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URBAN AG PRODUCTS

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Urban Ag Products is an ***information resource*** dedicated to helping the **vertical farming, controlled environment, and urban agriculture industries** ***grow*** and ***change*** through education, collaboration and innovation.

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Urban Ag Products is an ***educator*** providing content through a variety of different media. Through its educational efforts, including its online quarterly magazine and blog, Urban Ag Products seeks to provide its users with a basic understanding of the industry and to **keep them informed** of the ***latest technologies***.

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From the creators of The Clean Bin Project

JUST EAT IT.

A food waste story

In The Clean Bin Project, Jen Rustemeyer and Grant Baldwin attempted to produce zero waste in an examination of our throw-away society. As a followup, they turn their eye to food waste from farm to fridge. They vow to stop buying groceries and for six months to survive exclusively on discarded food. The myths behind corporate food production and marketing make for easy pickings as the directors dismantle best-before dates and show how our idea of "perfect produce" encourages us to discard perfectly edible and nutritious food—collateral damage in an age of food security headlines. Living off rescued goods their stockpile of found food demonstrates how the supply and demand chain is out of sync. It becomes immediately apparent this is a widespread problem with simple solutions. Unlike many environmental films that portray apocalyptic outcomes or make viewers feel helpless, Rustemeyer's and Baldwin's personal investment makes major sustainability issues comprehensible, solvable and delicious.

Alexander Rogalski

Horticulture industry optimistic about potential of LEDs

By David Kuack

Scientists and growers are excited about the potential of LEDs for plant growth. Researchers advise growers that not all LEDs are created equal and that they should do their homework before investing in this new technology.

Photo by Joshua Craver, Purdue University

Light emitting diodes (LEDs) are gaining the attention of horticulture researchers and commercial growers.

"There is always an interest in lighting regardless of how new or old the technology is," said Michigan State University horticulture professor Erik Runkle. "Combining lighting with an emerging technology like LEDs, which are continuing to evolve, there is a natural attraction and an element of curiosity. Many LEDs emit a pinkish-purplish spectrum that makes them intriguing to people. People also want to be on the cutting edge, so they may be considering LEDs before they know all of the advantages and challenges with using them."

Purdue University associate horticulture professor Roberto Lopez said growers are very excited about LEDs and he receives a lot of questions about them and their applications.

"It's a new technology and the growers see their potential," Lopez said. "Growers who are using incandescent bulbs for photoperiodic lighting have to look at alternative light sources since incandescent bulbs are being phased out of production. Some growers are looking at compact fluorescents as replacements and others are looking at using LEDs."

Utah State University professor Bruce Bugbee said much of the interest in LEDs comes from the promotion they are receiving.

"Venture capital is funding many of the lighting companies," Bugbee said. "There is considerable interest in LEDs because of the promotion and advertising on the part of the LED manufacturers. People naturally get excited about new technology."

Funding LED research

While LED manufacturers may be spending money to promote their products to the horticulture industry, few are providing researchers with the funding to study the lights.

"Each lighting company is looking at research from its own business perspective," Runkle said. "There isn't a whole lot of cash coming from these companies, but often times they're helping to subsidize the cost of the LEDs."

Runkle said the funding for LED research is coming from a variety of sources.

"Some of the lighting companies have a lot of good

Purdue University graduate research and teaching assistant Joshua Genovac (left) and graduate student Joshua Craver are studying the effects of LEDs on microgreens.

Photo courtesy of Roberto Lopez, Purdue University.

Photo courtesy of Roberto Lopez, Purdue University.

Purdue University associate horticulture professor Roberto Lopez said growers are very excited about LEDs and he receives a lot of questions about them and their applications.

data, but they also want to see some independent testing," Runkle said. "Some growers are supporting the research because they realize the importance of generating unbiased, research-based data."

Lopez said he has received funding from companies including Philips Lighting and Hort Americas, a horticultural distributor.

