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CONTROLLED ENVIRONMENT AGRICULTURE
September 2014

Vertical Farming: Why We Think it Might Just Work

Partners and investors Mark Thomann (front) and Mark Weglarz check out the current crop of USDA-certified organic basil at FarmedHere, just outside of Chicago.

Page 10

PAGE 14

THE LOCAL FOOD MOVEMENT
When did it really begin?

PAGE 18

GROWING HYDROPONICALLY *AND* ORGANICALLY
Can it be done?

PAGE 28

USING BANKER PLANTS
Fighting aphids with aphids

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We've done it again.

For the second time this year, *Inside Grower* has burst out of the seams of its bi-weekly email format, filling a magazine edition to the brim with more in-depth coverage of greenhouse vegetable growing. These special editions allow us to dig even deeper into the topics that matter most in our industry.

Since the last print edition of *Inside Grower* found your mailboxes in January 2014, I've fine-tuned my skills as your editor. It took becoming a mother for the first time to become painfully aware of the importance of strengthening efficiencies in all aspects of my life. Since my daughter was born in January, I've learned to better identify and prioritize what's worthy of my attention and filter out everything that's not. Knowing that your time is just as valuable—whether you're a parent, up to your eyeballs in the business of growing or both—you'll find this issue of *Inside Grower* delivers the most pertinent, interesting and useful news in our industry.

In our cover story on vertical farming, Chris Beytes wastes no time, cutting right to the chase and asking some tough questions about an agricultural practice even he admits he's skeptical of. Some advocates tout vertical farming as the way of the future, but critics argue that the technology is too expensive for it to be a sustainable means of farming. Read how FarmedHere responds to being in Chris' hot seat on page 10.

Over the past several years, I've encountered the full spectrum of opinions on organic hydroponics. I've heard that it can, can't or shouldn't be certifiable under the USDA's organic guidelines. (It can and I'll leave it up to you to decide if it should.) Regardless of politics and semantics, the fact is, organic hydroponic systems are rare compared to traditional organic or hydroponic systems on their own. The reasons for the rarity are complex and involve discussions of nutrient management, pest control, productivity, marketing, semantics and politics. I touch on it all on page 18.

We don't often offer history lessons here in *Inside Grower*, but the evolution of the local food movement in the U.S. is a fascinating topic worth discussing, with deeper roots in American culture than you might expect. Turn to page 14 for Rich Pirog's account of how the local food movement has moved from the margins to the mainstream.

And Eliot Coleman is one well-known American Farmer who grows local food for the good folks in Maine year-round. Anne-Marie Hardie profiles Eliot's Farm on page 26.

In this issue, you'll also find valuable information on growing methods, including complying with the new Food Safety Modernization Act (page 24), using banker plants to fight aphids (page 28), understanding blossom end rot (page 30) and starting a strong lettuce crop using a new hydroponic fertilizer (page 32).

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

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A Friend Remembered
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ON THE COVER

Is vertical farming a viable part of agriculture or an unrealistic pipe dream? Chris Beytes stops by FarmedHere right outside of Chicago to find out. Turn to page 10 to read more.

DEPARTMENTS

FEATURES

Nexus Donates Greenhouse to Denver Hunger Relief Center

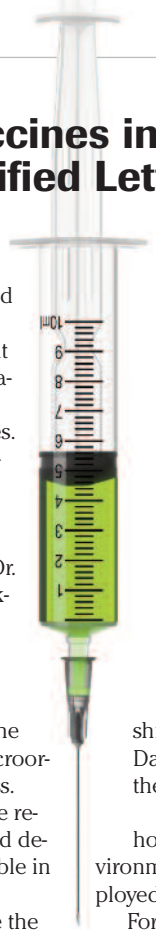
Thanks to a donation from Nexus Corporation, a new hunger relief center in Denver, Colorado, will feature a south-facing greenhouse for growing fresh veggies.

Metro CareRing recently broke ground on a new 16,000 sq. ft. Hunger Relief Center at the corner of 18th Avenue and Downing Street in Denver. The center, which will be completed in February 2015, will provide fresh food access and self-sufficiency programming for food-insecure people in the metro area.

Nexus says that the greenhouse they've donated is an aluminum Series E lean-to with a 16 mm acrylic covering and will attach to the south side of the new building. Metro CareRing says that the greenhouse will provide an experiential classroom, employment readiness training and year-round produce. Its learning gardens will allow participants to learn best practices and techniques to successfully grow food in their own homes and neighborhoods and also afford an entrepreneurial opportunity to promote Metro CareRing's products for area businesses.

In the new facility, Metro CareRing expects to distribute more than 2 million pounds of nutritious food annually for people in the Denver metro area. Sixty-two percent of the food distributed from Metro CareRing's Market is fresh and sourced from local grocery stores, farmers and community gardens.

Growing Vaccines in Genetically Modified Lettuce



Dr. Henry Daniell's $2 million greenhouse at the University of Pennsylvania has all the high-tech bells and whistles of a new controlled environment greenhouse. But Dr. Daniell isn't growing tomatoes or lettuce for the local market; he's growing vaccines.

A professor in the departments of biochemistry and pathology and director of translational research in the School of Dental Medicine, Dr. Daniell's doing ground-breaking research that could change the way drugs and vaccinations are delivered.

Traditional vaccines contain inactivated versions of the bacteria, viruses or other microorganisms that cause the illness. These costly vaccines require refrigeration during storage and delivery, making them unavailable in many parts of the world. Dr. Daniell's method doesn't use the pathogen at all; he uses lettuce.

Basically, he injects therapeutic proteins into lettuce cells. The genetically modified plant produces the proteins for the vaccines. The lettuce leaves are dried and made into capsules that can be taken orally, don't require refrigeration and can be stored for years.

Dr. Daniell's research has demonstrated the effectiveness of plant-based vaccines and therapeutics in treating nearly 30 conditions, from infectious diseases such as cholera, malaria and anthrax to autoimmune diseases like diabetes and hemophilia.

"This will be a paradigm shift in delivery of drugs," Dr. Daniell says. "This will change the landscape and save lives."

Perhaps it will also change how large-scale controlled-environment greenhouses are employed in the future.

For a glimpse inside Dr. Daniell's greenhouse, watch a short video on YouTube at www.youtube.com/watch?v=6z7qwwtHQTY.

Growtainer Trials Are Growing Strong

Back in April, we reported in our *Inside Grower* e-newsletter that a new high-tech hydroponic production system had arrived at Texas A&M Agrilife Research and Extension Center in Dallas, Texas. The "Growtainer" is a growing system from Greentech Agro LLC contained within a specially designed and modified 40-ft. insulated shipping container.

We got an update from Glenn Behrman, one of the founders and president of Greentech Agro LLC, about how things were growing down there in Texas.

"We are seeing results that are amazing," said Glenn. "About 10 days in the propagation area and then 20 days in the nursery area, and the lettuce is ready to eat. In fact, we served Growtainer grown salad to a group of A&M visitors [in July]."

The image (left) is Garrison lettuce being grown hydroponically in the Growtainer under the following cultivation scheme:

- Daytime Temp: 78F (25C)
- Nighttime Temp: 70F (21C)
- CO2: 1,000 ppm
- Lights on: 18 hours
- Lights off: 6 hours

The compact Growtainer system includes the soon-to-be patented Growtainer containers, Growtroller control system and the Growrack vertical production system.

"This is the real deal," added Glenn. "Every expert that's been in the Growtainer walks out amazed."

Learn more at www.growtainers.com.

Free High Tunnel Hoop House Construction Guide

High tunnel hoop houses are relatively easy to construct and have become a very popular addition to many small-scale veggie-growing operations. While there are numerous extension publications on hoop house crop culture, very few focus on construction.

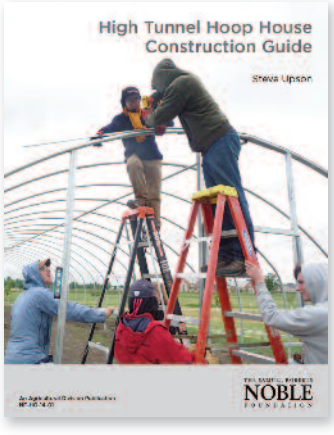
Steve Upson took his 17 years of experience in high tunnel hoop house design, construction, utilization and education to create a "how to" resource on hoop house construction.

Steve says it's not the intent of his publication to offer a complete set of construction plans for any particular type or size of hoop house, but rather to introduce the novice grower and hoop house builder to the various tools and techniques used in constructing a wide range of hoop house models.

Steve admits that his experience with hoop house structures has a southern flavor; consequently, the guidelines may or may not have application in other regions of the country.

"It is my belief that a careful study of this publication prior to purchasing a hoop house kit or materials to custom-build a structure will save the builder time and money as well as reduce the level of frustration encountered during the construction process," says Steve.

You can download the 100-page publication for free at www.noble.org/Global/ag/horticulture/hoop-house-construction-guide/nf-ho-14-01.pdf.



www.facebook.com/Kalettes

Possibly the trendiest super food yet, a cross between Brussels sprouts and kale is expected to hit U.S. supermarkets this fall. Marketed in the U.S. as "Kalettes," the green and purple frilly vegetable combines the sweet nutty taste of Kale with the complex flavors of Brussels sprouts.

Tozer Seeds, the largest family-owned vegetable breeding company in England, developed the kale and Brussels sprout hybrid after more than a decade of research. The company says that Kalettes are not genetically engineered and were developed by cross-pollinating Brussels sprouts with kale through traditional methods.

So far, the U.K. and the Netherlands have been introduced to the new super food, with promising results, according to Tozer. The veggie is marketed as "Flower Sprouts" in Europe and is currently being introduced as "BrusselKale" in Canada.

Tozer is working with several cooperators to grow and market Kalettes.

"We started selling seed in the U.S. in 2012 and quickly realized that this new vegetable was going to be a huge hit with consumers due to the popularity of both vegetables," said Kraig Kuykendall, U.S. sales manager of Tozer Seeds. "The idea behind gathering cooperators to market under the Kalettes brand was to give consumers a consistent name and brand identity to look for in the produce department."

The brand plans to launch a strong consumer media campaign, including social media channels.

Photos and recipes can be found on the website www.kalettes.com.

Historic USDA Support for Local and Regional Food Systems

The new 2014 Farm Bill is bringing historic investment opportunities to strengthen local and regional food systems, including food hubs, farmers markets, aggregation and processing facilities, distribution services and other local food business enterprises.

"As consumer demand for locally-grown food continues to skyrocket and the local food industry matures and expands, USDA Agriculture Secretary Tom Vilsack has identified local food as one of the four pillars of USDA's commitment to rural economic development," explains a release from USDA. "USDA support of local food gives farmers and ranchers more market opportunities, provides consumers with more choices, and creates jobs."

Vilsack said that $48 million in loan guarantees for local food projects is now available through USDA's Rural Development's Business and Industry Guaranteed Loan Program, and $30 million is available through competitive grants via the Agricultural Marketing Service's (AMS) Farmers Market and Local Foods Promotion Program.

Details on how to apply for local food funding through the B&I program are available on the Rural Development website. Applications are accepted on a rolling basis.

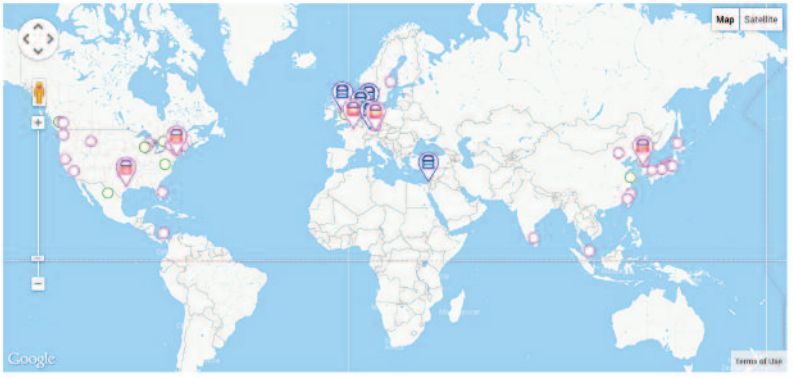
Certified Greenhouse Growers Accepting Associate Members

The Certified Greenhouse/Hothouse Vegetable Producers Association of North America (a.k.a. Certified Greenhouse Farmers), a trade association representing greenhouse veggie growers, is now offering associate memberships to the suppliers of their certified members.

