MAXIMISE YOUR HYDROPONIC CROP'S FLAVOUR AND AROMA

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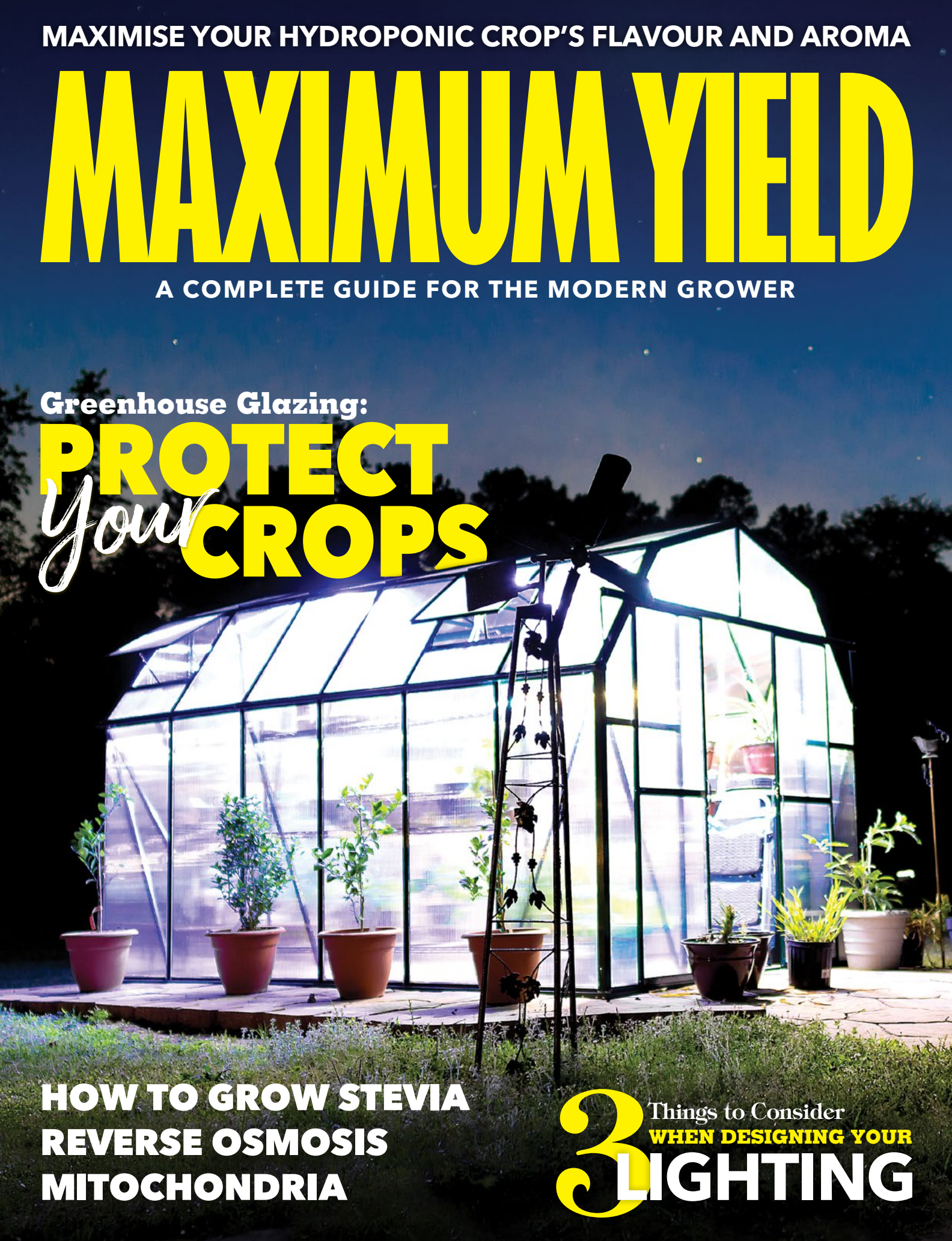
A COMPLETE GUIDE FOR THE MODERN GROWER



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“Ultimately, the selection of glazing material used is determined by balancing your crop’s need for sunlight to photosynthesise with the other climatic or site-specific challenges and conditions that exist.”

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Features

28 Greenhouse Glazing

by Chris Bond

Depending on what crop you want to grow in your greenhouse, the type of material covering the structure is very important for promoting photosynthesis. Chris Bond looks at the effects of materials like glass and poly and how much available light gets let in.

38 Sweet on Stevia

by Peggy Bradley

Used for hundreds of years by other cultures to sweeten food and drinks, stevia has been slow to enter modern diets despite obvious health benefits. However, a tiny house project in Missouri shows stevia can help address both health and economic challenges.

The biggest mobile climate room on the market

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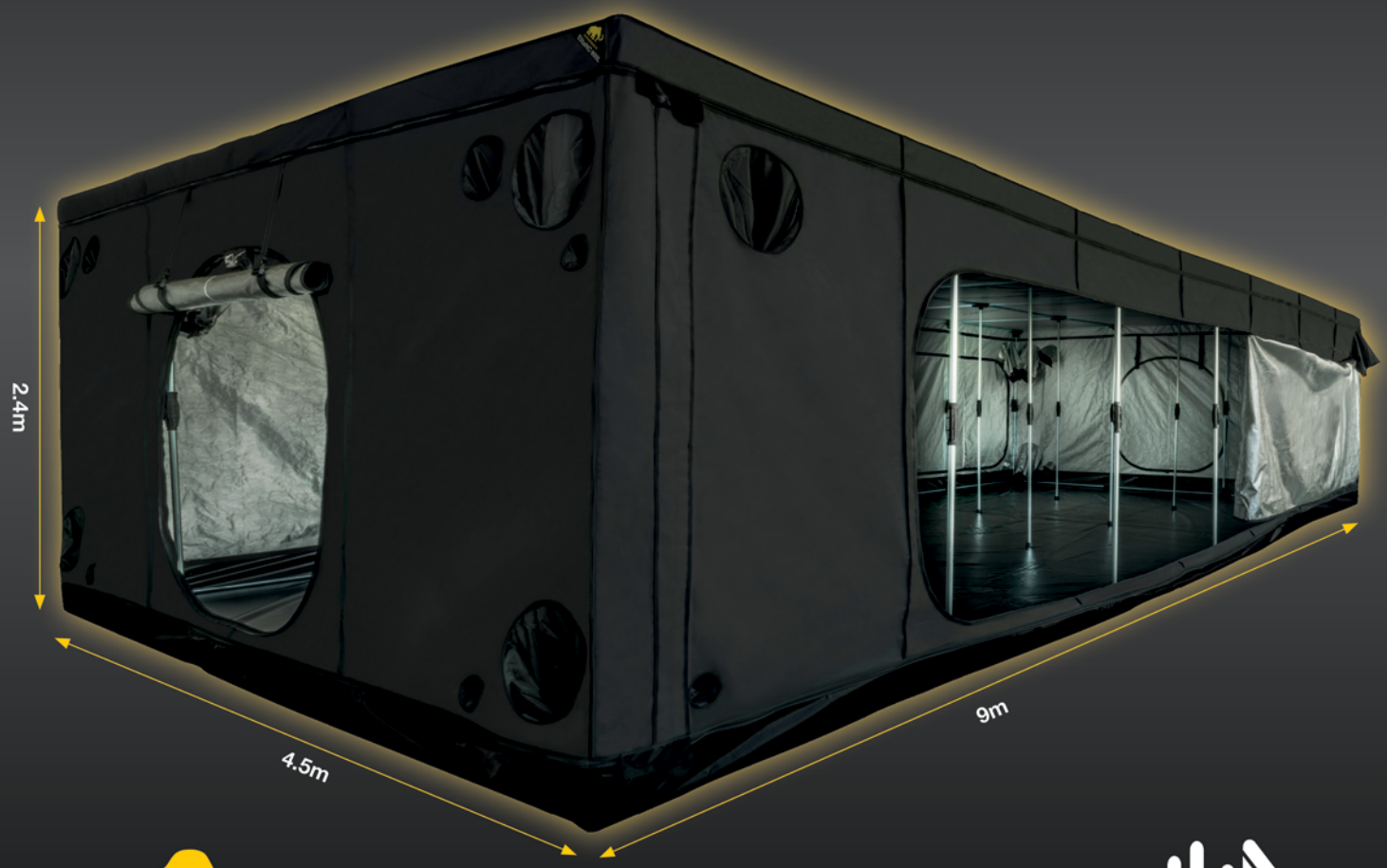