"I haven't received funding from other lighting companies," Lopez said. "Most of the companies are willing to donate the lights. But I explain to them that I have to pay the graduate students to do the research."

Runkle and Lopez are part of a team of university researchers who have received a $2.4 million grant from USDA to study LED lighting for greenhouse applications. An additional $2.5 million in matching funds was provided by the universities and private companies for the research.

"Funding is coming from the government including the Specialty Crop Research Initiative from USDA," Runkle said. "These are quite competitive proposals and a good team of scientists has to be put together in different areas of study. The researchers have to come up with a compelling case for why the research is needed and how it will benefit horticulture crop producers.

"In the case of the Specialty Crop Research Initiative proposals, there was a required matching component. For every dollar the researchers received from the government, they had to match it with a dollar from academia or private industry. This matching component could be either through direct cash or through in-kind contributions such as providing lights, plant material or industry time. This coming year, matching funds will not be required."

Bugbee said the money he has received for LED research came from NASA, but the funding from this federal agency has been limited in recent years.

Michigan State University horticulture professor Erik Runkle has been looking at LEDs for photoperiod control to replace incandescent or compact fluorescent lamps.
Top left photo by Daedre Craig, Michigan State University. Top right photo by William Meng, Michigan State University.

Utah State University professor Bruce Bugbee is studying the effects of colors of light on plant shape. He said LEDs can provide unusual color ratios not capable with other lighting technologies. *Photo courtesy of Bruce Bugbee, Utah State University.*

Learning more about LEDs

Runkle said research projects are generally funded based on a variety of factors.

"There has to be some short to intermediate term impact in a positive way to the specialty crops industries," he said. "Looking at the potential advantages of LEDs, whether they are realized this year or in two to four years, I expect most people would agree that we should understand the technology as it develops rather than letting the technology develop and then kind of figuring things out later."

Runkle advises growers to be cautious about investing in LEDs until they have examined how LEDs compare to other lighting technologies.

"Until recently commercial lamps used in agriculture were developed for human application," he said. "They weren't developed for agriculture, they were developed for people. With the new LED technology there is the ability to develop LED arrays that emit light that are very effective on plants. Many LED fixtures emit deep red and deep blue light, which humans poorly perceive and so they appear relatively dim. But from a plant perspective, they are intense."

Lopez said growers need to be wary of some of the claims being made about the energy efficiency of LEDs.

"What I tend to see is the "supposed" claimed efficiencies of LEDs or claims that the LED intensities are equal to high pressure sodium, when in fact there not. It really depends on the manufacturer," Lopez said.

Bugbee and graduate student Jacob Nelson recently published the results of a study on the economic analysis of greenhouse lighting. Their study compared 22 lighting fixtures, including LEDs, two types of high pressure sodium (HPS), metal halide

and fluorescent fixtures. The best LEDs and high pressure sodium lamps were equally efficient, but the cost of the technologies varied widely.

"Per photon, LEDs are considerably more expensive than the new double-ended fixtures, but there are specific applications where LEDs are useful," Bugbee said. "LEDs are more focused than HPS fixtures and this is valuable in some applications. LEDs are like spotlights and they can be focused right on the plants.

"LEDs probably aren't the best choice for a large greenhouse full of plants. They need to come down in price by about a factor of 10 to be comparable in price with high pressure sodium lamps for uniformly lighting large areas."

Bugbee, who uses LEDs in his research greenhouses, said LEDs are cost effective in many commercial applications.

"We are studying the effect of colors of light on plant shape," he said. "We cannot get unusual color ratios with other lighting technologies."

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Utah State University professor Bruce Bugbee (left) and graduate student Jake Nelson recently published the results of a study on the economic analysis of greenhouse lighting.

Photo courtesy of Bruce Bugbee, Utah State University.