The association says they established this nonvoting class of membership so that proprietors and firms supplying inputs, including services to association members, are able to participate in association affairs. Associate members must be involved in commercial activity where goods or services are supplied to certified greenhouse farmers engaged in the production of edible foods in greenhouses/hothouses, including tomatoes, cucumbers, peppers, lettuces and herbs. The annual associate membership fee is $2,500 and allows the member's logo to be listed on the "grower resources" page of the Certified Greenhouse Farmer's website.

The full members of the association must meet a strict definition of greenhouse grown. The entirety of the member's vegetable production area must be in a fully enclosed permanent aluminum or steel structure, clad either in glass or impermeable plastic for the controlled environmental growing. The grower must be using computerized irrigation and climate control systems, including heating and ventilation capability, grow in a soilless medium using hydroponic methods, use integrated pest management and avoid the use of herbicides.

Learn more about Certified Greenhouse Farmers and the new associate membership option at www.certifiedgreenhouse.com.



Association of Vertical Farming Maps Global Urban Ag

The first global map of urban agriculture is live on the Association for Vertical Farming website. This interactive map features data from vertical farms, community gardens and greenhouses around the world. It can be found on http://vertical-farming.net.

"We have been working hard to survey companies and organizations to build a single robust source for tracking urban agriculture globally," says the association. "Not only does this map offer the locations of vertical and urban farms, but it also tells you whether or not they use artificial light, what their primary purpose is, how and if they are integrated into existing structures and much, much more."

The Association for Vertical Farming is an internationally active nonprofit organization focusing on advancing vertical farming technologies, designs and businesses. They say their primary role is in bringing together all forces in the field of vertical farming from research, business, and policy to create opportunities for the sustainable growth of vertical farming around the world.

Backyard Farms Obtains GLOBALG.A.P. Certification

Backyard Farms, New England's largest year-round grower of tomatoes, is the first hydroponic grower in the U.S. to obtain GLOBALG.A.P. Produce Safety Standard (PSS) certification for the production of its tomatoes. Located in Madison, Maine, Backyard Farms operates 42 acres of greenhouse growing space that provides the northeast with fresh, locally grown tomatoes year round.

GLOBALG.A.P. is a Global Food Safety Initiative (GFSI) recognized scheme at the farm level to ensure safe and sustainable agriculture worldwide. It's a voluntary standard for the certification of production of agricultural, aquaculture and livestock products.

Certification to GLOBALG.A.P. standards supports the continuous improvement of farming systems with a holistic approach to farm assurance including food safety, environment and biodiversity, workers welfare, traceability, and animal welfare. You can download the standards and other related documents free of charge at www.globalgap.org/uk_en/documents.

The certification is offered by Gainesville, Florida-based Quality Certification Services (QCS). QCS offers a handful of other certification options including Certified Organic, Certified Transitional, Certified Hormone/Antibiotic Free, Organic Aquaculture, GLOBALG.A.P. (several scopes), specific trade practices and Food Justice Certification.

Rimol Donates Greenhouse to University Dining Services

University-grown fresh produce will soon be available to students dining at the University of Maryland thanks to a recent donation from Rimol Greenhouse Systems. Rimol, based in Hooksett, New Hampshire, donated a 30 ft. by 96 ft. Nor'Easter greenhouse structure to the University's Dining Services after the school expressed interest in growing greenhouse vegetables.

The donated greenhouse includes double poly with an IR inner layer, automated roll-up sides, gable shutters, polycarbonate end walls and double sliding doors. According to Rimol, the Nor'Easter is currently the strongest free-standing greenhouse available on the market and is designed to protect its crops against all weather conditions. Rimol explains that what makes the Nor'Easter such a strong and rigid structure is that for every bow there is a truss assembly.

UMD Coordinator of Sustainability and Wellness Allison Lilly said she originally asked for a 20 ft. by 48 ft. high tunnel structure, but was encouraged by Rimol Owner and Founder Bob Rimol to go with a bigger structure, which led to the Nor'Easter greenhouse series.

"It's important to give graduate and undergraduate students a chance to take their classroom outdoors and understand how sustainability is achieved," said Bob.

The greenhouse structure is set to be completed this month and house a variety of crops this summer.

Fresh from the (Computer Factory) Farms

How about a side of spinach with that Toshiba laptop or a head of lettuce with that Fujitsu mobile phone? These two Japanese companies, better known for their high-tech personal devices, are both (independently) combining their IT manufacturing businesses with factory farming.

The common denominator between making computer products and growing hydroponic produce is germ-free clean rooms. Toshiba is growing produce in repurposed clean rooms at a factory that once made floppy disks, while Fujitsu is farming in a sterile facility that once made chips for mobile phones and other devises.

Both companies are producing low-potassium veggies, targeted at the more than 1 million Japanese who have chronic kidney disease. Fujitsu is calling their new line of lettuce greens "Kirei Yasai," meaning "clean vegetables."

The lettuce crops are grown in hydroponic systems with the help of high-tech sensors and cloud computing systems. Fujitsu's own cloud service for crops, called Akisai, helps managers control factors such as internal air temperatures, humidity, CO_2 levels, fertilizer levels, pH and EC.

Although the anticipated revenue from growing and selling fresh produce is a fraction of what the companies bring in with tech products, they say there's a real demand for vegetables that are free of pesticides, as well as produce with specific nutritional profiles. It could be argued that Fujitsu's sudden venture into farming isn't about making money growing veggies; it's about demonstrating their cloud service for farmers.

2014 Farm Bill Expands Crop Insurance for Fruits and Vegetables

A new risk management option will be available for fruit and vegetable growers and producers with diversified farms. The 2014 Farm Bill's policy, called Whole-Farm Revenue Protection, will provide flexible coverage options for specialty crop, organic and diversified crop producers. The pilot program will be implemented in counties across the U.S. and will expand in availability over the next several years.

Basically, whole-farm insurance allows farmers to insure all crops on their farm at once, rather than insuring commodity by commodity. Traditionally, many fruit and vegetable crops have not had crop insurance programs available for them. This has made it less attractive for a farmer that primarily planted a commodity crop like wheat or corn to use another part of his or her land for growing fruits and vegetables or other specialty crops. According to the USDA, new insurance options will allow farmers greater flexibility to make planting decisions on their land.

"Crop insurance has been the linchpin of the farm safety net for years and continues to grow as the single most important factor in protecting producers of all sizes from the effects of unpredictable weather," said Agriculture Secretary Tom Vilsack. "Providing farmers the option to insure their whole farm at once gives farmers more flexibility, promotes crop diversity and helps support the production of healthy fruits and vegetables."

As part of the pilot program, Whole-Farm Revenue Protection will be available where Adjusted Gross Revenue (AGR) and AGR-Lite are currently offered, and will expand to other counties as data becomes available for ratemaking. The Risk Management Agency (RMA) will release information on the policy later this summer when it becomes available. This information will be announced on the RMA website at www.rma.usda.gov.

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Vertical Farming: A Critic Asks Some Hard Questions

"Vertical farming"—multiple layers of plants grown under lights in abandoned urban warehouses—is still in its infancy, but it's already a media darling. Advocates call it the future of agriculture. Critics say it's too expensive to be viable. What's the truth? To find out, *Inside Grower* visited America's largest vertical farm, FarmedHere, just south of Chicago, to find out what they've learned in their brief four-year history—and to find out if vertical farming is a viable part of agriculture or an unrealistic pipe dream.

Samples of FarmedHere's biodegradable packaging. Note the "Harvested Locally On" date. Retail price at Chicago grocery chain Mariano's? $3.49 to $4.99 or upwards of $2.00 per ounce. High end, yes, but that helps fund R&D and expansion.

Story and photos by Chris Beytes

When I sat down in the FarmedHere conference room with new (three and a half months) CEO Mark Thomann, he looked me in the eyes and cut to the chase: "At the end of the day, the skeptic in you wants to know if it's viable."

Mark was right. I was skeptical—or at least critical. Can a warehouse filled floor to ceiling with electricity-sucking lights and HVAC replace tried-and-true greenhouse or field production? And what about the fancy-pants crops coming out of these systems—organic basil, gourmet lettuce, microgreens? Come on—how will these solve the food desert and "global food production crisis" that supporters talk about?

So I asked Mark, along with two of his fellow partners and investors, Mark Weglarz and Steve Denenberg, to address these points and more. They did. And now I'm a believer—at least in FarmedHere's business model.

Criticism: Vertical farming is being promoted by anti-traditional farm environmentalists with no grasp of reality.

In some cases. But not at FarmedHere. The five partners and their investors have real-world business backgrounds. John Hall, a lead investor, founded Goose Island Brewery. Executive Chairman Mark Weglarz owns a portfolio of hotels. CEO Mark Thomann has launched at least a dozen brand-based businesses as CEO of Riverwest Brands. Co-founders Paul Hardej and Steve Denenberg have real estate investment backgrounds. Co-founder Jolanta Hardej has a marketing and design background.

"These are legitimate, highly successful business people who like to make return on their capital," says Mark.

In other words, capitalists—which would almost seem to go against the grain of the low-carbon-footprint, "save-the-planet" image of the indoor farming movement.

Mark disagrees. "There has to be an equal balance. If you don't have that [profit] mentality, then you're not going to succeed. You have to look into every cost that goes into every harvest that you're doing out there in order to make this viable. We're trying to do that."

Criticism: It's only grant money and naïve investors supporting the vertical farm movement.

"We built this without subsidies," says Mark. "And as far as the people like myself who've invested in indoor farming, no, we invest based on rational business decisions and based on whether or not we believe there can be a return. And based on everything I've seen, this business can be profitable and can be replicated throughout the country."

I asked Steve Denenberg how long he would stick around if the numbers weren't working.

"I'm not going anywhere," he answered with a laugh. "The numbers do look good—they are good."

"We wouldn't be doing this if we didn't think we could ultimately get to profitability," Mark continued. "And I see, based on the demand that we currently have, that if we continue to build our systems, we will be profitable and, hopefully, a showcase for other vertical farms around the world."

Nor is Mark a naïve investor.

"I had the same issues going into this [that you have]. But once I got here and saw the bigger picture and saw the demand that was there, I knew that this was something I wanted to do. The same things that bother you about indoor farming, I've looked at, and I've realized we can overcome them."

Criticism: There are no business plans in vertical farming, just dreams.

At FarmedHere, the plan was formulated early. Steve told me that they got a sound piece of advice from advisor Jim Slama, founder of familyfarmed.org, and that was to create a brand first. So, of the first $100,000 they spent on the company, he estimated $75,000 of that went towards developing the brand and packaging. (The original name their agency suggested was HarvestedHere, but it was already being used, so they simplified it to FarmedHere.)

Says Steve, "The reason we've achieved a modicum of success compared to other people so far is because we weren't >>>

FarmedHere keeps a low profile in this former corrugated box facility near Chicago's Midway Airport.

Much of FarmedHere's aquaponic (fish and hydroponics) growing system was developed in-house. What you don't see (because it's proprietary) are the "fish engines"—tanks of tilapia that provide nutrients that are pumped through the hydroponic growing beds. While they do sell the tilapia, fish is not a main focus of what they do; they provide the "fuel" for the system, Mark says. The vertical aspect of the farm is the five to six layers of beds in the warehouse. The beds don't move; worker access is via scissor lift, while plants are lifted via forklift. Certainly, there's need for automation here.

FarmedHere has tested LEDs and found a "significant" increase in production, so they will be replacing all the older fluorescent lights with LEDs supplied by Illumitex.

thinking about how cool the technology is to grow indoors—we weren't growing to grow. We figured out how to sell it first. We wanted to be marketers first and then we'll be growers second. That's what we've been doing. We created a business and the technology we have supports the marketing, as opposed to the other way around."

CRITICISM: The operating overhead—electricity for lighting and cooling—makes indoor farming too costly to ever be viable.

True today, but not necessarily for the long term. The first thing I noted when touring the farm was that they used fluorescent lights, not LEDs. Mark said that's because the technology was too expensive when they built the facility. He compares the current state of vertical farming technology to the first cell phones, which were bulky and expensive. Nobody ever dreamed that 40 years later they'd be an estimated 6.8 billion cell phones in use around the world.

However, on the day I visited, FarmedHere announced a partnership with LED manufacturer Illumitex of Austin, Texas. Illumitex will be providing LEDs to replace FarmedHere's fluorescent fixtures. Mark wouldn't elaborate on the relationship, but presumably Illumitex will give FarmedHere a deal on the lights in exchange for being able to promote the relationship and show off the installation for PR and marketing purposes.

They'll be making the conversion to LEDs over the next few months. That will reduce energy costs somewhat while increasing production "significantly," Steve said guardedly, not wanting to give away trade secrets. The LEDs, combined with installing additional growing beds, should help them meet the growing demand from existing customers, such as Whole Foods, along with new customer Jewel-Osco.