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> “Its health and environmental benefits far surpass those of refined sugar and high-fructose corn syrup, which are known to cause diabetes and tooth decay.”

from the **EDITOR**

TG **Toby Gorman**

If you’re just starting out in indoor growing and are considering which plant might be most beneficial for you and your family, you might want to give stevia a try.

Stevia is a healthy sugar substitute. It is most widely used in drinks such as tea, replacing sugar-sweetened drinks like juice and soda that account for the majority of the 129 pounds of sugar people consume annually on average. It can also be used in baking (another leading contributor of refined sugar in the average diet), salad dressing, and yogurt.

As Peggy Bradley states in her story on stevia on page 38, the $97-billion sugar industry has fought the introduction of stevia and, as a result, it is not a common product in many places.

This is unfortunate as its health and environmental benefits far surpass those of refined sugar and high-fructose corn syrup, which are known to cause diabetes and tooth decay.

What’s more, the stevia plant is a perennial, so it can live for several years once established in a hydroponic system and produce enough for several people while taking up a small amount of space. If better health and a reduced environmental impact are on your priority list, then it’s time to get sweet on stevia.

As always, thanks for reading *Maximum Yield*, and if you have any questions, feel free to contact us at *editor@maximumyield.com*.

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bare **ROOTS**

Featured Contributor

Chris Bond is the manager of the McKay Farm and Research Station at Unity College in Maine. His research interests are with sustainable agriculture, biological pest control as well as alternative growing methods. He is a certified permaculture designer and certified nursery technician in Ohio and a certified nursery professional in New York, where he got his start in growing.

Contributors

Peggy Bradley
Kent Gruetzmacher
Eric Hopper
Philip McIntosh
Dr. Lynette Morgan

REVERSE OSMOSIS

Osmosis refers to the diffusion, or flow, of liquid moving through a selectively permeable filtration membrane. In growing, the process of **reverse osmosis** is typically performed through the use of a specialised filtration system. This process is used to clean water so it's better suited for effective irrigation. In fact, reverse osmosis can remove all the dissolved solids from water, leaving pure H_20, which allows a grower to more accurately control nutrient dosage and uptake.

Check out Chris Bond's article on page 46 for more information.

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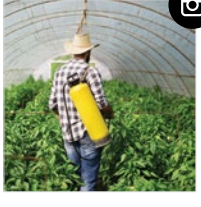
branching **OUT**

Steve G.
Love the many and wonderful articles you have. I may even become a gardener because of this magazine! Terrific! Thank You!!!

John C.
I wouldn't grow without, it just does so many beneficial things.
(responding to "Make Room for Mycorrhizae in Your Growroom.")

@hydrohollica
Been into hydroponics for about 3 months.
Really learned a lot from *Maximum Yield*. Thanks.

Josh H.
You can also apply bacteria that produce auxins such as *Azospirillum brasilense* or types of *Azotobacter*.
(responding to "The Various Forms of Rooting Hormones & Organic Rooting Stimulants.")



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You guys are one of our favourite reads!

Article Archives

Can't recall that great gardening recommendation from a few months ago? Look it up online. We have hundreds of indoor gardening articles available at *maximumyield.com*.

Ask the Experts

Stumped by something strange happening in your garden? Fill out our Ask the Experts form and we will find you answers.

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DO YOU HAVE A QUESTION FOR A GROWER? Email *editor@maximumyield.com* to get an answer.

ask a **GROWER**

Q I'm an indoor hydroponic farmer (culinary herbs and leafy greens), and I recently had a bout with some spider mites. Being that we are a 100-per cent pesticide-free operation, I'm trying to source some other methods to deal with the problem. I tried using some predatory mites, and while they certainly helped, I'm still noticing signs of new problems. I stumbled upon ozone (O_3) generators and found a *Maximum Yield* article regarding the use of them to kill pests. I also did some research and found that the O_3 generator may also cause some damage to the plants that are still growing. Can you recommend a method for using the generator, and the levels/duration needed to kill the pests while doing the least amount of damage to the plants? Thank you!

Have a great day!
Billy

a *Hello Billy,*

Thank you for your question. Although there is not a lot of information on the subject, some indoor growers claim to have successfully used ozone to treat pest insects. For ozone to be an effective insect killer, the concentration of ozone in the air must be extremely high. Again, there is not a great deal of information on the subject, but it appears that a concentration of 1,000-2,000 ppm or even higher (some people say as high as 10,000 ppm) is required to kill spider mites. In an environment with a concentration of 2,000 ppm of ozone, pest insects will most likely perish in anywhere from a half hour to two and a half hours. However, ozone at this high concentration can be extremely dangerous for people and pets. In fact, ozone levels of 25 ppm and higher are considered immediately hazardous to human life. It is also very difficult to achieve this high of a concentration of ozone without a special ozone generator (an oxygen-fed ozone generator). High concentrations of ozone can also cause damage to plants, which is why high levels of ozone are usually reserved for treating or sterilising an empty room. Horticulturists who decide to implement high concentrations of ozone as a method of pest control need to do so with the utmost caution.

I do not know how your specific plants will react to ozone treatments, so I do not feel comfortable giving you specific recommendations for treatment. I can tell you that sensitive, leafy greens will probably be more adversely affected by ozone treatments than robust plants. If you want to experiment with ozone as a pest insect treatment, you could increase the level of ozone for half an hour to an hour and then wait 24-48 hours to see if it is effective or if there are any adverse reactions. If no noticeable plant damage occurs after 48 hours, you could slowly increase the concentration of ozone and/or the duration of the treatment time until you have achieved the results you desire. Just be sure to completely evacuate the ozone from the garden before any people or pets enter the area. I hope this helps.

Keep on Growing,
Eric Hopper

EH **Eric Hopper** has more than 10 years of experience in the hydroponic industry as both a retail store manager and owner. He continuously seeks new methods and products that could help maximise garden performance. Eric resides in Michigan where he and his family strive for a self-sufficient and sustainable lifestyle.