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FRESH WITH EDGE:

taking locally-grown to new heights

by David Kuack

Chris Lukenbill at Fresh With Edge is differentiating his hydroponically-grown greens and herbs by delivering them to his customers while still in their vertical production towers.

Photos courtesy of Fresh With Edge

As Chris Lukenbill and his wife Lisa became more educated about what they were eating and how their food was distributed they felt there were a lot of things that could be done better.

"There are a lot of things that are occurring in agriculture that need improvement is probably the best way to say it," Chris said. "We felt that this was an opportunity for us. Since we both come with a computer science background, we were interested in aquaponics and hydroponics, which have a technical side to them. By day I am a web developer, that's what I do for a full time job.

"Part of it was, if we don't do it, who else is going to do it? It was a little of an arrogant attitude that we needed to try to do something. It was one of those things of it being hard just to sit in the background waiting for things to happen. I'm more the type of person who has a "go out there and get it done" attitude.

LOOKING FOR THE RIGHT SYSTEM

Prior to starting Fresh With Edge in Rochester, Minn., in February 2013, Lukenbill and his wife spent a couple of years researching various production systems. While attending The Aquaponics Association conference in 2012 they learned about ZipGrow Towers from Bright Agrotech.

"We were intrigued with this aquaponic/hydroponic growing system," Chris said. "The original towers were designed for use in the Virgin Islands. The towers that we eventually began using were designed for use in northern climates.

"In our area there are a lot of people who are doing great things with local food markets. At the aquaponics conference one of the things people were talking about was how to differentiate aquaponically-grown or hydroponically-grown produce from everything else? There are a lot more inputs involved with them, but there are also a lot of advantages to them. It really comes down to the marketing aspect."

Lukenbill said the ZipGrow Towers offered him the opportunity to take growing produce directly to the point of sale when it is ready to harvest. He said even though this required more hands-on education of potential customers, it also offered him the opportunity to talk with them and answer their questions about the system and the plants they would be harvesting.

TOWER EXPANSION

Lukenbill started with 60 5-foot tall towers which hold about 600 individual plants. The addition of a new 30- by 84-foot greenhouse built at the end of last year has enabled Lukenbill to expand his production to around 200 towers. He is currently using about 60 feet of the greenhouse length with plans to expand production into the unused area.

Lukenbill said the fish used in the aquaponics system stay in the greenhouse. He initially started with tilapia, but is now using catfish.

"Last year we did aquaponics and we expect to do aquaponics next year," he said. "Because of the expansion this year, we only grew hydroponically. Next year we are going to incorporate the fish and plants together. We are learning all of the different facets of production with and without fish. By doing hydroponics this year we were able to remove some

FRESH WITH EDGE STARTED WITH 60 5-FOOT TALL TOWERS WHICH HOLD ABOUT 600 INDIVIDUAL PLANTS. THE ADDITION OF A 30- BY 84-FOOT GREENHOUSE BUILT AT THE END OF LAST YEAR HAS ENABLED THE COMPANY TO EXPAND ITS PRODUCTION TO AROUND 200 TOWERS.

of the variables so that it made the expansion easier."

Lukenbill is producing a variety of crops in the towers, including herbs and greens. Greens include lettuce, kale, chard, bok choy and arugula. Herbs include sweet basil, lemon basil, mint, parsley, chives, thyme and tarragon. Normally there are 10-15 plants on a tower.

"We usually have companion plantings on a tower where we would have a lettuce and a bok choy or a kale and a chard," he said. "Considerations for which plants are grown together include how they take up light compared to other plants and the speed at which the plants grow."

Depending on the species, Lukenbill said it usually takes a crop three to four weeks from sowing until seedlings are transplanted into the towers.

"We don't want the seedlings to be too large because then there can be issues with transplant shock," he said. "Time to grow on in the towers takes three to five weeks for most crops. Thyme and tarragon take a little longer at seven to eight weeks."

Lukenbill said he is using organic pest control products.