Partners and investors Mark Thomann (front) and Mark Weglarz check out the current crop of USDA-certified organic basil.

CRITICISM: Expensive organic basil and microgreens won't solve the food desert or world hunger problem.

True. But let's go back to the cell phone analogy. The earliest cell phones could only be afforded by the wealthy. But their interest in and support of the technology made R&D investments possible, which led to today's global cell phone phenomenon. So it could be with vertical farming.

"I think ultimately we will get to the point where we can produce things economically that are more for the masses rather than for the Whole Foods shopper," Mark says. Strawberries, tomatoes and peppers are next to experiment with.

But he adds, "[Vertical farms] are not going to solve the problem 100%. Are there things we can do with our knowledge and our technology to advance the solution? The answer is yes. Is that going to come within a year or two years? Probably not. But 10 years down the road? Potentially, when you start looking at the LED pricing and other factors that would make this much more viable."

Even in the two years since constructing their current farm, Mark estimates costs could be reduced by 40% to 50% if they built another one. "That's a big deal," he says.

"So to answer your question, I hope so," he says. "I know you're a critic and I know you probably would say no. But I think what we are doing ultimately will lead to some part of that solution."

CRITICISM: Supporters think vertical farms will replace traditional agriculture, which they say is "broken."

"It's a percentage of [agriculture]," Mark says. "It's a part of the equation. We're happy just to be progressively growing and taking a small piece of the market share. Hopefully, in 30 or 40 years, it will be a much bigger piece of the pie. But right now we're on the cusp of actually showing that it can be viable. And if you can show that it's viable, it will grow."

As for replacing other forms of high-tech agriculture, such as hydroponic greenhouses, Mark sees the opposite: partnership opportunities.

"If we're going to be successful, everyone else within the community also needs to be successful. We need to embrace other growing methodologies, other technologies that may be out there. People need to learn from us what we know and how we harvest and distribute. Other brands and other forms of greenhouse growing could probably utilize the brand that we've established.

"I absolutely see partnering with other growers and other technologies to enhance what we have here," he concludes. Then he points at a picture of greenhouse tomato grower Casey Houweling on the cover of an issue of *Inside Grower* that I'd brought along and says, "I'll call him tomorrow!"

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This article is based on the publication "The Local Food Movement: Setting the Stage for Good Food" co-written in May 2013 by the author and found at the MSU Center for Regional Food Systems web site: http://foodsystems.msu.edu/resources/local-food-movement-setting-the-stage

The Local Food Movement's Evolution in the United States

Consumers wondering about the origin of their food didn't just happen overnight; the seeds of the local food movement have been growing since the Great Depression.

by **RICH PIROG**

The local food movement in the United States has moved from the margins to mainstream in recent years. Riding a wave of farmer's markets and community-supported agriculture expansions and celebrity chef and restaurateur testimonials, the movement has spurred more source-identified food products in small and large food retailer offerings, and a growing recognition by USDA of the importance of local food commerce in rural and urban economies. The movement has evolved and matured since the early 1990s, when it was still considered novel to serve local food at a farmer conference. References to local food today can be found everywhere, from television shows and comic strips to the White House Garden.

A historical accounting of the emergence of the local food movement in the United States can be somewhat subjective, since we've always had farmer's markets and our founding laws and constitution were shaped at a time when agrarian society was the dominant cultural and economic framework. We can trace back the seeds of the current local food movement to the creation of the Agricultural Adjustment Act (AAA) of 1933, which spawned today's controversial agricultural subsidies and price supports.[1,2] As a result of the Great Depression and the severe drought of the 1930s, more than 20% of the Great Plains rural family farms sought federal emergency relief.[3] Originally created to protect family farm systems from economic failure during the Great Depression, these commodity price support systems took on a more important role over time with the help of the USDA. Over the coming decades and spurred by the increased production of the green revolution following World Word II, the commodity support system and increased productivity allowed the opportunity for corn, wheat, rice, sugar and soybeans to be purchased at low prices by vertically-integrated food-manufacturing companies and then used in a wide variety of value-added food products. The nation's agricultural colleges at land-grant universities, as well as USDA, focused their research and outreach agendas on building the efficiency of this commodity-based production, processing and marketing system.[4]

Today, commodities such as corn and wheat are the primary or secondary ingredients in many of the food products found in the middle aisles of a typical large supermarket. Commodities are the primary feed for many livestock-based meat and dairy products found at the same supermarkets. Cheap feed ingredients for livestock made it easier to dramatically scale up the size of livestock operations through the 1970s and '80s to supply a growing demand for meat as Americans began eating more meals outside of the home. The growing availability of this meat supply fueled the proliferation of franchised fast-food restaurants.[5]

With narrow profit margins in many food industry arenas, many food and farm businesses chose to scale up production and throughput capacity in order to survive. Consolidation and focus on efficiency and profit, coupled with increasing size of operation, made it harder for smaller-farm and food businesses to compete without specialization.[6,7] Many small and midsized farms went of business during this period, with the sharpest declines occurring from the 1950s through the 1970s.[8] As farms and food retail outlets increased in size, and national and global supply chains developed in response to global trade laws to capitalize on economic efficiency, food that historically had been provided by local and regional sources now came from wherever land and labor costs were the lowest. By 2004, the volume of food imported into the U.S. exceeded the amount exported.[9]

To remain in business, common survival strategies used by small and mid-sized farms and food businesses have included selling differentiated food products directly to consumers or grouping together to sell those same differentiated products through specialty retailers, food co-ops and food service companies.[10] These survival strategies to increase profit margins for small and midsize farms converged with a growing prevalence of more "anonymous" food in the marketplace. Increasing numbers of consumers were curious about the farmers who produced their food and how the food was grown. This growing consumer interest during the past 20 to 25 years has spurred a sharp and steady growth in buying directly from farmers. A recent study of grocery shoppers

shows that two-thirds of consumers are interested in buying local to support local economies.[11] We've seen dramatic increases in the numbers of farmer's markets, community-supported agriculture enterprises, as well as farm-to-school programs. In the 2011/2012 school year, there were nearly 39,000 schools in the U.S. participating in these farm-to-school programs.[12]

In addition to increased local food sales and new businesses, there's been a groundswell of new urban agriculture enterprises developed throughout the country. Increases in vacant properties due to the recent economic downturn that started in 2008 have spurred innovative farmer entrepreneurs, community leaders and city planners to rethink agriculture as a local community development tool and start new food enterprises in the city.[13] Another critical emergent trend is the growth in the number of food hubs—businesses that aggregate, distribute and market source-identified foods. Food hubs are a response to the increased demand in local food by larger volume buyers who prefer to not deal with the high transaction costs of multiple small farms. Hubs also have potential to provide a variety of producer, operational and community services related to food.[14]

In recent years several related movements—including healthy food access, food justice, >>>

Previous page: A recent study of grocery shoppers shows that two-thirds of consumers are interested in buying local to support local economies.

Above: We've seen dramatic increases in the numbers of farmer's markets, community-supported agriculture enterprises, as well as farm-to-school programs.

Below: This timeline chronicles a sample of important U.S. events, policies and statistics that mark the growth of local food within the context of evolving conditions of each of the four "good food" elements.

Figure 1

Good Food Timeline 1941-2014

The timeline charts the evolution of the local food movement in the U.S. within the context of the four elements of good food: healthy, fair, affordable, green.*

Turn to Appendix for more details and information for each of the events found in this timeline and photo credits.*

1941 1. Recommended Daily Allowances (RDAs) are established to allow individuals to assess nutrient intake levels.

1942-1964 2. The Bracero program between U.S. and Mexico brings in more than 4 million Mexican farm laborers.

1949 3. The Agricultural Act of 1949 makes commodities available for distribution to needy people through school lunch programs, Bureau of Indian Affairs and public welfare organizations.

1950 4. The U.S. federal minimum wage is set to $0.75 per hour, $7.25 in 2013 dollars.

1955 5. The first McDonald's restaurant, owned by Ray Kroc, is opened in Illinois.

1960 6. The rate of obesity for adults, defined as a body mass index over 30, in the U.S. is reported to be 13.4% of the population.

7. Four African-American university students begin a sit-in at a Woolworth store lunch counter in Greensboro, N.C., after being refused service based on their race.

1962 8. The first convention of National Farm Workers Association is held.

1964 9. The Civil Rights Act of 1964 prohibits discrimination based on race, sex, ethnicity or religion.

1965 10. The U.S. federal minimum wage is increased 50 cents per hour, to $1.25 ($9.27 in 2013 dollars).

1969 11. The Black Panthers begin a school breakfast program for students; the program eventually is adopted by the U.S. government.

12. 2.8 million Americans are utilizing the federal Food Stamp Program (1.4% of the population).

1970 13. The number of farmers markets in the U.S. is estimated at 340.

14. The first national Earth Day is celebrated in the U.S.

1972 15. The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) begins, safeguarding the health and wellness of pregnant women and children.

1974 16. The rate of obesity for adults is reported to be 14.5%.

1975 17. The U.S. federal minimum wage is increased to $2.10 per hour ($9.12 in 2013 dollars).

18. The California Labor Relations Act becomes law, allowing farm workers the right to boycott and to collectively bargain.

1976 19. The Farmer-to-Consumer Direct Marketing Act passes, prompting the development and expansion of direct marketing.

1979 20. U.S. food expenditures as share of disposable personal income is 13.4%.

21. 7.6 million Americans participate in the federal Food Stamp Program (3.4% of population).

1981 22. The U.S. federal minimum wage is set at $3.35 per hour ($8.61 in 2013 dollars).

1983 23. The Migrant and Seasonal Agricultural Worker Protection Act (MSPA) passes to provide agricultural employees financial and safety protection in the workplace.

1984 24. The National Center for Food and Agriculture Policy (NCFAP) is founded to inform public policy on food, agriculture and natural resources.

25. The first community supported agriculture (CSA) enterprise opens in the U.S.

1987 26. The first food policy council forms in Knoxville, Tennessee

1988 27. The first graphic USDA "food pyramid" is released to help individuals visualize a healthy, balanced diet.

1990 28. The community supported agriculture (CSA) count in the U.S. grows to 60.

1991 29. The federal minimum hourly wage in the U.S. is increased to $4.25 ($7.29 in 2013 dollars).

1992 30. A new USDA food guide pyramid is released.

1993 31. The Coalition of Immokalee Workers is founded to fight for fair worker wages.

1994 32. The Nutrition Labeling and Education Act requires a nutrition label to be on all packaged foods sold in the U.S.

33. The number of farmers markets in the U.S. grows to 1,755.

1996 34. The first pilot farm to school program is launched in California and Florida.

1998 35. Rising costs for diabetes-related treatment accounts for 9.1% of U.S. medical care.

36. Walmart opens its first fully stocked grocery stores at supercenters. The chain has 4% of national food grocery sales.

2000 37. The average hourly wage for non-supervisory farm workers is $10.05.

38. The rate of obesity for adults aged 20-74 in the U.S. jumps from 23.2% in 1994 to 30.9%.

2002 39. USDA Organic Food Regulations take effect.

2004 40. The number of farmers markets in the U.S. grows to 3,706.

41. All 50 states, Washington, D.C., the Virgin Islands and Guam are operating EBT systems to issue food benefits.

42. 25.5 million Americans are utilizing the federal Food Stamp Program (8.7% of population).

2005 43. The new visual for the USDA food pyramid, MyPyramid, is launched.

44. The community supported agriculture (csa) count in U.S. grows to an estimated 1,046, an increase of about 1,740% since 1990.

2006 45. The Kellogg Foundation and partners develop indicators and measures of "good food."

2007 46. The National Good Food Network is established to support growth of good food value chains.

47. "Locavore" is word of the year.

48. The National Farm to School Network is founded.

2008 49. The former federal Food Stamp Program is renamed "Supplemental Nutrition Assistance Program (SNAP)."

50. Nearly 1 in 4 (23%) of Native American and Alaska Native households are food insecure, versus 15% of all U.S. households.

51. Local food sales across the U.S. gross nearly $5 billion.

52. The prevalence of hunger in the U.S. is estimated at 14.6%, up from 11.9% in 2004.

53. The Food, Conservation and Energy Act (Farm Bill) of 2008 requests a study of areas with limited access to affordable and nutritious food.

2009 54. The federal minimum hourly wage in the U.S. increases to $7.25 ($7.89 in 2013 dollars).

55. Taco Bell pays more for tomatoes so that farm workers can earn more.

56. The count of U.S. schools participating in the Farm to School program grows to 2,000 schools.

57. The CSA count in the U.S. grows to 2,932.

58. The American Medical Association passes a resolution supporting sustainable food systems.

2010 59. Managerial occupations within the food chain are composed of 47.8% white men, and 8.6%, 4.3%, and 3.4% of Latino, Asian, and black men, respectively.