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Diet Changes Could Reduce Carbon Emissions from Food System

A new study, published in *Food Policy*, suggests that if Americans directed their food purchases away from meat and animal protein, greenhouse gas emissions could be reduced. "We found that households that spend more of their weekly food budget on beef, chicken, pork, and other meats are generating more greenhouse gas emissions. Our study shows that encouraging consumers to make food choices that are lower in greenhouse gas emissions can make a real difference addressing climate change," says Rebecca Boehm, the study's lead author and a University of Connecticut postdoctoral fellow. Altering food consumption could be a key area for reducing greenhouse gas emissions, as food purchases accounted for 16 per cent of US greenhouse gas emissions in 2013, according to the study. By comparison, commercial/residential activity accounted for 12 per cent and industrial activity accounted for 21 per cent of America's greenhouse gas emissions.

–sciencedaily.com

Robotic Apple Packer Speeds Up Processing Times

A newly launched robotic apple packer will help commercial apple growers ship more product more quickly, helping meet the challenges of global demand for more fresh food. Global Pac Technologies launched the Aporo packer, which was developed by New Zealand agritech company, Robotics Plus. Data published by Rabobank earlier this year shows the market for fresh fruit has increased four per cent around the world over the past decade (most of that growth is from countries outside the US and EU). The packer, which identifies and places the apples in their trays, has the ability to safely handle up to 120 pieces of fruit per minute, the equivalent of two people's output. A number of Robotics Plus packers have already been installed, with more on the way, in commercial post-harvest operators in New Zealand and the US.

–freshplaza.com

Emirates Airline Partners with Crop One to Build World's Largest Vertical Farm

The world's largest vertical farm facility is set to get built in Dubai via a $US40 million partnership between Emirates Airline and California-based Crop One. Emirates said the 130,000 square foot facility will be built near Al Maktoum International Airport at Dubai World Central. Once at full production levels, the vertical farm is expected to produce 2,700 kilograms of pesticide- and herbicide-free leafy greens every day. Moreover, the facility will have a much smaller carbon footprint than a traditional farm as it's predicted to use 99 per cent less water with 0.003 per cent of the space. And it will produce the equivalent of 900 acres of farmland. "This investment to build and operate the world's largest vertical farming facility aligns with the UAE's drive for more agricultural self-sufficiency," says Sheikh Ahmed bin Saeed Al Maktoum, CEO of Emirates Airline.

–themastonline.com

Drones Seeing More and More Uses in Agriculture

While many farmers are leery about embracing change and technology, drones can make a grower's life much easier. American agricultural consultant Dwayne Reed says a drone and smartphone can save farmers a lot of time and energy. "Drones save growers time," says Reed. "They don't have to walk the field inspecting acres and acres of crops. It's all about trying to increase your yield and decrease your costs." Plants reflect and absorb light. Healthy plants reflect more near-infrared light, while a stressed plant will absorb more light, so farmers can tell which crops are struggling. Reed says he can see plants stressed because of infertility, drought, and disease from the analytics captured from drone images. "Drones are GPS-coordinated," he says. "You can walk straight to those stressed plants. It keeps you from walking the whole field. The (normalised difference vegetation index) image will show you the area you have potential disease and if you can spray just that area."

–decaturdaily.com

Study Identifies Striga-resistant Corn Varieties

One of the biggest dangers to corn yields in sub-Saharan Africa is the semi-parasitic plant, Striga, which can destroy an entire crop in an infested area. But there is hope, as a study recently published in *Crop Science* identified several types of corn that are resistant or tolerant to Striga. Moreover, these strains also have improved nutrient content, specifically protein, and high yields. The combination of Striga tolerance and better nutrition is key. Farmers, as well as local populations, will benefit, says Peter Setimela, a study co-author and scientist at the International Maize and Wheat Improvement Centre in Harare, Zimbabwe. Striga infestations can force small farmers in sub-Saharan and southern Africa to abandon their farms. "Striga is known to affect fields that have poor soil fertility. Its seeds can stay in the soil for more than 15 years," says Setimela. "Many small farmers can't afford to buy chemicals to control Striga."

–sciencedaily.com

Rotating Crops Reduces Greenhouse Emissions: Study

A study by the University of Illinois (U of I) shows that rotating corn and soybean crops lowers greenhouse gas emissions compared with continuous planting. "I think farmers … are looking for reasons to avoid growing in a monoculture. They're looking to diversify and rotate their systems. If they're doing that partially out of a concern for the environment, well, it lowers greenhouse gases. And it could potentially result in a substantial yield increase," says Gevan Behnke, a research specialist with the U of I's department of crop sciences. Behnke sampled greenhouse gas emissions from fields that had been maintained as continuous corn, continuous soybean, rotated corn-soybean, or rotated corn-soybean-wheat, under tillage and no-till management for 20 years. Comparing the corn phase of a corn-soybean rotation to continuous corn showed an average yield benefit of more than 20 per cent and a cumulative reduction in nitrous oxide emissions of about 35 per cent.

–agriculture.com

good
TO GROW

1 | Stealth Garden Green House Bio Feeders

The Green House Bio range of feeders is an excellent organic soil production formulation. It uses biologically derived nutrients which are mixed into a horticulturist's substrate and provides fertigation for the entire growth cycle. Green House Bio range is available in BioGrow for vigorous vegetative growth and BioBloom for big, beautiful flowers. Also check out BioEnhancer. The Green House Bio range is produced by the famous StrainHunters team. Biological nutriment allows for complete plant phenotypic development, with stronger flavours, smells, and density of flowers.

2 | Sol Sense 315W Sol-Unit

The 315W Sol-Unit complete CMH kit is a sophisticated, all-in-one grow light system designed to optimise yield with a lower operating temperature and lower energy consumption when compared to conventional HID grow lights. The built-in 315W digital ballast comprises quality components to deliver a high-intensity and full-spectrum output. The Sol-Unit includes one 315W, 3,000K CMH grow lamp which produces a higher output compared to conventional HID lamps, so less lamps are needed, less energy is used, and growers save on their operating budget.

3 | Grotek Monster Grow 12-7-15

Monster Grow is Grotek's pure supplement designed to really maximise vegetative growth, enhancing leaf and root development in anticipation of flowering. This water-soluble powder has optimised nutrients essential for plant development. Quality nitrogen boosts leaf production and size, while phosphorus stimulates root development and floral initiation. Added kelp provides for drought tolerance and increased root development to ensure plants can feed. Monster Grow ensures your plants are strong and vigorous as they head into flowering phase of growth.

4 | Cyco Dr. Repair

Another from Cyco's trusted line of Platinum Series products, Dr. Repair is an additive growers can use throughout both the vegetative and flowering phases to help ease environmental stress and prevent chlorosis. Dr. Repair has balanced amounts of urea-based nitrogen, which is key in forming amino acids, and the reparation of missing chlorophyll molecules. It also contains chelated iron (in the form of iron EDTA). A necessary component in the production of chlorophyll, this infusion of immediately available and pure iron works to reverse chlorosis.