"We are using as safe as methods as we can," he said. "We are using certified organic products. Although we haven't gone through the process to become organically certified that might be something we decide to do in the future. Right now we are a small operation and we can have a personal connection with our customers. If for whatever reason we start to lose some of that personal connection then becoming organically certified might become a valuable asset for us."

REALLY "FRESH" PRODUCE

Once the plants are fully grown the towers are delivered to the customers.

"The towers are a fully contained hydroponic system," Lukenbill said. "There is a DC water pump to irrigate the plants and an aerator that run on the same timer. The drip irrigation system is similar to what is operating in the greenhouse with the water dripping down from the top. There are few locations where there is actually enough light so that the plants continue to grow on the towers."

Lukenbill said for most of his customers the towers are swapped out once a week. This year he has been focusing on promoting the system to local restaurants.

"We have a few restaurants that are doing farm to table," he said. "For restaurants we usually deliver three towers of herbs and can mix-and-match a combination of six different plants. The towers allow them to harvest throughout the week. If they don't use a whole tower of arugula, we can bring it back and regrow it and then take it back to them so they don't have to waste anything."

Lukenbill also works with a food co-op.

"At the co-op customers are supplied with clam shells that they fill. We supply four different varieties of herbs such as basil, parsley, mint and chives. A customer can come in, pick up a clam shell and fill it with whatever combination of herbs that they want and then they pay a standard price for it."

Lukenbill said he is looking to expand the market for the towers with local grocery stores.

"The biggest market going forward that we see is the individual in-home systems," he said. "We tested out a prototype this this summer. An individual system consists of a reservoir and a single tower that can fit in a home. The user will be able to swap out a full tower of produce at a time. They can buy a tower of produce, harvest that over a week to three week period and then when they're finished with that, swap it out for a new tower of produce."

Lukenbill said he is also looking at offering a 3-foot tall tower.

"The shorter tower would finish faster and would be easier to move around," he said. "We would grow the plants in a 5-foot tower and then transplant them to the 3-foot one."

THE ZIPGROW TOWERS THAT FRESH WITH EDGE DELIVERS TO ITS CUSTOMERS CONSIST OF A FULLY CONTAINED HYDROPONIC SYSTEM. EACH TOWER CONTAINS A DRIP IRRIGATION SYSTEM, A DC WATER PUMP AND AN AERATOR THAT RUN ON THE SAME TIMER. SOME LOCATIONS RECEIVE ENOUGH LIGHT SO THAT THE PLANTS CONTINUE TO GROW ON THE TOWERS.

ASSISTING OTHER GROWERS, THE LOCAL COMMUNITY

Another area that Lukenbill is looking to expand is to provide other growers with software to use with the towers.

"We have a lot of metrics that we have collected along with spread sheets," he said. "We receive a lot of requests from individuals about aquaponics-focused business plans. What they want to know is what are the numbers and how does this work out if they are doing this many towers, how many fish are needed and how much fish food is needed? There are a couple different ways that we are working on it. Right now we are focused on doing vertical hydroponic towers because that's what we know best. We are using information from Bright Agrotech and the company is using our information. As we collect more information we will be able to help other growers determine their weekly production with the towers."

Lukenbill is working with a local non-profit called Growing Home. "It's based on the concept of Growing Power in Milwaukee, Wis.," he said. "We are doing a very similar thing using urban agriculture as a vehicle for education, job training and employment.

"There is a great community here of local growers, but there are some disconnects with members of the community and how they can be a part of that. The Growing Home program can help individuals with job training and educational avenues."

For more: Fresh With Edge, chris@freshwitrhedge.com.

Editor's note: For more information on Growing Power in Milwaukee, Wis., see the article in Urban Ag Products Issue 1.

David Kuack is a freelance technical writer in Fort Worth, Texas; dkuack@gmail.com.