60. Obesity rate for adults aged 20-74 in U.S. is at 36.1%, up from 30.9% in 2000.

61. Let's Move! First Lady Michelle Obama campaign fights childhood obesity.

62. The Healthy Hunger-Free Kids Act authorizes funding and sets new policy for USDA's core nutrition programs in schools.

2011 63. Nearly one in three African-American children (32%) live in food insecure households, as compared to one in six (16.0%) Caucasian children.

64. The number of farmers markets in the U.S. grows to 7,864.

2012 65. The national average hourly wage for non-supervisory farm workers is increased to $10.80.

66. Since 2010, $77 million has been allocated to the Healthy Food Financing Initiative.

67. Nearly 86% of U.S. food service workers earn wages at or below the poverty level.

68. USDA's first-ever Farm to School Census shows 38,000 schools with 21 million students participating.

2013 69. 47.7 million Americans participate in the SNAP program (15.1% of population), with SNAP rates at farmers markets doubling between 2011 and 2013.

70. The National Survey of Food Hubs report reveals that two-thirds are operating without grant funding, and one-half accept SNAP benefits.

2014 71. Nearly 500 U.S. hospitals have signed on to the Healthy Food in Health Care program.

72. Walmart becomes the third major U.S. food retailer (following Whole Foods and Trader Joe's) to sign on to the Coalition of Immokalee Workers' Fair Food Program.

*Timeline and Appendix developed by the MSU Center for Regional Food Systems. Timeline is part of the publication "The Local Food Movement: Setting the Stage for Good Food."

racial equity and the environment—have converged with the local food movement to not only broaden the tent, but increase the expectation for local food to bring benefits not only to farmers, but also to low-income community residents and all those who want a healthier diet that's within their economic means. Many people who are active in these movements have come to understand local food through its connection and use of the term "good food" coined less than a decade ago by the W.K. Kellogg Foundation and its strategic partners. The term "good food" has been used to describe food that has four key elements:

Healthy | Providing nourishment and enabling all people to thrive
Green | Produced in a manner that's environmentally sustainable
Fair | No one along the food chain is exploited in its creation
Affordable | All people have the economic means to access it

If local food is only interpreted and referenced in terms of geographic proximity (how many miles from farm to point of sale?), one could imagine a food system that is geographically local but reflects none of the four above elements used to describe "good food." The timeline on page 15 chronicles a sample of important U.S. events, policies and statistics that mark the growth of local food within the context of evolving conditions of each of the four "good food" elements. We have a tremendous opportunity to thoughtfully rebuild a food system by increasing local food that embodies all four elements of "good food" across America, with special focus on those marginalized by race ethnicity, gender, size of business/farm or economic class. Local food farmers and their advocates—along with advocates of food access and health, food justice and racial equity—all must understand and embrace their unique, yet interdependent, roles in realizing this opportunity.

RICH PIROG is Senior Associate Director for the Michigan State University Center for Regional Food Systems in East Lansing, Michigan.

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Double Trouble or Twice as Nice?

The challenges encountered in organic hydroponic vegetable production are complex and run the gamut from nutrient management, pest control and productivity to marketing, semantics and politics.

by **ANNIE WHITE**

Can hydroponics be organic, too? The straight answer is yes, but the caveats are plentiful and it's even a somewhat controversial topic among growers.

Certifiably organic hydroponic growing systems can, and have been, developed in the U.S., but a typical hydroponic growing system is not an organic system and a typical organic growing system is not hydroponic. Both industries are growing strong in the U.S., so why aren't more hydroponic growers seeking USDA organic certification?

The reasons for the rarity of organic hydroponics are complex and involve discussions of nutrient management, pest control, productivity, marketing, semantics and politics. Individually, each system has its merits, but a marriage of the two evokes a unique set of challenges. Many produce growers decide to pursue hydroponic or organic growing, but rarely both.

In the simplest sense, organic growing is more about feeding the soil than feeding the plant and hydroponics is about feeding the plant and eliminating the soil. With this in mind, it should be little surprise that practicing organic agriculture—a system created for soil-based farming—is challenging for a growing system that doesn't use soil.

The Great Debate—Should Hydroponic Crops Qualify for Organic Certification?

The U.S. Department of Agriculture's National Organic Program (NOP), the organization responsible for overseeing organic certification standards in this country, says that organic hydroponic production is allowed as long as the producer can demonstrate compliance with all USDA organic regulations. The basic requirements for organic certification involve the avoidance of synthetic chemical inputs, including unapproved fertilizers and pesticides, and the avoidance of genetically modified organisms.

To date, the NOP has not addressed the recommendations of its own advisory board, the National Organic Standards Board (NOSB), which concluded in 2010 that hydroponic growing should not be allowed organic certification in the U.S. Most other countries, including Canada and Mexico, do not permit hydroponic crops to be labeled organic.

"The NOP continues to work on evaluating and implementing a backlog of older NOSB recommendations," said Miles McEvoy, deputy administrator of the NOP, in a statement addressing why the NOP hasn't acted upon the NOSB's recommendation.

A number of organic farming associations are angry that hydroponic growing methods are still certifiable as organic despite the NOSB's 2010 recommendation. Keepthesoilinorganic.org is just one such organization with a petition urging the NOP to take action. It blames the NOP for failing to maintain the integrity of the national organic standards.

Dave Chapman, owner/grower of Long Wind Farm in East Thetford, Vermont, and founder of the petition, isn't against hydroponics; he just doesn't think it should be certifiably organic.

"It is ingenious, and it works well, which is why virtually all the conventional greenhouse vegetables are grown this way. But it is NOT organic," Dave proclaims. "There is no reliance on the microbial activity of the soil to provide the biological diversity that is the basis of organic growing."

Despite the debate, Miles McEvoy says that accredited certifying agents are certifying organic hydroponic operations based on the current organic regulations. In the future, the NOP may provide additional guidance regarding organic hydroponic production and how the regulations apply to such methods.

What Makes Organic Hydroponic Systems Challenging?

The organic food market has increased every year since 2002, even through the economic downturn, according to the Organic Trade Association. Consumer demand for organic produce, in tandem with the price consumers are willing to pay for it, is inspiring some growers to pursue organic hydroponics, despite a myriad of challenges. Here's a look at the specific challenges in setting up and managing an organic hydroponic system.

Setting Up a Growing System

Designing the growing system is a critical step in planning an organic hydroponic operation.

"Both nutrient film technique (NFT) and drip systems with growbags, the two predominant commercial hydroponic set-ups, can be designed to meet organic certification standards," explains Chris Higgins, general manager of Hort Americas, a distributor of hydroponic products and services in North America. "Tomatoes, peppers and cucumbers are grown in drip systems with growbags and lettuce greens and culinary herbs are grown in NFT systems."

In a drip system, the inert substrate used to support the root system of the plant must also be certified organic. This prevents growers from using Rockwool substrates. According to Higgins, most growers use an organic coconut fiber base, such as Riococo hydroponic coir growbags. Providing the right volume of the substrate is critical for supporting a healthy microbial community, which converts organic nutrients into forms useable by the plants.

Large-scale commercial organic hydroponic operations do exist, and are expanding in the U.S., but few details are known about their growing systems. Wholesum Harvest in Nogales, Arizona, is growing 12 acres of organic hydroponic vegetables with plans to expand to up to 60 acres. Grimmway Farms grows 10 acres of organic hydroponic tomatoes in Tehachapi, California. Protecting the hard work and investment they've put into establishing successful growing systems, both companies are tight-lipped about the details of their organic hydroponic practices.

Managing an Organic Nutrient Program

Devising a satisfactory nutrient program remains one of the biggest challenges for an organic hydroponic grower. The components of organic fertilizer are largely dependent upon organisms in the soil to convert the "organic" materials into a useable form for plants. Soil or no soil, the organisms are still needed. This is where things start getting tricky.

By relying on microbial release of nutrients from organic sources, the nutrient supply is less predictable in an organic hydroponic system. Chris says that most growers provide their own source of nitrogen via compost or fish waste and then supplement with a commercial organic fertilizer.

The refined substances and mineral salts that are the foundation of most conventional hydroponic fertilizers are prohibited in organic growing and unrefined minerals, which are "organic," don't dissolve well in water. Options for organic hydroponic fertilizers are, however, expanding, but remain far more limited than conventional options. Some complete liquid organic programs are offered by Kimitec and distributed in the U.S. through Hort Americas. General Hydroponics also offers an organic fertilizer line.

Dr. Kim Williams, professor of greenhouse management at Kansas State University, says organic nutrient sources support a thriving microbial community that brings with it both some management drawbacks and potential benefits. Kim studies water and nutrient management in greenhouse production, including organic hydroponic systems.

"Drawbacks may include depletion of oxygen levels in the recirculating solution, which will negatively influence plant health and growth of organisms that clog equipment," says Kim. "A benefit may include the beneficial organisms out-competing pathogens for resources, serving as a buffer against some disease problems."

Kim also explains that managing pH is much more difficult when carbon-based organic fertilizers are used in hydroponics compared to conventional fertilizers.

"Microbial activity feeding on the carbon in the organic nutrient source contributes to rapid fluctuation in pH during the first few days of nutrient addition," she said. "Adding to the challenge is that organic certification limits the materials that can be used for pH management and of the materials available, such as microbially produced citric acid, greater volumes are required to influence pH of the recirculating solution compared to conventional acids and bases."

Controlling Pests Sans Synthetic Pesticides

In addition to nutrient management, pest management can be a challenge in organic hydroponics, requiring growers to recognize and treat pest problems before they get out of hand. Dr. Patricia Rorabaugh, professor of controlled environment agriculture at the University of >>>

Arizona, says that products available to organic growers often work slower than traditional chemical pesticides.

"Things like oils, sulfur, soaps, bicarbonate products or even beneficials (predators and/or parasites) may be only partially successful or take some time to get the pest populations under control," explains Patricia. "And then it may just be a 'control' rather than eradication."

Many hydroponic greenhouse businesses, including Gotham Greens in Brooklyn, New York, use biological controls, combined with strict sanitary policies, to prevent pest problems from starting in the first place. Although Gotham Greens is not certified organic, they market their produce as pesticide-free.

"Gotham Greens' products are free of any harmful chemical pesticides, insecticides or herbicides," touts the company on their website. "We employ integrated pest management solutions, including biological controls such as using beneficial insects to prey on harmful pests."

Can Organic Productivity Match Conventional Hydroponics?

Growing vegetables hydroponically in climate-controlled greenhouses is both capital and labor intensive. The investment per square foot of growing space is much higher than field-grown or high tunnel production. To be profitable, any controlled environment agriculture practice must maximize productivity, growing more per square feet to offset the increased greenhouse and technology investment.

Growers have struggled to get the same growth using organic fertilizers compared to inorganic fertilizer. Although more challenging, some researchers argue that an organic system can be just as productive with the proper management. Graduate student Jason Nelson, working with Kim Williams at Kansas State University, investigated overall plant performance in a hydroponic system with organic and inorganic fertilizers. He found that the growth rate of organic-fertilized Rex butterhead lettuce plants grown in NFT troughs was slower than inorganic-fertilized plants, allowing the inorganic lettuce to be harvested about five days earlier. However, Jason believes that with some tinkering—specifically adding some calcium nitrate to the organic nutrient solution—the plants would catch up and be equally productive.

The Marketing Strength of the Organic Label

Growing challenges aside, that little "organic" sticker on a tomato can make all the difference when it comes to marketability and profitability. A "hydroponic" label holds less appeal to consumers. In fact, most hydroponic growers don't use the word "hydroponic" at all in their marketing, avoiding any negative stigmas associated with soilless hydroponic systems.

Conventional hydroponic growers, however, are increasingly labeling their produce with information that's important to consumers. Even without being certified organic, greenhouse-grown hydroponic produce is often labeled as "GMO-free" and "pesticide-free," which some argue are the most important principles in organic farming.

With all these challenges, why bother? Why choose to pursue organic hydroponic over a conventional hydroponic or soil-based organic system? High market demand in tandem with consumers' willingness to pay a premium for organically grown still makes a strong case for growing a certifiably organic product. If designed and managed carefully and skillfully, a fine-tuned organic hydroponic system has the potential to grow premium produce year-round and on a small footprint.