5 | **Gorilla Grow Tent RecRoom**

If you've been thinking about growing your own cannabis, one of the easiest ways would be by using Gorilla Grow Tent's RecRoom. It's an all-in-one grow tent kit that uses high-end KIND Led lights for maximum yields. It takes mere minutes to set up, so novice horticulturists can be growing quickly. The well-constructed RecRoom comes with easy-to-follow guides and lifetime support from the Gorilla Grow Tent professionals.

6 | **Cyco Coco Coir**

Growers can trust Cyco's Coco Coir because it displays the RHP stamp of quality. The RHP Dutch Standard of quality for horticultural substrates ensures a strictly monitored quality assurance that will give horticulturists constant proven results. The RHP Certification, which has been used since 1963, ensures the quality and consistency of Cyco's Coco Coir product, which is free from harmful parasites and diseases, while being pre-buffered and pH stabilised. It's available in 50-litre bags and commercial sizes.

7 | **Reiziger Root Booster**

Norwegian sea kelp contains many root-sustaining properties and is a proven organic booster to maximise root function and generate maximum yields. Reiziger Root Booster has been a staple of many professional gardeners and growers for more than 20 years to activate, revive, and stimulate indoor hydroponic plants, outdoor plants, seedlings, trees, flowers, bulbs, natives, and more. This nutrient-rich, organic root stimulator has the power to save, revive, or help newly-potted plants and transplants grow early white healthy roots, give more uniformity, and improve survivability.

8 | **Sunmaster Full Nova Ceramic Metal Halide Lamps**

Sunmaster's new range of CMH lamps include two 315W full nova variations that are designed to generate a balanced light spectrum. The 315W full nova (#80440) has a full spectrum designed to add more blue/violet and red light, while the WX model (#80430) boasts two µmol/J with a tailored spectrum weighted in blue, red, and far red to boost robust flowering. This balanced approach offers advantages over the partial (or non-balanced) spectrum provided by other light sources such as LED or HPS lamps.

9 | **Bio Diesel Aloevate**

A 100 per cent natural plant tonic containing hundreds of vitamins, minerals, and enzymes, Aloevate is made from blended desert plant extracts. It contains natural salicylic acid (silica), auxins, amino acids, saponins, and enzymes that enhance micro-life, protect the root zone, and break down any dead roots and unused mineral salts to keep the plant roots clean and functioning at peak performance with healthy microbe colonization. Aloevate improves your plants' size, vitality, and overall growth rates while protecting them from disease. Available in one-, five-, and 20-litre sizes.

10 | **Uvonair CD-1200 In-Duct, 12-inch Ozone Generator**

High-output and maintenance-free, the Uvonair CD-1200 corona discharge ozone generator treats air as its exhausted. Adjustable high/low settings conveniently match ozone demand load for odour control and energy conservation in low-demand periods. Treats rooms from 40,000 cubic feet up to 100,000 cubic feet. The CD-1200 works in areas with high humidity and a wide range of temperatures. It deodorises growrooms, is environmentally friendly, creates no hazardous waste, and comes with a full one-year warranty.

11 | **Reiziger Bloom Minerals**

Specially formulated in Holland from pure and toxin-free earth minerals, Reiziger Bloom Minerals contains a carefully balanced blend of rapidly absorbable, proprietary phosphorus and potassium elements that award the grower with optimum quality, weight and fruit swelling. Bloom Minerals contains no nitrogen, making it an ideal source of phosphorus and potassium for late applications to fruiting plants when nitrogen applications need to be controlled. The ammonium-free formula ensures it is perfectly suited for hydroponic applications.

12 | **XED 200W Ballast Kit**

XED provides a grow light that has the full light spectrum with the closest light available to natural sunlight. It has a colour rendering index greater than 90 (sunlight is 100) and uses 70 per cent less energy than HPS and 54 per cent less energy than MH lights. The XED 200W, also called "Small Sun", has a greater than 91 per cent lighting efficiency with a lifespan of more than 20,000 hours.

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Greenhouse Glazing:

PROTECT *Your* CROPS

by Chris Bond

Depending on what crop you want to grow in your greenhouse, the type of material that covers the structure is very important for promoting photosynthesis. Chris Bond looks at the effects of materials like glass and poly and how much available light gets let in.

All greenhouses, cold frames, and other structures built with the intention of growing plants within, while allowing natural light to enter, have some kind of glazing. Glazing is the term for the type of translucent material that, apart from the frame, the structure is made of. It can be likened to the skin of an organism. There are essentially three types of glazing: glass, rigid panels, and polyethylene film. Each of these is ideal for different applications, but all are intended to protect crops growing inside. Each material needs to be chosen for the type of climate it's in. How each lets light in will also affect the photosynthesis of your plants. Most plant crops produced under cover do best when receiving about 70-80 per cent of available light. Factors such as snow load, orientation or aspect, and amount of wind will also help to inform the decision as to what type of glazing best promotes photosynthesis.

A typical greenhouse, with its support beams, gables, struts, spans, or any other structural component, coupled with its location in respect to the angle of the sun and the choice of glazing, may in some instances only allow 40-50 per cent of available light. So, the choice of glazing materials is critical in these situations to the amount of photosynthesis plants can undertake growing in greenhouses.

GLASS

Glass was the only option for indoor growing for hundreds of years. Because of its clarity, glass glazing is not an obstacle to photosynthesis; plants grown under glass receive almost as much light as if they were out in the open. Glass can also last for decades, if not centuries, and is arguably the most attractive of all glazing options. It would hardly be the draw of horticultural and architectural enthusiasts alike if the Temperate House at London's Kew Royal Botanic Gardens was made of plastic film and bent pipe, or if the Enid A. Haupt Conservatory at the New York Botanical Garden was constructed of polycarbonate panels and 2x4s. Despite its beneficial attributes as a glazing material, glass is not necessarily the best choice in all cases.

"Rigid Polymer panels, such as polycarbonate, have become the standard in greenhouse installation over the last few decades."

Because of its clarity, plants grown under glass glazing are more prone to leaf burn and other light-induced stressors than plants grown under polycarbonate or plastic films. Glass greenhouse owners and managers have gotten around this by using shading compounds (see below).

Glass is more prone to breakage, is much more expensive to install and repair, and is less tolerant of extreme temperature fluctuations. It is also less efficient as an insulator and for heat retention than other glazing options. Modern glass greenhouses are usually constructed of tempered or laminated glass as it requires less structural support than comparably sized glass panels used in the past.

RIGID PANELS

Rigid polymer panels, such as polycarbonate, have become the standard in greenhouse installation over the last few decades. They are much easier to install, easier to repair and, while not cheap, cost less than glass of comparable size. They can be manufactured in varying thicknesses to both reduce the amount of light entering the growing area and to increase insulation value. Many polycarbonate panels are manufactured with negative space between the layers, which bolsters their ability to retain heat. Plants grown in greenhouses with polycarbonate glazing are less likely to burn, but may not grow as full or fast as plants grown under glass since there is less available light to photosynthesise. Acrylic panels are sometimes used as an alternative to polycarbonate as they allow more light to penetrate and tend to last twice as long.

Be wary of panels that are not UV stabilised as they will discolour over time and then, despite being an eyesore, will impede the photosynthesis process even more. Polycarbonate panels are also prone to scratching, which besides negatively affecting the aesthetic value, impairs light penetration and thereby photosynthesis of those plants.