FRESH WITH EDGE HAS TESTED A PROTOTYPE TOWER (TOP PHOTO) THAT COULD BE USED AS AN IN-HOME SYSTEM. SIMILAR TO THE COMMERCIAL TOWERS (LOWER PHOTO), THE USER WOULD HARVEST THE PRODUCE OVER A ONE TO THREE WEEK PERIOD AND THEN SWAP IT OUT FOR A NEW TOWER.

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This is not an advertisement. The Urban Ag Team feels that others can learn from these corporate videos.

Maximize your plants' growth with supplemental CO2

By David Kuack

Whether you're growing ornamentals or vegetables in a controlled environment, if you're not providing supplemental carbon dioxide you could limit your crops from reaching their full potential.

Photos, graphs courtesy of Jonathan Frantz

If you are growing ornamental plants or vegetables in a controlled environment, including greenhouses, warehouses or growth chambers, carbon dioxide (CO_2) could be considered another nutrient like nitrogen. Plants require carbon dioxide in order for the process of photosynthesis to occur enabling the plants to grow, flower and in the case of vegetables produce fruit.

"Ninety-nine percent of the plants that are grown for food or ornamentals in controlled environments would benefit from supplemental carbon dioxide," said DuPont Pioneer research scientist Jonathan Frantz. "The outside ambient level of carbon dioxide is just over 400 parts per million. Once inside a greenhouse or other closed structure that contain plants, the plants start to draw down the carbon dioxide level. Depending on how much plant material is in the greenhouse and how tight the greenhouse is, the carbon dioxide level will be drawn down a lot. Warehouses and growth chambers are going to be tighter than greenhouses so the draw down is going to be faster in those types of structures."

Frantz said that some growers think a greenhouse has to be very tight with very few leaks to create a carbon dioxide deficit.

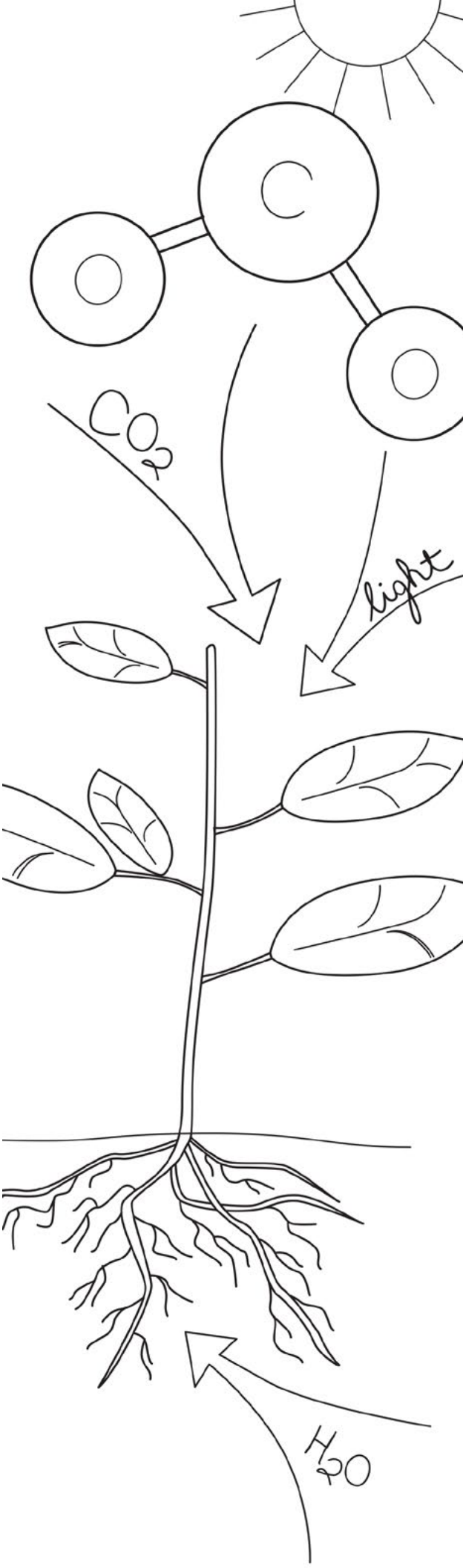
"It doesn't take much for a carbon dioxide deficiency to occur and the level to drop well below 400 ppm," he said. "How fast carbon dioxide will decrease depends on the light level and how many plants are in the greenhouse or growing structure. If there are plants in the greenhouse, then the carbon dioxide level is going to drop down quickly. In an hour the carbon dioxide level can drop 100 ppm."