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Greenhouse Edibles Taking Center Stage

University of Arkansas researchers are getting serious about greenhouse edibles, as an increasing number of growers look to expand their offerings of locally grown products.

by **DAVID KUACK**

The interest and demand for locally grown foods continues to increase among retailers and consumers. The USDA 2007 Census of Agriculture reported that direct-to-consumer food (D2C) sales increased three times from 1992-2007. Sales rose from $404 million to $1.2 billion. D2C sales grew twice as fast as total agricultural sales (105% versus 48%). The USDA reports some of the reasons that locally grown produce is gaining interest among consumers include:

- Obtain food items with superior quality characteristics, including freshness, flavor, ripeness and longer shelf life.
- Amid concerns about food safety, learn about farming practices used, often directly from growers, which engenders trust in the integrity and quality of the food purchased.
- Support agriculture and small business development in the consumers' local communities.
- Preserve local farmland/open space by supporting economically productive use of land.

Increased student interest

Just as consumers are showing an increased interest in locally grown food, University of Arkansas horticulture professor Mike Evans is seeing a shift in the type of greenhouse crops that horticulture students want to learn how to grow. Of the university's students majoring in horticulture, food crop production is exceeded only by turf management.

"More and more students who are interested in greenhouse production want to learn about growing food crops," Mike said. "To accommodate this interest, we have started a new class in which we are teaching about the production of tomatoes, cucumbers, greens and other edible crops."

Mike said the university's greenhouses are being equipped with different production systems, including hydroponics. The students will have a well-equipped facility in which they'll be able to have hands-on experience raising various edible crops.

Identifying new crops

The changes that Mike has seen with the university's horticulture students reflect similar changes occurring within the horticulture industry. Identifying the major greenhouse food crops currently being grown, he began to look at greenhouse food production and found the area of herbs and greens has been neglected. Mike has started working with fellow university horticulture assistant professor and breeder Ainong Shi.

"We are interested in looking at new species of fresh greens and the breeding of greens," Mike said. "We are particularly interested in developing crops that can take Southern hot climates. By converting our facilities to focus on greenhouse food crops, we are looking to become a central institution to study new species of greens, developing new crops, breeding new cultivars and developing production protocols for these crops."

From field to greenhouse

One of the crops that Mike is looking at for potential greenhouse production are fresh greens.

"Most of the greens research—including breeding—being done in this country, by-and-large, is for field production," he said. "Those same varieties that were originally evaluated in the field are then taken and grown in the greenhouse. We typically have not bred varieties for greenhouse production."

Mike is interested in identifying greens that have lower inputs—including water and fertilizer—are relatively pest- and disease-resistant, have a rapid production cycle and are heat-tolerant. Mike said the issue with heat is a major obstacle for greens grown in the southern United States.

"The problem that growers in the southern half of the U.S. run into during the summer is what kind of greens can they produce?" he said. "Greens in the South are more of a fall-to-early-spring crop. As temperatures start to get

University of Arkansas horticulture professor Mike Evans is working with other plant scientists to develop a program on greenhouse food production for both students and commercial growers.

Photo courtesy of Mike Evans, University of Arkansas.

Photo courtesy of Mike Evans, University of Arkansas.

University of Arkansas researchers are interested in identifying greens that have lower inputs—including water and fertilizer—few pest and disease problems, a rapid production cycle and are heat-tolerant.

Research at the University of Arkansas on greenhouse food crops will include new species of greens, breeding new cultivars and developing production protocols for these crops.

hot, growers either have to stop growing greens or begin practices such as chilling the nutrient solution to try to delay bolting. The question is can we develop greens that can be grown in the heat of summer?"

One of the crops that Mike said has a lot of potential for heat-resistance is spinach. Former University of Arkansas professor Teddy Morelock did a lot of spinach breeding.

"He passed away, but left us with hundreds of spinach lines," Mike said. "We're trying to figure out what we've got. Teddy never conducted greenhouse trials or evaluated the germplasm for production in greenhouses. All of his evaluations were done in the field. We might be sitting on the best spinach variety to grow in a greenhouse."

Dandelion (*Taraxacum officinale*) is another plant that Mike thinks may have great potential as a greenhouse crop.

"Dandelion has a higher nutritional value than spinach," he said. "It is loaded with iron, vitamins A and C and beta-carotene. It was considered a medicinal plant. The early immigrants to America brought dandelions with them for food. A lot of people suffered vitamin deficiencies and developed scurvy so they brought the dandelions with them."

Dandelions are quick growing, don't need a lot of inputs and are very heat tolerant.

"They are short-day plants so they might need some night interruption lighting," he said. "That's not real a concern because the plants would probably be harvested before they flower."

Mike said dandelions have a lot of genetic diversity because they're spread out globally and the plants are segregated from each other. Because dandelions have a wide range of flavors and traits, the researchers will be collecting germplasm from all over the world. He said this will enable them to breed dandelions with the traits considered to be most important for greenhouse production.

Strawberry cam show-and-tell

Vegetables and herbs won't be the only crops University of Arkansas researchers will be working on. As part of the National Strawberry Sustainability Initiative, Mike will be working with professor and fruit extension specialist Elena Garcia. The research they're conducting is part of a program funded by the Walmart Foundation, which is being administered by the university's Center for Agricultural and Rural Sustainability.

Mike said the goal of the project is to demonstrate and teach growers about various types of hydroponic systems for strawberry production. These systems might include nutrient film technique troughs, gutters and Dutch buckets. Mike said some of the hydroponic systems offer significant advantages to the production of greenhouse strawberries. He has also been working with University of Arizona horticulture professor Chieri Kubota and research specialist Mark Kroggel to prepare videos on the strawberry production research they've been conducting at the university's Controlled Environment Agriculture Center.

Another topic of discussion will be the type of structures that can be used to grow strawberries.

"If a grower considers using high tunnels, he can extend the season," Mike said. "Or a grower might consider using drop-wall greenhouses. There is the possibility of providing supplemental heat, which could result in year-round production. There are a lot of possible benefits for our growers."

Mike and Elena have been traveling around the state and meeting with growers, talking to them about the different production systems and explaining how they can be used for strawberry production. Mike said many of the growers that they've met with didn't know about the differences in the production systems and didn't understand the differences.

Two of the university's greenhouses have been renovated to accommodate various strawberry production systems. About 4,000 sq. ft. have been converted to hydroponic food production with about 1,600 sq. ft. devoted to strawberries and the remaining used for greens.

"Our goal is to put in several different systems and to shoot video of what we are doing from the beginning to end," he said. "We will shoot video of the assembly of the different systems, as well as the production of the strawberries in each system. The videos will walk the growers through all aspects of design, build, manage, maintain and grow the strawberries using a specific system."

Mike said the videos (which can be viewed at https://www.youtube.com/user/sustainablehydro) will be used as an educational tool allowing growers to look at the different production systems and to see the advantages and disadvantages of each system.

"Not every system is perfect for everyone," he said. "Everyone has to look at what they are growing or planning to grow and what is their market. We want to use the videos as a way to demonstrate these systems to teach growers how to effectively select one and how to effectively use it."

For more information, contact Mike Evans at (479) 575-3179 or mrevans@uark.edu. Some of the information presented in this article first appeared in the July 2013 "News from Hort Americas!" newsletter, www.hortamericas.com.

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Photo courtesy of Mike Evans, University of Arkansas.

Photo courtesy of Mike Evans, University of Arkansas.

About 4,000 sq. ft. of the University of Arkansas greenhouses have been renovated for the study of hydroponic food production, including greens and strawberries.

Photo courtesy of Elena Garcia, University of Arkansas.

University of Arkansas professors Mike Evans and Elena Garcia (pictured) have been meeting with growers around the state, talking to them about different strawberry production systems.

Protecting Greenhouse Edibles

In order to comply with the Food Safety Modernization Act, you'll need to follow these best practices.

BY ROB LAROSE

The 2010 Food Safety Modernization Act (FSMA) has recently made growers question whether or not their methods of growing are up to par with the newly revamped requirements. Even though there are a few exceptions (mainly for smaller growers), most greenhouse growers and conventional field farmers are facing similar hurdles to overcome. Food safety regulations are becoming strict, while more growers move into the greenhouse edibles market. With consumers seeking higher quality produce, food suppliers such as restaurants and supermarkets are looking to accommodate them by supplying commodities from their own state. With this rapidly growing market, it's important for growers of greenhouse edibles—especially new ones who formerly focused on ornamentals—to be well aware and up to date on the new food safety regulations that the FSMA has put into effect.

Although greenhouses are thought of by many to be a controlled environment, there remain numerous steps to be taken in order to be sure that edibles meet the standards. Every step of food production, from seed to shipment, must be carefully analyzed for any type of potential contamination risk. With this risk analysis, growers are encouraged to implement preventative measures in order to abate contamination in their product.

Create a food-safety plan | In order to cultivate effective preventative measures, you'll first need to document every single step in your food safety plan. Check with your fellow growers or use the wide array of resources available on the Internet. As a general guide, your plan should include steps involving cleaning, sanitation, water treatment, pest control, packing, visitation regulations, monitoring and testing. A training schedule for greenhouse employees wouldn't hurt, either.

Keep it clean | Sanitation and cleaning are crucial to any effective food safety plan. While sanitation is important, cleaning equipment and other food environment aspects will drastically reduce the risks of your product becoming contaminated. Personal sanitation requirements are equally significant as facility sanitation—as every person that comes in contact with food can be considered a liability. Many growers typically sanitize and clean their greenhouses in between growing cycles. However, with the FSMA in place, it's essential that cleaning is performed on a daily basis, especially in areas where edibles are harvested and packed. It's wise to implement a zero-tolerance policy with employees regarding relaxed cleaning practices. Sanitization of equipment, tools and structures are essential, along with making sure that greenhouse workers are meeting sanitation standards as well. Peroxycompounds, such as hydrogen peroxide and peroxyacetic acid, have proven to be very effective in greenhouse sanitation, along with percarbonates, copper and chlorine. It's important to note that not all chemistries kill spores and may be harmful to the worker or the environment. Aim for your sanitation chemicals to have a minimal or zero REI to eliminate any delay in production.

Treat your water | One of the most important food safety measures you can take to meet mandates is proper water treatment. Water that comes in contact with food must be tested for contamination regularly. Plant pathogens are commonly brought on by untreated water, especially if irrigation is from a well, tank or pond. Antimicrobial chemicals will work best for these specific cases. The best agent to use for water treatment is peroxygen chemistries, according to research. Other options include copper ionization, ozone and chlorine.

Wash your produce | Produce must be thoroughly washed before packing in order to dispose of any lingering pathogens. For maximum efficiency, use an antimicrobial treatment (EPA approved) that doesn't call for a water rinse. This method effectively prevents food safety issues, as well as food spoilage during transportation.

Test your water | A great way to reduce food safety risk is to regularly test and monitor your irrigation water. Testing (at least) quarterly should provide growers with a reliable knowledge of their water's quality. Monitoring changes and patterns in water quality is always a great preventative measure, along with keeping records of any sanitation or pest management applications. These records are ideally updated on a weekly basis. Also, be sure to test your produce wash and sanitation treatment levels. Since getting an accurate reading is so important in this process, it's critical that you use a tester that can record levels, as test strips are often much less accurate. There are greenhouse and chemical companies that do offer water testing to help implement a treatment plan. They'll likely be able to provide you with or recommend testing equipment of your own so that you can continue to run your operation independently.

Keep wildlife out in the wild | Animals and wildlife are not commonly thought of as able to get into greenhouses, but they have, and will, continue to find ways in occasionally. Establish standards in order to prevent entry from birds and rodents, as well as a plan of action to get them out in the event that they do gain access. A great way to keep wildlife out is screening windows. Setting traps is also effective. These intruders pose a huge risk of contamination to your food, so it's imperative that you take any measures necessary to keep them away from your crops.

Keep insects out | Insects prove to be an even larger issue than birds and rodents. Insects should never be found in growing or packaging areas. Of course, it's nearly impossible to always remain 100% insect-free, but growers must try their hardest to keep the populations minimal. A good quality sanitation program will be your best friend in reducing or eliminating insects inside work areas. Insect growth regulators will help you succeed even more in this process. Azadirachtin-based products, some of which are organic listed, are very effective and will eliminate larval and nymph stages of insects. However, it's also important to choose products with anti-feedant capabilities so that insects that have come in contact with the plants are suppressed. Not all of these products are the same, but it's best to avoid those with a glycogen base, as this can become a food source for unwanted insects.

Train your staff | Having a universal training program for all of your workers is an excellent method of making sure that everyone has a full understanding of a food safety program. All workers should know that food safety is extremely important to a business in your industry. Training your entire team (as opposed to those only handling the crops) will yield the best preventative results. Your team should demonstrate understanding of the fundamentals so that each individual will practice on his or her own, as opposed to just "following the rules." Encouraging employees who are sick to stay away from produce or simply not come into work is crucial.