POLY FILM

Polyethylene (poly) film is an easy glazing choice for temporary structures. It's cheaper than polycarbonate panels and easier to install. It is manufactured in a variety of widths and colours (usually clear or white) to fit the situation. When the sunlight is most intense and the grower wants to prevent burning, white poly film works well. To achieve maximum light penetration and therefore photosynthesis, clear poly can be used. Poly is not as efficient as polycarbonate panels for retaining heat, losing as much as 60 per cent, but many growers will add a second or even third layer and often inflate the space between the layers, or place spacer blocks or materials to create that negative air space to aid in insulation. It is important to note in greenhouses where an inflating fan is being used, outside air should be pumped in to reduce the amount of condensation. There is some debate, especially in northern climates that do not receive much sunlight during the winter months, as to whether the second layer of poly film's added insulation outweighs the dilution of available light and subsequent photosynthetic value. Research on this continues.

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"Polyethylene (poly) film is an easy glazing choice for temporary structures. It's cheaper than polycarbonate panels and easier to install."

Poly is the most versatile of the three materials because it can easily be tailored to the season, the climate, and the crop. However, of the three options, it has the shortest usable life span, sometimes only a single season, and is especially prone to ripping and tearing in high-wind areas.

BY THE NUMBERS

When deciding which material is best suited for your particular situation, an overview of the various glazes and their respective properties is useful, as per a 2008 Rutgers University publication.

A somewhat dated article (1993) in the journal *Hort Technology*, stated it accurately when it reported "the geographic location of the greenhouse (because of microclimate), grower experience and/or preference, and the local industrial support all have an important influence on the design and selection of a glazing system for a greenhouse operation. The crop and its required heating and/or cooling costs also enters into the decision. It is important to remember glazing, while vital to the overall system, is just one component.

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GLAZING MATERIAL	LIGHT TRANSMITTANCE (UP TO)	HEAT TRANSMITTANCE (UP TO)	UV TRANSMITTANCE (UP TO)	AVERAGE LIFE EXPECTANCY OF THE MATERIAL (YEARS)
Glass	90 per cent	3 per cent	70 per cent	30+
Polycarbonate Panels	75 per cent	3 per cent	44 per cent	10
Acrylic Panels	86 per cent	3 per cent	18 per cent	20
Poly Film	88 per cent*	50 per cent	80 per cent	1-4

**A 2010 article in the journal* Computers and Electronics in Agriculture *reports that this number drops to 75-76 percent when using a double layer of poly films.*

SHADING OPTIONS

For growers who find glass or panels still allow too much light into their growing spaces for the crops being produced, shading options such as draping or hanging shade cloths, or applying a light-coloured paint material onto the roof can be used. Paint-like substances known as shading compound or shade paint can be applied directly onto various types of glazing and serve to block out some light, allowing enough to penetrate for photosynthesis, but reducing the intensity to avoid burning of foliage tips and canopies. These compounds are sometimes brushed on, rolled on, or, more often, applied with a sprayer nozzle. Most of these materials generally wash off over the course of the season and then are reapplied the following spring or summer.

A 2010 study published by the American Society of Agricultural and Biological Engineers examined the effects of flowering times on crops when comparing different types of shading compounds. They looked at NIR-reflecting (NIR-R) paints and neutral (N) shading paint. They found in their study that "The NIR-R paint transmitted 67 per cent, eight per cent, 24 per cent, 30 per cent, and 29 per cent less ultraviolet-A (315-380 nm), red (R; 600-700 nm), far-red (FR; 700-800 nm), NIR, and SWR, respectively, than the N paint. Transmission of blue (400-500 nm) and green (500-600 nm) light was 4.7 per cent and 4.5 per cent greater, respectively, under the NIR-R versus N paint." Salvia, pansies, and petunias used in this study flowered one to three days earlier under the NIR compounds versus the N compounds.

An alternative to shading compounds is to place a shade cloth over top of the structure as well during the months of peak sun intensity, or suspend one inside, over top of the crop. Light-coloured shade cloths will block some light but not absorb as much heat, while darker cloths will block more light but can absorb and radiate more heat, which is not always good in an already-warm greenhouse.

Ultimately, the selection of glazing material used is determined by balancing your crop's need for sunlight to photosynthesise with the other climatic or site-specific challenges and conditions that exist. Remember that you can always supplement with grow lights if the glazing material you choose obstructs too much natural light.


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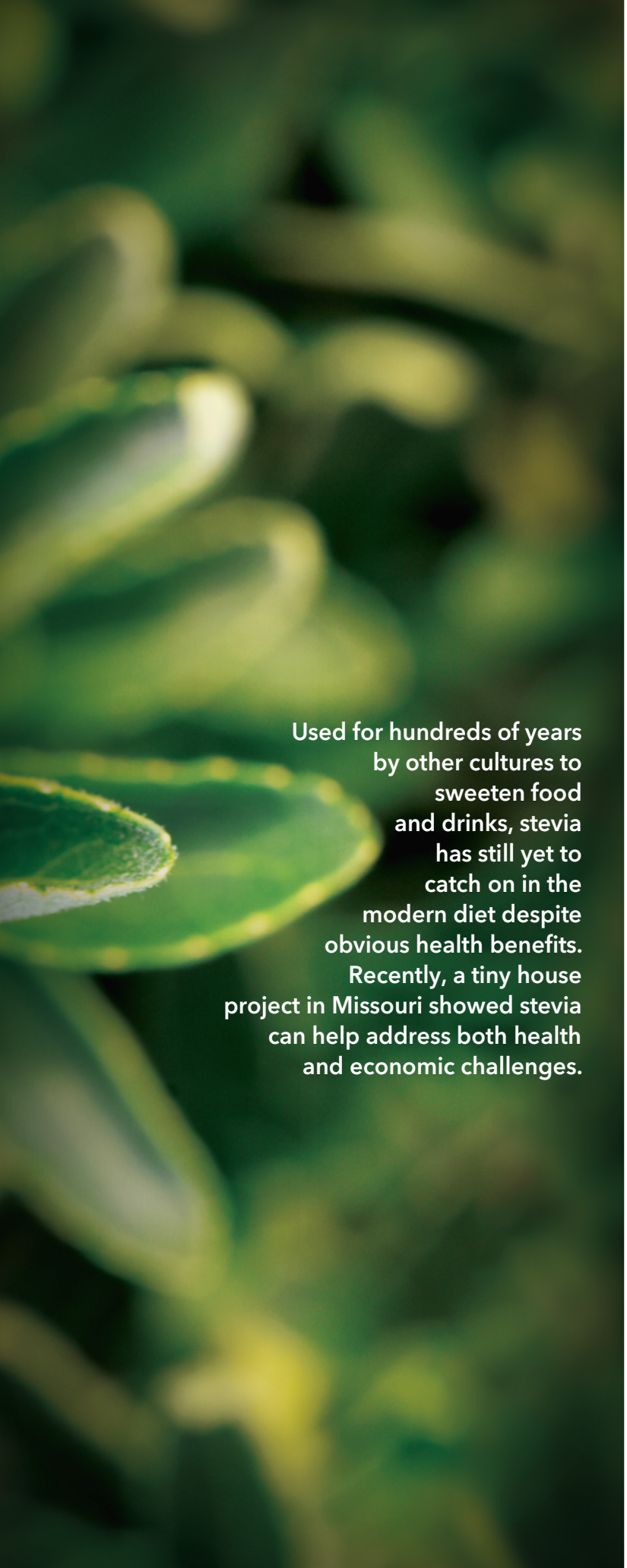

Used for hundreds of years by other cultures to sweeten food and drinks, stevia has still yet to catch on in the modern diet despite obvious health benefits. Recently, a tiny house project in Missouri showed stevia can help address both health and economic challenges.

by Peggy Bradley

A tiny, prototype house used to display how urban dwellers can grow much of their own food has proven a single plant can play a big role in the reduction of refined sugar consumption.