Working with an ornamental plant grower, Frantz said the effect of a carbon dioxide deficiency was most noticeable in the greenhouse during the winter months.

"From December through February when this grower was starting to propagate his geraniums for the upcoming spring season, the plants just sat there," Frantz said. "The cuttings didn't put on a lot of new roots. Growth was just slow."

Frantz said if there is a carbon dioxide deficit in a vegetable greenhouse the plants would have low fruit yields and little growth.

"Growth is adding mass," he said. "Development rate is important in the timing of flowering. I'm interested in how carbon dioxide might accelerate that development rate."



How much CO_2 is too much?

Frantz said a plant's photosynthesis rate usually peaks at 1,000-1,200 ppm carbon dioxide.

"It really comes down to a matter of economics," he said. "If the carbon dioxide level is doubled above 400 ppm, there is probably going to be a doubling of photosynthesis. But as the level of carbon

dioxide gets higher, the photosynthesis response starts to flatten out. That's where economics start to come in. If the level of carbon dioxide is tripled to 1,200 ppm, the rate of photosynthesis is not going to triple."

Frantz said that the type of crop will influence how much supplemental carbon dioxide a grower wants to add to the production environment.

"In the case of low-value crops like lettuce, a grower is probably not going to want to inject a high level of carbon dioxide unless faster development rates are going to pay for themselves. For high value crops like herbs that are repeatedly harvested, it might be worthwhile to raise the level of carbon dioxide above 400 ppm."

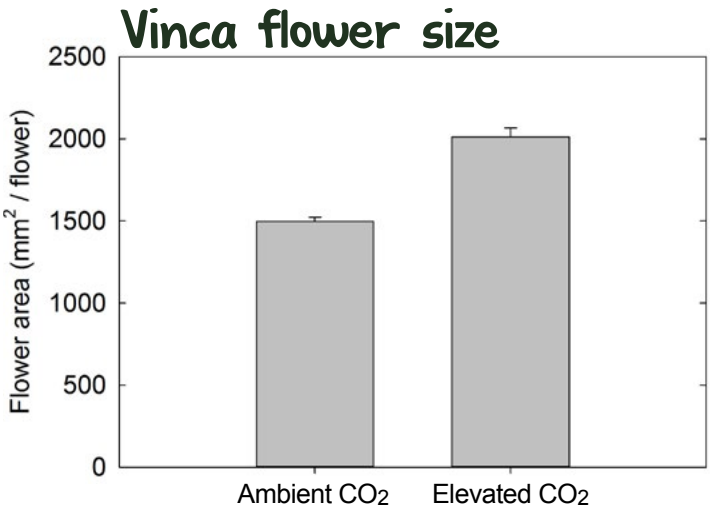
Benefits of supplemental CO_2

Frantz said there is a strong belief among some growers that their crops don't need supplemental carbon dioxide or that their crops won't respond to it.

"The culprit behind that belief isn't the crop, it's the way in which the crops are grown," he said. "Greenhouse vegetable growers who use hydroponics to produce their crops have plants with essentially an unlimited root zone. And growers of tomatoes, bell peppers and cucumbers constantly harvest fruit off of those plants. In these cases, the supplemental carbon dioxide has some place to go and the plants continue to respond to it.