These are only general guidelines to follow when setting up your own food safety program. Many choose to add their own ideas and regulatory practices. In some instances, visitors are kept away from produce because they don't know the preventative measures being taken for this cause. Others add in details about how to properly package materials. This includes using sanitary packaging products that are new and unused. Recycled cardboard and plastic aren't recommended for this job. It may seem insignificant, but working through all these small details will help to contribute to making your operation as efficient as possible.

The new regulations in food safety may come across as too strict or overbearing, but making permanent changes to the way your business is run will offer your customers the safest produce and ultimately get your revenues booming. Investing the time into writing a carefully thought out plan will ensure that you can offer the freshest and safest produce for many years. Your business will likely increase because restaurants and other food suppliers are now only going to want to work with suppliers who take the time to meet the new FDA regulations in order to maintain a desirable image. A detailed and well-executed food safety plan will give you the opportunity to offer the best and safest products in your market.

ROB LAROSE is the President and CEO of BioSafe Systems based in East Hartford, Connecticut.

Increasing the Availability of Local Produce

One grower shows that four-season farming is possible—even during those New England winters.

by **ANNE-MARIE HARDIE**

All photos courtesy of **BARBARA DAMROSCH**

Salads of cold-hardy colorful baby leaves are a wintertime staple at Eliot Coleman's farm in Maine.

As the drive to eat local continues to grow, farmers in cooler climates are beginning to look at how they can meet this growing demand and offer fresh produce in every season. At a glance, growing fresh produce in the winter season seems like a daunting task. However, pioneers like Eliot Coleman have shown that four-season farming (and winter farming, in particular) is possible year round without investing in a heating and lighting system.

Eliot started farming in New England back in 1968. His business was thriving in the traditional season, but each fall the produce in the region would come from warm-weather states, like California. Eliot wondered if there was a way to decrease the amount of produce that was imported to Maine. His initial thought was to extend the growing season, but he learned that in order to change the infrastructure of food produce, more had to be done.

"A friend explained to me that unless we manage to deal with the whole year, the infrastructure to ship food from California to here for just one or two months still had to be in place," said Eliot. "So we said, 'Okay we're going to do it for the whole year.' And it worked."

To make a four-season farm financially feasible, both the crops themselves and the planting dates need to be diligently planned. Paying careful attention to both the climate and temperature is essential for successful four-season crop growth. Over the years Eliot has learned how to precisely determine these factors.

"If you do it right, you can grow most crops including spinach, scallions, carrots, Swiss chard, kale, all the Asian greens, baby leaf salads, arugula and lettuce," said Eliot.

Eliot discovered that unlike traditional lettuce, which turns to mush after freezing, baby leaf salads can freeze and thaw night after night without any damage. Not only are some crops more durable than Eliot originally thought, but he discovered that for those that require a warmer climate, there are cost-efficient ways to heat them.

Passive heating systems

One of the biggest misconceptions, shared John Piotti of Maine Farmland Trust—an organization that supports farmers and protects farmland in the state—is that people assume that four-season farming is extremely fuel intensive. The main misconception is that either natural gas or oil has to be used as an alternate heat source to keep the crops at their desired temperature level. However, successful winter gardeners have learned that this isn't the case.

"Eliot Coleman has shown that, simply by wise selection of crop, judicious use of a good composted manure [which gives off heat] and using a couple layers of plastic, you can keep produce in the ground 12 months out of the year," said John.

Eliot's research with computerized thermometers revealed that each layer of covering moved the area approximately one and a half USDA zones south.

Spinach in a cold house before being covered for winter.

Spring in the cool house.

Under the covers, it looks like a perpetual spring even in wintertime.

"When I walk to the greenhouse, I'm in Maine. When I get inside there, I'm in New Jersey. And when I reach my hand under that inner layer, my hand is in Georgia," said Eliot. "And so anything that would survive out of doors in the winter in Georgia will survive very nicely under that double layer in Maine."

Greenhouses not only provide insulation, but are a natural barrier for wind. Plants that may be able to survive cooler temperatures are often devastated by the strong winter winds. Greenhouse structures ensure that the plants are protected from all of the elements, providing a bountiful harvest.

When considering which crops to farm, the factor to consider isn't the heat (which can be easily adjusted), but sunlight.

"Sunlight is the determinant—more than temperature—because temperature you can control," said John. "You can add heat with good compost and layers, but you can't add light unless you use the sun lamps."

John believes that lack of sunlight is the one factor that could limit some areas from farming all year round. He cautions that when farmers are considering extending their season, they must look at the amount of sunlight available and select crops accordingly.

Years later, Eliot continues to look at ways of advancing winter farming and further extending the season. At his own farm, he begins most of the winter crops outdoors in the fall, while the greenhouse continues to house the warmer climate crops like tomatoes, peppers, eggplants and cucumbers. Once everything freezes, the winter crops are put into the greenhouse.

"When you put all that money into a greenhouse, if you can get more than 12 months of use out of it every year, you're getting a great return on your capital investment," said Eliot.

The business of four-season farming

Although winter farming is definitely doable in cooler climates, it may not always make the best business sense.

"Farmers can't think of production decisions outside of business decisions. Or at least they shouldn't," said John. "So, as they're analyzing what they can grow, they really need to be analyzing their market."

Eliot determines whether a crop is worth investing in by gauging what profit each square foot will bring in. His current formula, which he admits should probably be increased, is that a crop has to bring in a minimum of $1.50 a square foot for every two months it's in the greenhouse in order to be profitable.

John's advice is to start off small, extending the growing season bit by bit and learning how the climate impacts the crop development. This can be done relatively simply by involving some basic technology (like covers) and making a careful selection of the type of crop grown. Although expensive technology, like heat and lighting systems, could grow winter crops, it will substantially decrease a farmer's ability to remain profitable.

"The minute you put heat in, boy, that's a slippery slope because crops I can grow if I keep it above 35F in the winter would be even better if I kept it above 45F and even better if I kept it above 55F," said Eliot. "And the next thing I know, I'm Maine's largest mango grower and I'm in Chapter 11. Those are the things you have to try and avoid."

Know your market

In order to be successful, farmers must look at four-season farming as part of their business plan and discover where the market opportunities are. Traditionally, this market has been limited to CSAs and direct sales through farmer's markets, but John would like to see this extended into other areas.

In order to expand the potential market for winter farmers, John—in conjunction with Eliot's daughter Clara Coleman—are looking at the feasibility of different food hubs around the state of Maine. As part of the process, they've created their own food hub involving six farms, including one that is a non-profit food bank farm.

Each of the six farms will feed directly into the food hub, shares John, elevating both the knowledge base of the farmers (as they get to share best practices), while creating a marketing opportunity. The value of the food hub is that these farmers can now begin to target some of the wholesale markets, instead of the traditional format of direct sales.

"Small farms have stayed alive, and in many cases grown and prospered, by selling direct," said John. "The simple truth is that the vast majority of consumers are not going to get their food by going to a farmer's market or being part of a CSA. They want to go to a store. A lot of us feel that the challenge of the next 20 years is figuring out how to elevate local, keeping the best features of local—which are not only quality and freshness—but ensuring that most of the benefits flow back to the farmer, rather than flow back to the middle men."

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

Fight Aphids With Aphids

Using banker plants for greenhouse vegetable crops can be a key tool to fighting your aphid issues.

by **STEVEN FRANK**

Aphids are common pests of greenhouse crops. Peppers, tomatoes, cucumbers, lettuce, herbs—they all get aphids. And aphids are one of those pests that can damage plants in several ways.

First, of course, they damage plants by feeding. Aphids are phloem feeders, which means they drink the sugary fluid that's produced by photosynthesis in the leaves. By drinking phloem, aphids are tapping the energy plants need to grow. Phloem provides energy (sugar) for plants, but not much nutrition or protein for aphids. Its like if you tried to raise your kids on soda. To compensate for poor nutrition aphids have to drink a lot of phloem. With specialized guts, they quickly sieve out the proteins and excrete a sugary fluid called honeydew. Honeydew coats leaves and fruit, making them shiny and sticky.

If that weren't enough, a fungus called sooty mold grows on honeydew causing leaves and fruit to turn black. Not exactly the "perfect tomato" customers have in mind. As aphids are probing for phloem with their syringe-like mouthparts, they damage cells in leaves and meristems, causing leaves to be distorted and stunted. Probing can also transmit viruses, such as cucumber mosaic virus. With all the potential for damage, these little bugs can be a big deal. But you already know that.

There are many aphid species, but green peach aphids *(Myzus persicae)* and melon aphids *(Aphis gossypii)* are the most common. More growers are turning to biological control to manage these pests and there are quite a few biological control agents available to help. Biological control works best when natural enemies are present in your greenhouse all the time. This means purchasing and releasing natural enemies even if your scouting (you *are* scouting aren't you?) doesn't turn up any pests. Releasing natural enemies—"whether you need them or not"—is good practice because even your best scouting will not find every aphid or other pest in the greenhouse. In addition, pests can arrive at anytime. Aphids develop from birth to adult in a couple days and produce several babies each day. So a couple of stray aphids will quickly disrupt your IPM program.

Photo: S.D. Frank, NCSU

Banker plants provide hosts for aphid parasitoids in a greenhouse.

Bank on Banker Plants

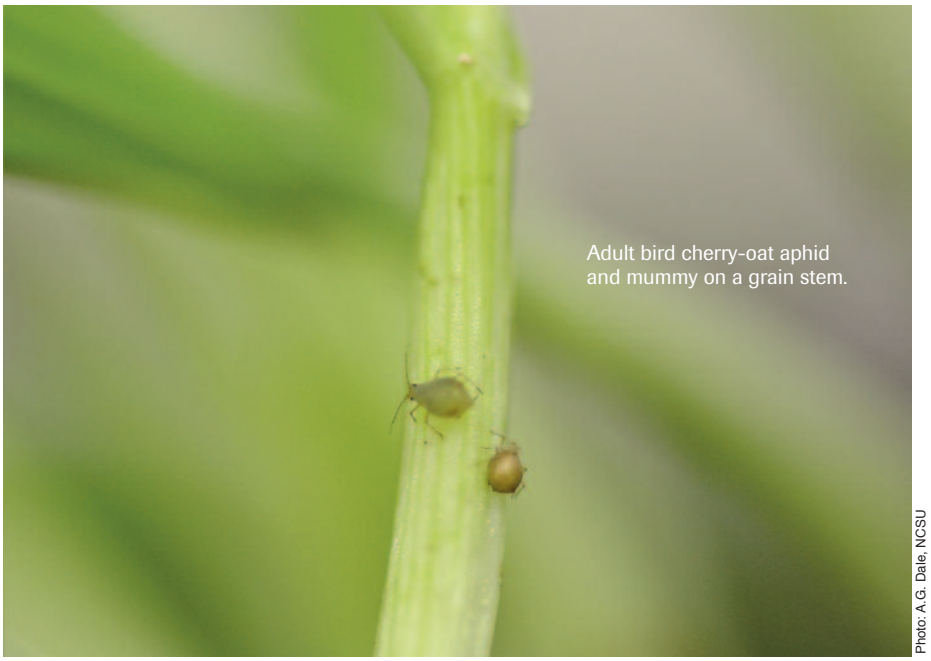
Unfortunately, most natural enemies like the aphid parasitoid *Aphidius colemani* don't survive or reproduce well in greenhouses without pests. *Aphidius colemani* are the primary natural enemies used for biological control of aphids. They're tiny (less than 1/8 in.) wasps that lay eggs inside aphids. The wasp larvae develop within aphids feeding on the aphid innards. After several days, the aphid becomes bloated, hardened and bronze or brown—the color of paper bags. This is called an aphid mummy. After a few more days the adult parasitoid chews a hole in the mummy and emerges to parasitize more aphids. So without aphids, *A. colemani* can't reproduce.

But do you know what does reproduce well in greenhouses? Aphids. What if there was a way to pit one aphid against another? What if there were "good" aphids that could help manage the bad ones? In a sense, this is how banker plants work. Banker plants, in a general sense, are plants that provide resources such as food or hosts to sustain natural enemies within the greenhouse.

For the aphid banker plant system this means grain plants infested with bird cherry-oat aphids, *Rhopalosiphum padi.* Bird cherry-oat aphids are the good aphids (for us, not for grain farmers). They help us control pests because *Aphidius colemani* parasitizes pests like green peach aphid and parasitizes bird cherry-oat aphids. Thus, if you're lucky enough not to have pest aphids in your greenhouse, *A. colemani* can reproduce and build up a population on bird cherry-oat aphids instead. Then when aphids come in on transplants, worker clothing or a gentle breeze you have an army of parasitoids ready to attack them.