In Fair Play, MO, a team at the Institute of Simplified Hydroponics has grown stevia, a natural sweetener, at the 220-square-foot home. They found numerous health issues were avoided by substituting it for refined sugars. A number of other benefits, including economic, were also realised.

In the modern diet, sweeteners, usually supplied by refined white sugar derived from sugar cane and sugar beet, are recognised as being the leading factors for chronic diseases such as diabetes and tooth decay. It is estimated the average person consumes 58 Kilograms of refined sugar annually. Another source of sweetener, often found in processed foods and beverages, is high-fructose corn syrup, which has also been linked to several chronic diseases.

An inspiration for the project came from an unexpected source. Looking for alternatives, an idea emerged while the team was in Peru. During a filming session on Inca agricultural terraces of the Andes, a local farmer picked some stevia leaf growing wild and handed leaves to the film crew. He pointed out it was used as a sweetener and medicine by the local people. When asked what the medicine was used for, he enthusiastically replied, "Everything!"

Stevia is a staple of the Guarani people of South America, who have used it for 1,500 years as their diet sweetener. *Stevia rebaudiana* was first identified for the developed world by Santiago Bertoni, a Swiss botanist, in 1899.

Hydroponic Experiments with Stevia

In the first season with stevia plants at the prototype house, the team found that one square meter of growing space is all that is required for the sweetener needs of one person. This allows for harvesting six to eight springs of stevia each day, and the three-inch springs can be used with other herbs for daily tea. The herbal teas are served hot and replace sugar beverages such as soft drinks, fruit juices, and other sweetened beverages. As stevia, like most herbs, is calorie-free, using stevia as the replacement for sweetness eliminated the daily 28 teaspoons of sugar, or 450 calories.

"**IN THE FIRST** season with stevia plants at the prototype house, the team found that one square meter of growing space is all that is required for the sweetener needs of one person."

Stevia can be grown from seed, but like some herbs, it is difficult to germinate and slow to grow, so the other option is purchasing plants from a plant nursery. The stevia plant is a perennial that can live for several years in a hydroponic system. For the project, stevia is grown in hydroponic culture using our bloom formula, which is a reduced nitrogen modified Steiner formula. Their plants are now about 30 cm tall after six months of growth and harvest, and they can grow to about one metre tall. When that happens, one square meter will hold about four plants.

Also, if growing outdoors, stevia is a tropical plant and needs a frost-free environment, so winter growth requires climate control. Individual plants can be placed in 30-cm diameter pots and grown indoors as decorative plants.

Switching from Sugar to Stevia

According to studies, the average adult is getting about 60 per cent of their daily sweeteners from beverages, so switching to stevia-sweetened beverages could reduce sugar intake by more than half. Baked goods are also a leading source of refined sugar consumption. In most recipes, dried or fresh stevia can replace sugar. The need for sugar in baked goods is further reduced by replacing flour with sweet potato. About 25 per cent of flour can usually be exchanged with sweet potato, further reducing the needs for sweetener.

In the UK, the whole stevia leaf is not yet allowed in processed food. However, it is legal for homeowners to grow and use stevia for their own use. Naturally, the $97-billion sugar industry has fought the introduction of stevia, so it is not yet a serious marketplace competitor. In Japan, however, it is widely used. And while stevia doesn't necessarily have verified direct diet-related medical benefits, by using it in place of sugar, the average person can remove 450 calories a day from their diet, equal to a pound of excess weight every week.

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Stevia as a Treatment

One of the many research papers on stevia suggests a possible treatment for Lyme disease. One report shows that using whole leaf stevia extract can kill the agent of Lyme disease in petri dishes. It appears as effective as antibiotics in treating live bacteria, though stevia goes one step further. Antibiotics do not recognize or kill the cysts of bacteria or the bacteria that hide under a protective cover called biofilm. These other forms of bacteria can resurface into active bacteria, leading to relapse. According to this paper, whole stevia extract will also kill the cyst and biofilm-protected bacteria, whereas the antibiotics do not. This remarkable research implies that stevia might be useful in chronic Lyme disease, malaria, and other infections that reoccur. This has huge implications for human health, but, admittedly, it is a long way from human trials.

Environmental Benefits

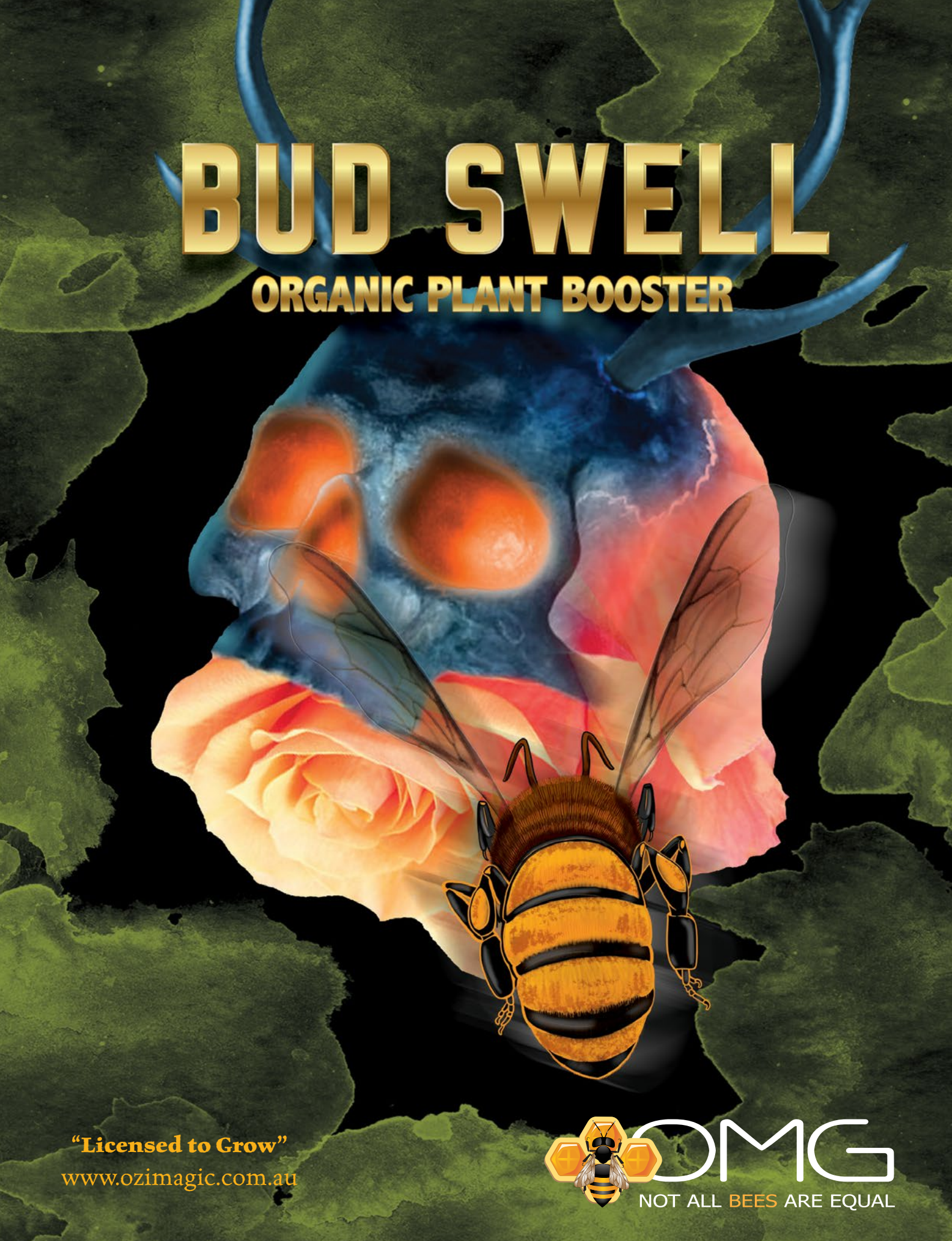
Current agricultural practices require 246 litres of water a day to produce 793 grams of sugar. A square meter of stevia requires 1.8 litres of nutrient water a day, a daily savings of 244 litres. Over the course of a year, one square meter of stevia requires 689 litres of water while 793 grams of sugar requires more than 87,000 litres.