"In the case of ornamentals it's a different situation. The plants are grown for their flowers. These plants are often produced in small containers, including cell packs, pots and even mixed containers. The root zone in these containers is finite, it's defined. And no fruit is being harvested off of ornamental plants. For these plants there is a benefit from supplemental carbon dioxide for a while and then it is minimal because the carbon fixed by photosynthesis has fewer places to go."

Frantz said ornamental plants grown with supplemental carbon dioxide can develop and finish faster. The benefits of supplemental carbon dioxide on ornamental plants have been seen in various container sizes including plug trays.



Jonathan Frantz found that vinca plants supplied with supplemental CO_2 produced larger flowers.

Frantz also found in the case of vinca that plants also produce larger flowers.

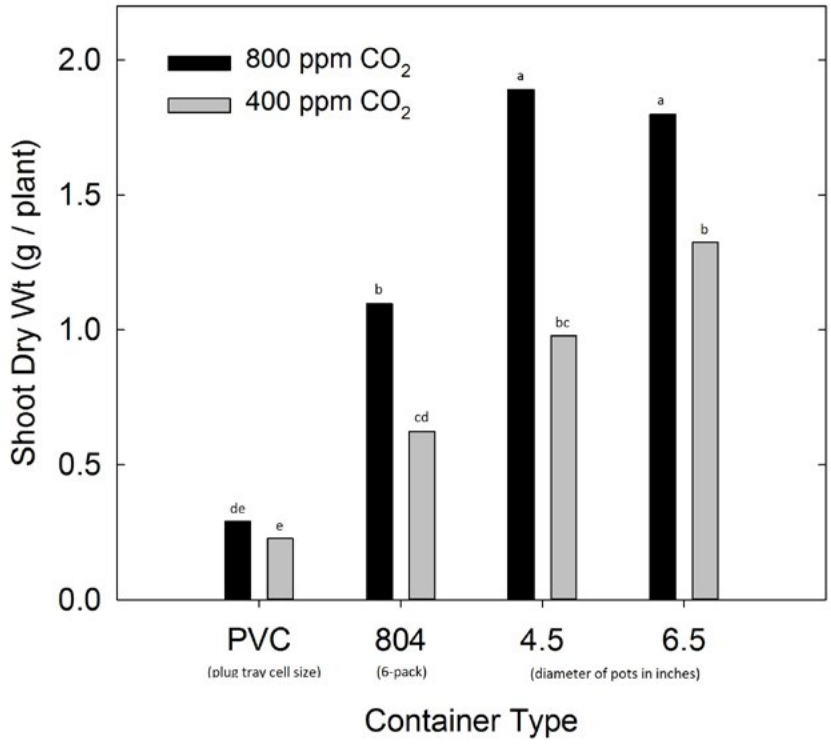
"I wasn't even looking for the effect on flower size," he said. When I was harvesting the plants I noticed that there was such a huge difference in the flower size with the plants that received supplemental carbon dioxide that I started to document those differences.

