps (=Hypoaspis), which will eat thrips when they drop to the ground. The former, being flight capable, can colonize large areas quickly and are used for structures with soil or gravel floors. Stratios are more useful for localized introductions, like tomatoes grown in bags of media or in seedling trays. Both critters are introduced only once, at planting, and will remain all year. Just sprinkle them on the soil near the plants at a rate of 2 beetles/10 sq. ft. or 12 to 25 mites/sq. ft. Because adult thrips live as long as four weeks, you'll continue to see them for a while after introducing bios, but the skies start to clear thereafter. Once your thrips controls are in place, it's time for an even mitey-er task.

SO LONG TO SPIDER MITES

I'm speaking, of course, about spider mites. Difficult to detect on hairy tomato leaves, mites can explode to biblical proportions during a week of hot, dry weather. Rather than straining your eyes looking for mites on your tomatoes, try some indicator plants—those plants that show pests early and easily. Bush beans are cheap and easy indicators for spider mites. Tiny, white pinpricks (stippling) are clearly visible on the upper side of the leaf, so monitoring the beans is a cinch. One bean plant per 200 sq. ft. is plenty. You'll want to have them up and growing by mid to late April, or a few weeks be-

fore you've historically spotted your first mites. Then watch those bean leaves for spider mite damage. If you released cucumeris earlier in the year, you may not see any spider mites at all, but luck favors the prepared.

As always, make the call to your biocontrol supplier at the first sighting, "If someone had a mild spider mite problem, I would recommend several releases of Persimilis," suggests Judson.

Persimilis are predatory mites that can stick around long-term, provided the beans continue to host spider mites. You'll want to release them at a rate of one mite per square foot every week for at least two weeks. After the predators establish, it's likely that you won't be able to find spider mites anywhere but on the beans, as the predators pick off the few spider mites they find on the tomato. The bean plants are a great place to assess the number of spider mites per predator and decide if the predators are in good balance with the pest.

Predatory mites are

distinguished from their prey by their teardrop shape, cream to red coloration (never green) and their speed, as they zip around on the leaves while spider mites move slowly, when they move at all. Generally, a ratio of 10 spider mites per predatory mite is safe, while 20 spider mites per predator indicates another predator release is in order. Keep your eyes on the lower leaves, where spider



Aphid parasites are shipped still inside their aphid "mummies." Keep the bottle in a warm, humid, shaded place overnight or until you see adult wasps in the bottle before releasing in the evening.



Spider mite predators are commonly sold with vermiculite to maintain ample humidity in shipping. Sprinkle the contents of the bottle onto infested plants and leave the bottle and cap in the plants so remaining predators can disperse into the canopy.

mites are most numerous, along with our last pest, whitefly,

WAVING GOOD-BYE TO WHITEFLIES

Whitefly adults, with their erratic flight patterns and habit of flying up people's noses, often catch the scout's attention before translucent green immatures. >>> If you catch them right out of the gate, the prognosis for biocontrol is good.

"It's so easy," says Carol Glenister, owner of IPM Labs, a biocontrol supplier. "It's just four weekly introductions of parasites at the first sign of whitefly. It's inexpensive, it's fast and it's effective."

Release one wasp (Encarsia formosa) per square foot at each introduction and you're good to go. Just like with spider mite predators, check the pruned leaves before discarding them. Whiteflies with parasites developing inside turn black, so any leaves with blackened whitefly pupae should remain on the plant for several days longer.

SOME FINAL TIPS

Perhaps the biggest change when shifting to biocontrols needs to happen in your mind. Bios will not eradicate pests, nor should you want them to. They provide gradual and constant pressure on pests, keeping pest levels at consistently

low levels. So expect to see a few unwanted visitors every so often, especially when they start coming in from outside. Calming the knee-jerk reaction to any pest sighting is a slow process, but you'll relearn what thresholds work for your biocontrol program pretty quickly. Should pests exceed that level, you'll need to use other tools at your disposal.

Pesticides and bios aren't mutually exclusive. In fact, due to the increased adoption of integrated methods, many new pesticides are target-specific and compatible with many beneficial critters. Check with your biocontrol supplier to ensure that your chemicals are biocontrol-friendly and if their use is warranted. Keep in mind that chemical control takes a back seat to biological control once adopted and should be used as a last resort. But you can rest assured that this isn't your biocontrol supplier's first rodeo. Because tomatoes are such widespread high-value crops, tomato biocontrol has

been fine-tuned over many decades and we know what to expect by this point.

For most growers, not needing to sweat it out under layers of Tyvek and respirators isn't a tough sell. Talking about your biocontrol program resonates extremely well with the public, especially given how educated and inquisitive consumers have become about their food. Bumblebees will buzz your praises, while naturally-occurring beneficial insects including pollinators—will become more abundant through the year. Over the course of the year, you'll see healthier. more robust and productive plants, as they won't be stressed by spray phytotoxicity.