Sugar cane and sugar beet are now grown on 74 million acres of land in 120 countries. Sugar is produced at the rate of 4.5 tons per acre of land, or about 450 grams per square metre. At this rate, it takes 108 square metres to produce each person's sugar requirement. The annual production is 375 million tons a year. The World Wildlife Fund claims sugar production may be responsible for more loss of diversity than any other crop on the planet due to heavy needs for water and soil-based chemical fertilisers.

"
THE WORLD WILDLIFE Fund claims sugar production may be responsible for more loss of diversity than any other crop on the planet due to heavy needs for water and soil-based chemical fertilisers."

The environmental impacts of using refined sugar include the agricultural runoff, the impact of sugar refining, and transportation. There are also human rights issues for agricultural workers producing sugar crops, especially in developing countries. All of that can be eliminated for the person who switches to growing their own fresh herb.

Easy to grow, stevia is an excellent replacement for refined sugar and high-fructose corn syrup, and it offers many indirect health benefits in the form of a tasty sweetener in baking and in beverages. For people on a tight budget, it should be considered to help reduce grocery costs by eliminating sodas and unhealthy snack purchases. Environmentally, homegrown stevia can reduce water consumption, reduce arable land consumption, improve crop diversity, reduce harmful fertiliser use, and address human rights issues. With further research, it is possible that many medicinal benefits will also be realised through this versatile and healthy plant.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Three Considerations to Make When DESIGNING GROWROOM LIGHTING

Deciding which indoor horticultural lighting to purchase for your growroom can be a confusing endeavour. To make the process smoother, Kent Gruetzmacher says there are three things all growers should consider before anything else: initial cost, energy demands, and growroom infrastructure.

by Kent Gruetzmacher

The indoor gardening industry evolves with the technology that supports it. Lighting is one segment of indoor gardening technology that has major influence. To illustrate, the inclusion of light emitting diode (LED) lights has begun to alter the way in which cultivation operations are designed and operated. In a similar vein, and some years ago, the invention of double-ended (DE) high pressure sodium (HPS) lighting had a similar paradigm-shifting effect.

While advancements in both technology and methodology are doubtlessly exciting, the rapid influx of changing lighting technologies on the market proves both confusing and intimidating for all levels of growers. When designing a growroom, it's all too easy to become overwhelmed with the complexities of lighting schematics, as well as with sales pitches and marketing gimmicks. Unfortunately, this often leads to illogical impulse buys. To avoid this, cultivators looking to design a system for an indoor garden can follow the simple criteria below to logically plan their growroom lighting.

INITIAL COST AND ENERGY DEMANDS

Perhaps the most efficient way to begin planning a growroom lighting system is to consider initial cost versus energy demands. Weighing one's initial overhead against the light's intended usage, including both regularity and scale, will give a grower a concrete starting point in choosing the correct system.

A quick financial overview of the three primary lighting systems on the market today—single-ended (SE) high pressure sodium (HPS), double-ended (DE) HPS, and light emitting diode (LED)—provides a great roadmap for making informed consumer decisions. Depending on the shop, a traditional single-ended, air-cooled 1,000-watt (W) grow light retails for approximately AUD$270. Secondly, a 1,000W DE HPS light starts at around AUD$523. Finally, a 550W LED lighting rig costs about AUD$1,082 (due to spectral efficiency, a 550W LED light emits a similar amount of usable light as a 1,000W HPS lamp). As one can see, LED lighting presents a far greater initial cost than the first two set-ups.

The regularity and scale of usage of the growroom lighting directly results in the system's energy demands, which then translates into a power bill. With this notion in mind, growers can make sound consumer decisions based on how much they will use their lighting system. To illustrate, if an individual only plans on producing one or two crops a year in a 1,000W grow operation, it probably makes the most economic sense to opt for either an SE or DE HPS system, as it will take an exorbitant amount of time to recuperate the initial cost of an LED set-up on such a small scale. Conversely, if a grower intends to produce five or six harvests a year, or operate on a commercial scale, LEDs could be a more practical purchase as the regularity and scale of energy usage at this level will quickly recoup the higher initial cost.

GROWROOM INFRASTRUCTURE

Other important factors to consider when designing a lighting system are the spatial and infrastructural constraints of the growroom. The height of a growroom's ceiling directly influences the options a cultivator can consider. For example, some DE HPS lights put off an immense amount of heat but don't have options for air cooling. As such, these lamps should be kept at least three to five feet above the garden canopy so that they don't burn plant foliage. In gardens with taller plant species, these DE HPS set-ups can require 12-foot ceilings. So, if the ceiling height of their indoor growroom is limited, a cultivator may choose to use an air-cooled SE HPS system or LED lights instead.

Grow lights also affect the ambient air conditions inside a growroom, so cultivators need to consider how they will combat this in the design process. To illustrate, if a grower chooses to utilise an air-cooled lighting set-up in their operation, they must account for the functionality of ducting, exhaust fans, intake ports, and outtake ports. Likewise, an indoor gardener opting for a DE HPS setup will likely require an A/C system, so they must consider the placement and installation of variables like copper tubing, industrial airflow, exhaust ports, and condensation hoses. Not all growrooms can accommodate these requirements, especially those built inside another room.