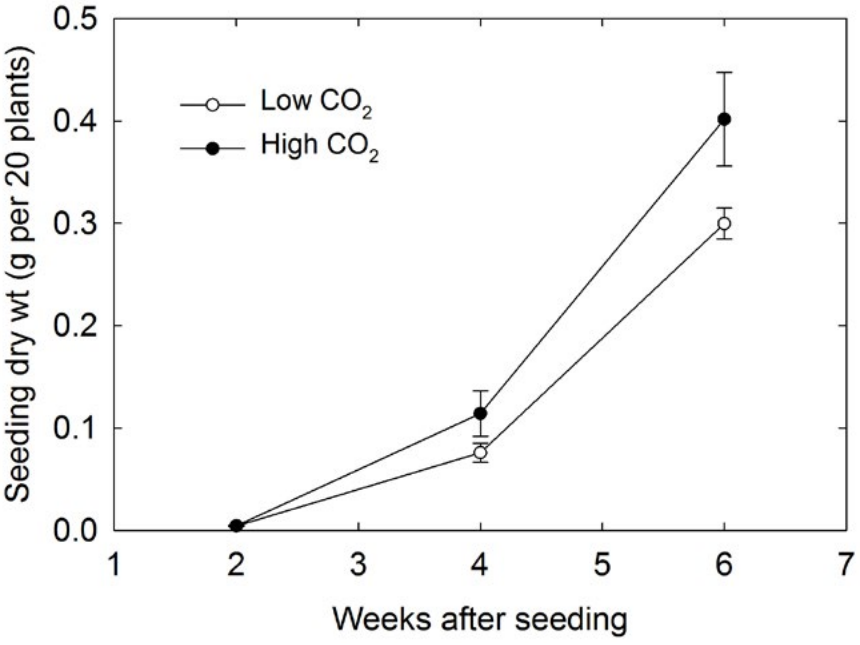
"I was growing plants in flats and I wanted to see if I could shorten the production time. I was able to shave off a week of time, which is significant for flats.

If a grower can the reduce crop time for flats from six weeks down to five weeks, that's a major reduction."

Although ornamental plants develop faster using supplemental carbon dioxide, Frantz did not do any studies to determine if vegetative cuttings would root faster.

"The ornamental grower that I worked with was growing vegetative geraniums. Anecdotally he noticed that the rooting of cuttings was better," Frantz said. "And with his stock plants he was able to take more cuttings off of the plants. In the case of stock plants, it's similar to greenhouse vegetables because cuttings are constantly being harvested, so the plants can continue to respond to the carbon dioxide. The grower also indicated that the stem diameter of the cuttings was broader, but we did not measure that. That would be something that I would expect to occur."





The benefits of supplemental carbon dioxide on ornamental plants have been seen in various container sizes including plug trays.

Jonathan Frantz grew snapdragons and petunias in flats comparing growth at low and high CO_2 levels. Plants of both species developed more quickly with high a level of CO_2.

In the case of greenhouse vegetables like tomatoes, Frantz said supplemental carbon dioxide could possibly increase yields per area and yields per day.

"If the production cycle enables a grower to harvest every 14 days, he may find that he is able to produce larger fruit using supplemental carbon dioxide," he said. "However, he may be able to produce more fruit and not necessarily larger fruit. Cherry tomatoes would be a good example of producing more fruit. With some trialing of supplemental carbon dioxide, a grower may be able to train his plants to produce larger or more fruit depending on market demand."

Keep the air moving

Frantz said the key to adding supplemental carbon dioxide is to ensure there is good mixing of the air regardless of whether production is in a greenhouse or other type of closed environment.

"Carbon dioxide is heavier than air," he said. "If there is insufficient turbulence when the carbon dioxide is added that could result in a layer of carbon dioxide that is quite high at the bottom of the greenhouse or controlled environment structure. If the carbon dioxide is stirred up, it's not going to settle out again. Once it's mixed, it's mixed."

For more: Jonathan Frantz, DuPont Pioneer, jonathan.frantz@pioneer.com; (207) 745-3403.

Editor's note: In the next issue (Issue 8) of Urban Ag Products learn about the economics of using supplemental carbon dioxide.

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The outside ambient carbon dioxide level is just over 400 parts per million. Depending on how tight the greenhouse is and how much plant material is in a greenhouse, the carbon dioxide level can drop 100 ppm in an hour.

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This year marks the 40th anniversary of Wendell Berry's speech about the culture of agriculture that was delivered at the "Agriculture for a Small Planet" Symposium in Spokane, Wash. The first few lines of this speech, written on a yellow legal pad en route to the symposium, inspired his book The Unsettling of America: Culture and Agriculture ", which was published in 1977. Berry's speech was also a catalyst for the launch of the Tilth Movement in the Pacific Northwest.

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