I know what you're thinking: "So, you want me to bring aphids into my greenhouse?" or "No aphids are good aphids" or maybe just "Dr. Frank, you're crazy!" This last thought may be true, but so is the first one. I *do* want you to bring bird cherry-oat aphids into your greenhouse. It's alright because bird cherry-oat aphids only feed on grasses and grains, so they don't spread to greenhouse vegetable plants. So with a handful of grain seeds and a few bird cherry-oat aphids you could start producing your own parasitoid army. Are you ready to get started?

Right now, the entrepreneur in you is saying, "Free parasitoids! Yippee! I never have to send money to that biological control supplier again!" I appreciate your



Adult bird cherry-oat aphid and mummy on a grain stem.

Photo: A.G. Dale, NCSU

Aphidius colemani parasitoid bending its abdomen forward to insert an egg into an aphid.

Photo: A.G. Dale, NCSU

enthusiasm but there are some logistics (read: costs) involved that will affect the extent to which you implement banker plants and whether you produce your own or purchase them from a supplier.

Let's start with the grain plants. Many different grain species have been used as banker plants to support bird cherry-oat aphids and parasitoids. Research in our lab has shown that rye and barley are both good choices that grow well, support aphid population growth, and most importantly, produce lots of large, female parasitoids. Large parasitoids are generally better because they produce more eggs, probably fly farther and can handle larger aphids. Of course, female parasitoids—since they lay eggs—are the only ones that parasitize aphids. Other grain species we've tested, like oats, were worse in that they produced fewer parasitoids, smaller parasitoids or more male than female parasitoids.

You can plant grain seeds in a pot with your standard potting mix and they'll grow fine. This is the easy part. Now you need some aphids. Some biological control companies sell banker plants with bird cherry-oat aphids, so you could use this as a starter colony. Depending on where you live you may be able to collect some, too. Bird cherry-oat aphids are common in wheat fields and in fields with grain cover crops. Here in North Carolina, corn and soybean fields are often planted in winter wheat or other grain as a cover crop in fall. In spring, you can find bird cherry-oat aphids feeding there.

Once you have grain plants and bird cherry-oat aphids, of course you need parasitoids. If you're already releasing *A. colemani* in your greenhouse, you can probably just set your banker plants out and the parasitoids will find them. In a week or so you should see brown mummies mixed in with healthy aphids on the banker plants. Other folks put banker plants into a cage with parasitoids to be sure they have lots of mummies before placing them in the greenhouse.

Once you have all the components, growers can customize and optimize the process for their operation and biological control needs. And this is where it turns out that parasitoids from banker plants aren't exactly "free." After several weeks, grains can get tall and floppy and can be replaced with new ones. Some growers produce grain plants in a separate space so they always have clean grains, grains infested with aphids, and grains with aphids and mummies. Other growers sow the grain seeds out in the greenhouse and let nature take its course. Banker plants can be placed on greenhouse benches, on the floor or in hanging baskets; wherever you can spare some space. Just remember to water them.

So you can fight aphids with aphids. Bird cherry-oat aphids on banker plants can help sustain the parasitoids you purchase and potentially produce all the parasitoids you need.

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Blossom End Rot: Understanding a Perennial Problem

Blossom end rot is a perennial problem on tomatoes, peppers and other crops. Understanding the causes can help reduce symptoms, but it's rare to be able to eliminate it completely.

by **RON GOLDY**

Blossom end rot is an annual problem for many fruit and vegetable growers. Vegetables especially susceptible to blossom end rot are tomatoes—Roma-types in particular—peppers, eggplant, watermelon and summer squash. Very simply, blossom end rot is caused by a lack of adequate calcium (Ca) in the fruit with the Ca concentration being lower at the blossom end compared to the stem end.

Tomato fruits with blossom end rot.

Blossom end rot is more prevalent on early fruit than it is on later fruit and varieties can vary in their susceptibility. Calcium is an important nutrient needed by plants for cell wall development and other processes. Calcium is non-mobile in the plant, meaning that once it's in place in the plant, it cannot be moved to another area within the plant. Therefore, plants need a continual Ca supply for good growth. On tomatoes, blossom end rot is often in combination with a black, sooty-appearing fungus that's a secondary problem. The solution to minimizing blossom end rot lies in understanding the reasons plants might have difficulty in maintaining adequate Ca.

The first reason plants lack Ca is that there may not be enough Ca in the soil. Inadequate Ca can be quickly determined by a soil test. Michigan State University Extension indicates soil tests can be done in the fall and, if corrective measures are needed, fall is a great time to add Ca as lime. Another plus is soil-testing labs are often not as busy in the fall, so results may be returned sooner. Low Ca can be accompanied by low magnesium, in which dolomitic lime can be applied. Adding standard or dolomitic lime will increase soil pH. Some situations may require additional Ca, but not increased pH, in which gypsum will be recommended. Gypsum is calcium sulfate and won't change pH. Most Michigan soils, whether they're sand or clay-based, generally have adequate Ca, but lime may need to be added to adjust pH.

Another reason plants may be unable to maintain a steady Ca supply is inconsistent water. Alternating wet and dry periods decrease Ca uptake and greatly contribute to blossom end rot development. Timely irrigation maintains consistent soil moisture, insuring an uninterrupted flow of Ca into the plant, which can happen even though there are adequate Ca levels in the soil.

Strangely enough, another factor contributing to blossom end rot is excellent growing conditions. A period of bright sunshine and warm temperatures often experienced in July can be a main contributor. So even with adequate soil Ca and soil moisture, weather conditions can work against you. I've seen this especially in peppers. Excellent growing conditions apparently cause plants to grow so rapidly that roots are unable to take up enough Ca to meet demand and the blossom end of the fruit is the first to suffer.

I often get calls about foliar Ca applications and I always tell the caller that plants best get Ca through their roots and foliar applications are only a short-term fix. As stated earlier, Ca is not very mobile in the plant, so application to older leaves has little benefit. If foliar applications are done, it's important to apply them to young, expanding leaves. Products of choice are calcium chloride or calcium nitrate at 1 to 2 lbs. of Ca in 30 gal. of water. Read more information on secondary and micronutrient applications at www.msu.edu/~warncke/E0486.pdf.

It's not possible to completely eliminate blossom end rot since some causal agents are beyond your control, but it can be greatly reduced by making sure soil Ca levels are adequate, proper irrigation practices are followed, good variety selection and foliar Ca are timely and properly applied.

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New Products September 2014

American Hydroponics Inc.

The Autogrow Multi-Controller is a powerful tool for the small to medium hydroponic farm. The Multi-Controller can monitor the following data points up to eight different zones including: temperature, humidity, light, C02, and most importantly, fertigation. American Hydroponics is the only distributor of this product in America. **Reader Service Number 225**

Atlas Manufacturing Inc.

At Atlas Manufacturing, Inc., their main goal is to provide ideal solutions for your specific growing needs. Whether you're growing vegetables or ornamentals, the Super Arch Gutter Connect series package provides an optimal growing environment for high-yield crop production at an affordable price. For more information on Atlas Manufacturing's products and services, visit www.atlasgreenhouse.com. **Reader Service Number 226**

P.L. Light Systems

You asked and P.L. Light Systems answered with the new 277V NXT2. This revolutionary fixture can now be used in 277V applications without having to install expensive transformers. The 277V HSE NXT2 boasts a high-efficiency electronic driver and built-in cooling ribs to keep the fixture from overheating and, as a result, maintains the longevity of all the components. Contact P.L. Light Systems to learn more about this new product offering and how your business could benefit from this innovative new fixture. **Reader Service Number 227**

OASIS Grower Solutions

OASIS Grower Solutions has partnered with JR Peters, Inc. to bring OASIS Hydroponic Fertilizer, a complete one-bag solution, to hydroponic growers. This water soluble 16-4-17 formula combines chelated iron components, increasing nutrient uptake for lettuce, herbs and most vegetables. By combining OASIS Hydroponic Fertilizer and Horticubes XL, growers experience nearly 200% increase in top growth while still building healthy roots. (Turn to page 32 to learn more.)
Reader Service Number 228

CropKing Inc.

Microgreens, popular in upscale restaurants, have intense flavor and nutrition. CropKing's Hydroponic MicroGreen Growing System features 16 12-ft. food-grade PVC growing channels, a support rack made of 1-in. square galvanized steel, plumbing to feed and drain channels, a submersible pump and burlap strips for direct planting in the channels. The channels are 10 in. wide to accommodate a 10/20 seed tray. Made in the USA. **Reader Service Number 229**

PanAmerican Seed

PanAmerican Seed introduces a novel, high-quality group of vegetables and herbs especially for those who supply fresh market farmers or hobby gardeners. What sets the new Handpicked vegetable varieties apart are their fresh, homegrown flavor; exceptional fruit quality; earlier and longer harvests; and loads of produce to sell. The collection includes award-winning eggplant Patio Baby, an array of sweet and hot peppers, fast and flavorful SimplySalad mixes, new Heirloom Marriage tomatoes and more. Download the Handpicked Vegetable brochure at www.panamseed.com. **Reader Service Number 230**

Growing Lettuce? A Beginner's Guide to a Strong Start

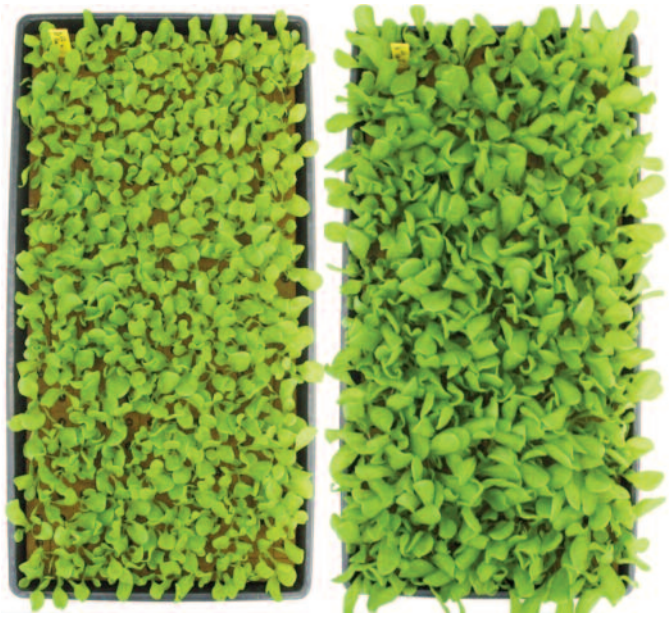
The key for successful hydroponic production is starting with strong young plants.

by **DR. VIJAY RAPAKA** *&* **DR. CARI PETERS**

Hydroponic lettuce is typically a six-week crop—two weeks for young plant production and four weeks from transplant to finishing. The end product is a delicious, healthy and marketable 5 to 6-oz. head of lettuce.

More than any other crop, making the right choices at the earliest developmental stage can set you up for much success later in the growing process. Your decisions aren't limited to choosing the right propagation media and nutrient blend for your system. Providing optimal environmental conditions, along with proper irrigation practices and fertilizer timing, is also crucial for successful production of strong young plants.

The young plant production consists of germination and seedling production stage. Germination happens during the first 24 to 48 hours. By the end of 48 hours the radicle (the first growing part of the seed to grow) will be penetrating into the propagation media and cotyledons will be emerging. Those seedlings will be ready to transplant in the next 12 days when they have two to three true leaves and roots emerging from the bottom of the propagation media.



Effect of fertilizer timing on Butterhead Skyphos seedling growth. Photos taken 14 days after seeding. On the left, Oasis Horticubes XL fertilized with Oasis Hydroponic Fertilizer 125 ppm N after seed germination (3 days after seeding), and on the right fertilized with initial watering. After Day 3, both treatments were fertilizer similarly. Note: With young plant production, make sure to use high-quality water-soluble fertilizers with low salt index. Using fertilizers with high salt index can cause phytotoxicity.

Media

The role of media in hydroponic lettuce production is very limited, but plays a crucial role. Media is used to start the seeds and grow the young plants. The media is also used as a stabilizing material after transplant into the production system. For optimal results, the propagation media should hold air for the roots to conduct respiration. The media should hold enough water and nutrients so the seedlings don't dry out between irrigation cycles. The physical properties of the media should be consistent and free of any pathogens to produce uniform, strong and healthy young plants. Choosing a media with these properties will promote rapid seedling growth and be easy to handle during seedling production and transplant.