And finally, your wallet—especially when labor and equipment costs are factored in-will be healthier and more robust, too. IC

SCOTT CREARY is an Entomologist at IPM Labs, Inc. in Locke, New York,





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Nature's Source Plant Probiotic is now available in water-soluble pouches for even easier application. Probiotic is a unique complex of beneficial soil microbes to enhance





stress. A single pouch dropped into 50 gal. of water will treat 10,000 sq. ft. of greenhouse production. Can be applied to hydroponic systems where substrate is used. Reader Service Number 217

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Hydroponic Production & Pythium

You can still experience root rot even when you're not growing in soil. Learning the symptoms and how to prevent Pythium can be a crop lifesaver.

by HELEN MARGARET GRIFFITHS

Eric Carr, Cornell University

Growing plants using a hydroponic system isn't new; it has a long history, which many believe started in the city of Babylon with the famous hanging gardens. Commercial hydroponic production started in the 1940s and today, due to the tremendous progress made in technology, every aspect of the operation can be computer-controlled (i.e., temperature, humidity, carbon dioxide, light, fertilizer, etc.).

Growers venture into hydroponic production for a number of reasons, which include year-round local production, reduced carbon footprint and avoiding root diseases that are often limiting in field and greenhouse production. With the ability to control many parameters associated with plant growth, shouldn't it be possible to have the perfect crop every time? Unfortunately, this is not the case.

WHAT CAN GO WRONG WHEN GROWING **HYDROPONIC CROPS?**

Although the diversity of root diseases observed in hydroponic production is less than in soil-grown systems, root diseases associated with Pythium species are still a problem for most crops. Once the organism is introduced into the system, disease can development rapidly and result in significant crop loss. This is particularly true with closed hydroponic systems and can happen in most crops. Professor Emeritus Gary Moorman from the Department of Plant Pathology and Environmental Microbiology at Penn State University said, "In my experience, just about any plant grown hydroponically is at risk to certain species of Pythium." He said that he'd recently detected Pythium aphanidermatum in hy-

Professor Emeritus Michael Stanghellini of the University of California-Riverside and Gary agree that if a grower gets a disease outbreak, it's importance to accurately identify the organisms involved and "identify to the species level." For assistance in pathogen identification, growers are encouraged to contact their regional co-operative extension educator. There are many species of Pythium found in greenhouse situations, but Pythium aphanidermatum and Pythium dissotocum are the most commonly observed, serious plant pathogens in hydroponic systems. Why is it important to know? The rate at which Pythium species populations develop is affected by temperature, with P.

droponically grown tomato, lettuce, spinach and arugula.

aphanidermatum being the prominent species at 73 to 80F (23 to 27C), whereas P. dissotocum is prominent at 62 to 73F (17 to 23C). Michael said that he's even seen Phytophthora species in hydroponically grown lettuce, but "it is often not recognized as this." he said.

WHY IT'S A PROBLEM IN HYDROPONIC SYSTEMS

Until relatively recently, Pythium species were considered fungi. Even though their mycelial growth and nutrition resemble fungi, their morphological characteristics and findings from molecular studies support the notion that they're more closely related to water molds. Both the open and closed hydroponic systems can support rapid Pythium growth, although it's generally thought that the closed system is more conducive, as it's recirculating the nutrients.

Oospores are the main survival structures of P. aphanidermatum and P. dissotocum. They can germinate to form germ tubes.

P. aphanidermatum zoospores releasing from vesicle.

which then may infect roots. Oospores produce sporangia that bear thin-walled vesicles from

which zoospores are released (Figure 1) and are the big problem. Zoospores are motile, unicellular, propagative bodies measuring in the case of P. aphanidermatum 14 micrometers long and 9 micrometers in diameter (approximate). This motile phase can last for up to 24 hours during which time through chemical signaling the zoospore locates a root, encysts and infects it. The reproductive capabilities of these zoosporic pathogens are enormous, which is one of the main reasons that an epidemic can occur so very rapidly under hydroponic conditions.

HOW TO COPE WITH PYTHIUM IN HYDROPONIC PRODUCTION

Keeping Pythium species out of a hydroponic system is clearly most desirable. Growing varieties with resistance to Pythium species would be ideal, but currently, no vegetables varieties with such resistance suitable for hydroponic production are available.

Starting with disease-free transplants is important and producers growing their own transplants can have greater control over the production than if they buy in transplants—particularly as plants on delivery may appear healthy and yet be infected with Pythium at the initial stage of infection when there are no symptoms. (The grey-brown root coloration doesn't appear until later.)











Figure 2. Roots of hydroponically grown sweet pepper (Capsicum annuum) seedlings infected with Pythium aphanidermatum. Close-up of healthy roots (far left) beside roots showing the progression of the disease over time.