The propagation media can be broadly categorized into stabilized and loose-filled media. Some of the examples of loose-filled media include variations of a typical soilless mix (peat, perlite, vermiculite, etc.). Loose-filled media isn't widely used because of the handling issues at transplant. In a word, it's messy! Peat-based media in a hydroponic system will have levels of degrading peat that competes for oxygen and can act as a breeding ground for pathogens. Some of the commonly used stabilized media include Grodan Rockwool and Oasis Horticubes and XL foam growing media. What's the difference? Oasis foam is a thermoset phenolic cellular material and Rockwool is a spun-bound fibrous material mined from basalt rock. Both are synthetic, inert and sterile and available in different configurations. Because of the process in which the foam is made, Oasis cubes are particularly consistent with regular dibble hole intervals, which make seeding more uniform and even. Rockwool is nontoxic, but can irritate the skin because tiny fiberglass spikes can penetrate the skin during initial handling. Also, the dibble holes aren't uniform, so the seeding can be time-consuming.

Nutrients

A water test is the foundation for grasping the key components of your water and will help you make the right choice of nutrients for your hydroponic system. Your results will help you balance these numbers with the essential nutrient inputs and keep them available in solution. Your water alkalinity and pH are related, but not the same. City and well water can have higher water alkalinity causing a rise in pH and require a need for acidification; rain or RO water can have lower alkalinity levels that can cause great swings in pH. The key is to keep your solutions in the pH range of 5.5 to 6.2. This allows for the most optimum nutrient availability to the plants. Remember, if it's not available or soluble, it's almost invisible to the plant and cannot be taken up.

There are many options in providing mineral nutrients and they're broken into three categories: Mix your own; two-part systems; and one-bag blends. With any nutrient option, it's crucial to choose raw materials that contain minimal impurities and are extremely water-soluble. The first two categories require more than one tank and/or a stepwise recipe for mixing nutrients. The benefits of a mix-your-own program (i.e., CropKing) is that it allows flexibility to bend to crop needs, but often for a smaller grower, the cost of buying materials in bulk and costly mixing mistakes/labor can be too much.

The next options are blended and guaranteed by the manufacturer—a two-part system (Tank A: 5-12-26, Tank B: Cal Nitrate) allows you some flexibility by ensuring at least two parts are in balance, as long as the suggested mixing ratios are followed.

The One Bag blend (*Oasis Hydroponic Fertilizer* 16-4-17) is designed to provide a balanced nutrient blend while using the most advanced chelating agents, keeping Fe available up to a pH of 9. Not only is it water soluble and non-adjusting, but it carries a low salt index, which virtually eliminates any concern about phytotoxicity. When mixing, the one-bag solution reduces confusion, as there's no specific "recipe" that workers are required to follow. This significantly reduces the chance of costly errors, especially when employing temporary help.

Growing conditions

Environmental: After initially watering the propagation media, it's not required to water the seeds during the first 48 hours. The lettuce seed can be germinated both under light and in darkness. However, for uniform germination and initial start, keep the propagating trays in darkness under high humidity at temperatures between 65F and 68F (18C and 20C). Right after 48 hours, the seedling needs to be moved to full light. Any delay in light interception can cause stretching of seedlings.

For seedling production, maintain the greenhouse day temperatures between 65F and 75F (18C to 21C) and night temps between 55F and 60F (12C to 15C). The relative humidity should be between 60% and 70%. Lettuce seedlings are very receptive to Daily Light Integrals (DLI) and light intensity. Lettuce seedling can handle DLI more than 20 mol/day. The light intensity can be maintained between 500 to 600 µmol/m^2/s and consider shading when levels get higher than 600 µmol/m^2/s. Excessive shading can slow down the growth and cause stretching of the seedlings. Consider supplemental light during winter months and overcast days.

Irrigation practices and methods

After 48 hours (i.e., on Day 3), mist the seedlings twice with a misting nozzle, and on Day 4 onwards, water the seedlings as required once a day or every alternated day. It has to be noted that hydroponic production doesn't start until the young plants are transplanted into the production system. Watering the seedlings several times a day or continuously during propagation can super saturate the media and minimize aeration, which will result in poor root development and weak seedling growth. Alternatively, never let the media dry out excessively, which can stress the seedlings and can cause damping off.

During seedling production, watering can be carried out by overhead irrigation using a hose and a breaker or misting system. Overhead irrigation promotes superior growth, as this method allows incorporation of higher amount of oxygen into the media. Watering can also be carried out by sub-irrigation, however, media will hold more water and aeration can be compromised. To counteract this phenomenon, reduce the frequency of irrigation and choose the media with bottom grooving so the media can drain excess water effectively.

Fertilizer Timing

Typically, it's advised to apply nutrients after seed germination (2 to 3 days after seeding) because the food reserves in the seed fuel the germination and the nutrient uptake starts only after the root emerges. However, our research indicated that it's extremely important to apply the nutrients with the first watering. It has to be noted that synthetic hydro- >>>

Figure 1: Effect of fertilizer timing on seedling growth. Lettuce harvested 14 days after seeding.

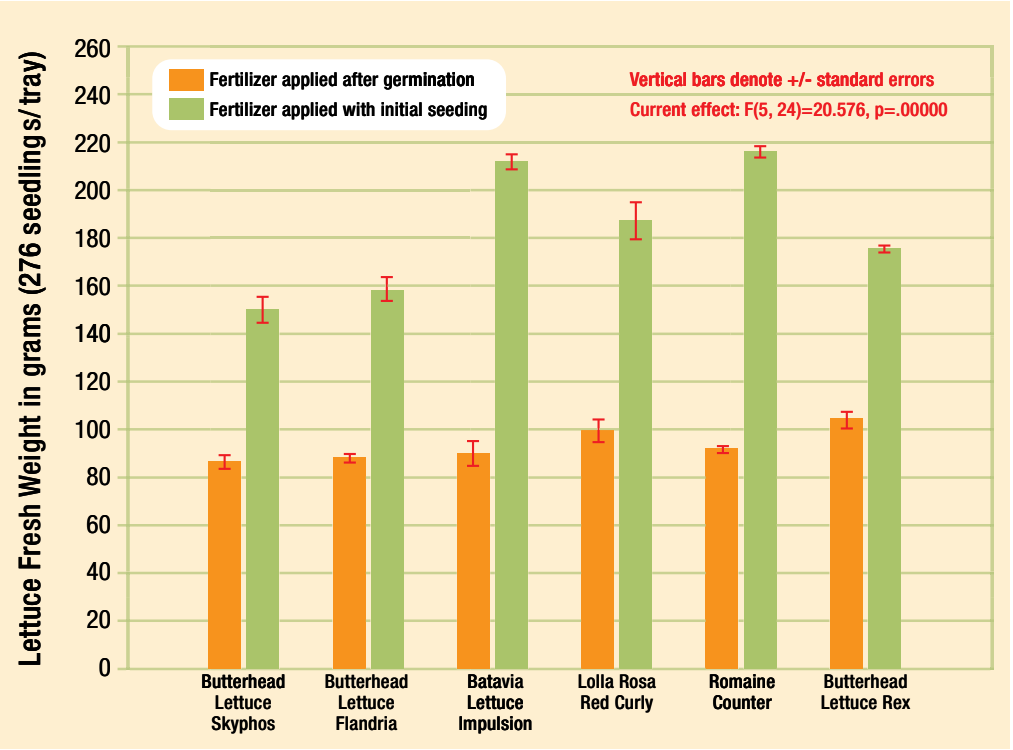
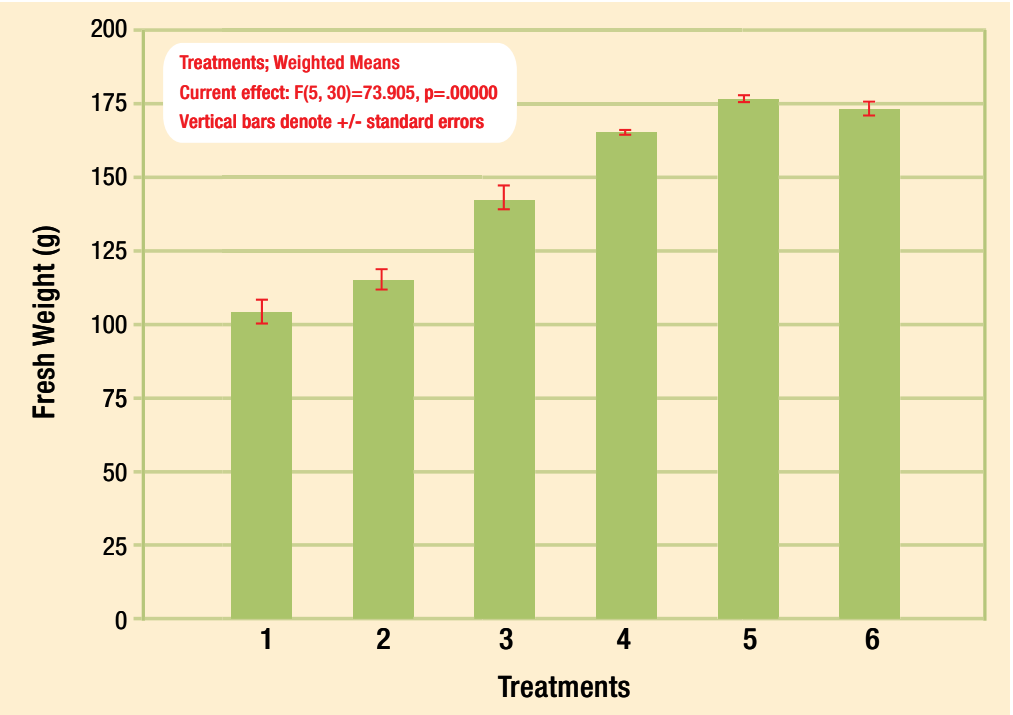


Figure 2: Effect of fertilizer concentration on seedling growth. Butterhead Rex lettuce harvested 14 days after seeding.



Treatment details: Treatment 1 was started with tap water and after germination the seedlings were watered with 150 ppm N during the course of seedling production. Treatment 2 started with 50 ppm N, treatment 3 started with 75 ppm N, treatment 4 started with 100 ppm N, treatment 5 started with 125 ppm N and treatment 6 started with 150 ppm N right from seeding and continued with their respective fertilizer concentrations.

ponic media is inert and free of any nutrients, which is designed to offer the grower maximum flexibility when providing nutrients to the plants. By virtue of this, when the media is saturated with clear water at seeding and followed with nutrient application after seed germination, the nutrients are not readily available at the applied concentration in the root zone for the roots to uptake. As a result, seedling growth is getting delayed when nutrients aren't being applied with initial watering.

Figure 1 shows a study with Oasis Horticubes XL media where Oasis Hydroponic Fertilizer was applied at 125 ppm N after germination (3 days after seeding) or with initial saturation of the propagation media. When the fertilizer was applied with initial watering, the seedling growth was doubled in almost all the lettuce cultivars that were tested. Note: In the case of foam where fertilizer was applied after germination, those propagation trays were started with clear water. From Day 3 onwards, both treatments were treated similarly and watered with 125 ppm N.

Fertilizer concentration

Typically the fertilizer concentration used for young plant production is 75 ppm N, which is half the strength that is used in the production area. However, our recent findings are that lettuce seedling growth can be significantly enhanced with much higher concentrations than 75 ppm N. Figure 2 shows the study conducted with Oasis Horticubes XL medium fertilized with Oasis Hydroponic fertilizer. The study demonstrates that the lettuce seedling growth increased with increase in fertilizer concentration until 125 ppm N and after that no improvement was observed.

Phytotoxicity observed when fertilizer with high salt index was used.

Target Feed Rates (in ppm N) as per crop type and stage

Type	Propagation	Production
Buttercrunch/Boston Bibb	125	150
Romaine, Red and Green Leaf	125	150
Basil	125	175
Culinary Herbs	125	150
Cole Crops	125	175
Garlic and Scallions	125	150
Tomatoes	125	200
Peppers	125	150
Cucumber	125	175
Heavy Feeder Cabbage, Kale, Spinach, Swiss Chard, Mustard Greens, Mizuna, Escarole	125	175-200
Light Feeder Lettuce Arugula, Watercress, Spring Mix	125	125-150

As the plant increases in size, the demand for more nutrient uptake increases. The chart above depicts suggested fertilizer concentration per stage and plant type.

Strong start = Profitable finish

Growing a high value lettuce crop takes time and experience in order to fine-tune all the areas that are covered in this quick summary article. Remember, there are useful free services out there that can help you improve each section of your seedling production. Use technical help, from your laboratory to your media provider or fertilizer manufacturer. Keep detailed records and be flexible—what works for the guy down the street may not work for you. But at least keep talking with your peers; it will help the entire industry improve.

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