WHAT ARE THE ENTRY POINTS FOR PYTHIUM **SPECIES INTO A HYDROPONIC SYSTEM?**

There are a number of possible ways the organism can enter a hydroponic system. Soil is a way Pythium species spread, and even though hydroponic production is a soil-free growing system, soil can still be brought into a facility if care isn't taken with cleanliness of foot wear, clothing and equipment.

Surface water, such as rivers, ponds and reservoirs, are major sources of Pythium inoculum and should not be used in hydroponics. Well water is usually considered safe. Gary says that chlorinated water is by far the most commonly used. Having a course filter in place is good because, according to Gary, removing particles is important, as from his experience, Pythium can be associated with the particles—particularly in ebb-and-flood systems.

Fungus gnats (Bradysia spp.) and shoreflies (Scatella stagnalis) are common in greenhouses and it's been shown that the adult shorefly can be involved in the transmission of P. aphanidermatum and, therefore, insect control is important.

WHAT ARE THE OPTIONS IF AN INFECTION OCCURS?

Rarely in hydroponics are growers able to consistently produce crops entirely by avoidance of Pythium; usually a number of disease-control methods have to be implemented to try to control what can become a challenging situation if a Pythium epidemic becomes established. And as Michael said, "There is no cure." Searching for fungicides isn't going to result in a grower finding products, as there are none registered for use in hydroponics.

Biosurfactants may be useful for control. Michael, who spent many years researching them, said that as long as the zoospore population is low, such products can be effective. Gary also worked with them in ebb-and-flood systems and agreed that they work, provided that infection isn't being caused by

mycelium. The biosurfactant Zonix is labeled for use in most states (California registration expected fall 2015) for hydroponics and is OMRI approved.

Eliminating zoospores can be accomplished by ozonation, sonication, heat,

UV and filtration. Some systems are cheaper to implement than others and UV requires iron to be added back into the nutrient solution. David de Villiers, a research scientist at Cornell University's controlled environment agriculture department, reminds the grower of the real problem when he said, "Killing Pythium is very easy, but you have to be able to get at it. Zoospores in the nutrient solution can be eliminated with any of the techniques, but trying to eliminate the pathogen from the plants is not possible."

At this point, the grower has to provide supportive care to the plants and reduce further stress if a crop is going to be obtained. Oxygenation is one of the few practical measures available to growers when root rot is well advanced. Temperature of nutrient solution affects the concentration of dissolved oxygen available to the roots of the plants. As the temperature of the solution increases, the concentration of oxygen declines and, therefore, keeps nutrient temperatures as low as possible—which is critical for the wellbeing of the plants, particularly if the roots have been compromised by infection.

Using temperature of the nutrient solution to regulate the rate of Pythium development is a possible control method depending upon the crop. David says that their approach at Cornell with research using baby-leaf crops is to grow so quickly and at a low enough root zone temperature that the P. aphanidermatum doesn't have time to reproduce itself. This works for crops like spinach, but lettuce growth falls when temperatures fall below 75F (24C). Purchasing specific equipment for temperature regulation may be outside of the budget of a small producer, but >>>



Figure 3. Roots of basil plants grown in floating beds. Plants grown with Worm Power (right) showed significant improvement in root structure, basil quality and quantity.

as Michael said, "There are plenty of innovative growers who would be able to design and build their own cooling system."

Optimizing the temperature of the nutrient solution for hydroponic plant growth is also important for producing high yields from hydroponics. Coralie Sopher at the University of Guelph in Canada demonstrated that in high temperature-pre-

disposed sweet pepper plants to P. aphanidermatum (Figure 2).

DISMANTLING AND CLEANING

Views vary on how often a hydroponic system should be cleaned and this will need to be determined by the individual producer, type of system and level of disease being experienced. Some of the large tomato producers have a yearly/bi-yearly clean as part of their operating procedure. The job is labor intensive and will

generate a large volume of waste liquid. Choice of cleaners are many, but David says that they use 70% alcohol for sanitization. Even though Clorox works well, they find it unpleasant, and some other products can leave residues.

PREVENTING PYTHIUM

Start with healthy plants with robust root systems and be extremely diligent about cleanliness. In addition, optimize the growing conditions for the particular crop aiming to eliminate stress.

Vermicompost has been used to increase the vigor of soil-grown plants and at least one hydroponic grower found it helpful in producing basil in floating beds with improved resistance to Pythium (Figure 3). A research project called "Using Vermicompost to Improve the Profitability of Hydroponic Spinach Production" funded by USDA SBIR is underway at the company Worm Power (www.wormpower.net) in collaboration with Cornell University and may generate information useful to producers.

Each producer will need to determine which methods best suit their situation, as all treatment methods have pros and cons.

Please note: The specific directions on fungicide labels must be followed and supersede any statements in this article if there's a conflict. Any reference to commercial products, trade or brand names is for information only.

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