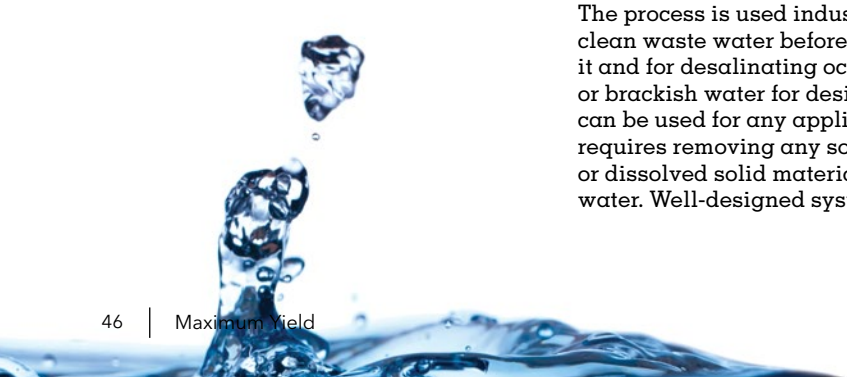
> "THE DESIGN and build of an economical, functional, and successful indoor garden is a careful balancing act of planning."

The design and build of an economical, functional, and successful indoor garden is a careful balancing act of planning. While lighting systems are crucial elements to consider in the creation of indoor growrooms, they are not always the most logical part with which to start the planning process. Instead, a grower should plan their lighting system around the infrastructural options they already have available in their room. Often, this means growers should think logically when planning their lighting systems rather than automatically latching onto the latest advancements and trends in horticultural lighting technology.

UNDERSTANDING REVERSE OSMOSIS AND HOW IT BENEFITS PLANTS

by Chris Bond | A reverse osmosis system can help keep unwanted contaminants, pesticides, and bacteria out of your grow system. Chris Bond explains how the process works and offers up some other water purification alternatives.

Reverse osmosis, often abbreviated as RO or R/O, is a process in and of itself, or part of a larger system of water purification. Reverse osmosis can remove a wide range of contaminants potentially found in both private and public water supplies. It is most well known as a treatment for rendering water potable (often in combination with a water-softening system) for private drinking systems but has several other applications as well. The process is used industrially to clean waste water before discharging it and for desalinating ocean, sea, or brackish water for desired use. It can be used for any application that requires removing any solid material(s) or dissolved solid materials from water. Well-designed systems will remove between 95 and 99 per cent of contaminants and particles.The reason for using RO can be generalised by saying it is used whenever one needs to remove anything affecting the colour, taste, smell, or quality of water. More specifically, it can remove unwanted and dangerous pesticides such as 2-4D, Lindane, and Atrazine, as well as metal ions like mercury, cadmium, copper, and aluminum, as well as particles such as asbestos. It is widely used by both home-owners and professional growers alike. These systems are either installed where water enters the home or building (point of entry/POE) or anywhere along the line where it will be needed (point of use/POU) if purified water is not needed everywhere in a particular structure.



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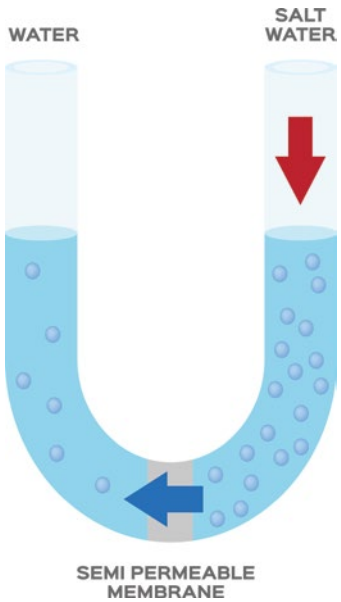
HOW REVERSE OSMOSIS WORKS

Water introduced into a reverse osmosis system first passes through a sediment filter to remove large particles, then through a semipermeable membrane for minute particles. This membrane is able to obstruct the flow of almost all microorganisms, pesticides, metals, and random particles. Unfortunately, it cannot restrict the transfer of dissolved gasses, but an RO system can generally remove nearly all other foreign or undesired material from getting through. The actual rate of material allowed to pass is proportionate and commensurate with size and type of the membrane, as well as how polluted the water is and the flow rate of said water.

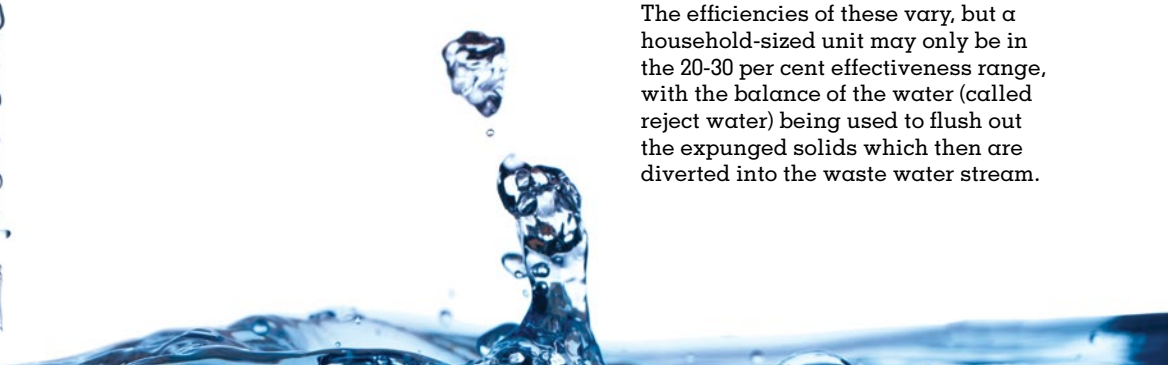


"It can be used for any application that requires removing any solid material(s) or dissolved solid materials from water. Well-designed systems will remove between 95 and 99 per cent of contaminants and particles."

Reverse osmosis membranes generally fall into two styles: spiral wound or hollow fibre types. Like anything, each has its advantages and disadvantages. Both types are designed to facilitate osmotic pressure and expose the pretreated water to as much surface area of membrane as each respective or particular system can allow. Hollow fibre membranes have more surface area, but as such they are often prone to clogging more than the spiral wound membranes. They are, however, easier to maintain. Spiral wound types are better suited for water with high volumes of total dissolved solids.

In addition to separate styles of membranes, RO membranes and systems range in their effectiveness of precluding materials of varying sizes. There are membranes that can prevent particles as small as 0.0001 microns to those that can trap particles as "large" as 0.1 microns. For purposes of scale, a micron (abbreviation of "micrometre") is one-millionth of a metre. A typical human hair ranges from less than 50 microns to just over 150 microns. Reverse osmosis membranes are made from various materials like polyamide thin film composites, or cellulosic types including cellulose acetate, cellulose triacetate, or various blends of each.

Membranes are also designated by their recovery rate, which means how much treated water they produce as compared to the amount of untreated water introduced to the system. This percentage is simply calculated by dividing the volume of expelled, treated water by the total volume of untreated water entering the system. The efficiencies of these vary, but a household-sized unit may only be in the 20-30 per cent effectiveness range, with the balance of the water (called reject water) being used to flush out the expunged solids which then are diverted into the waste water stream.



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"Water-borne bacteria that cause root rots and other fungal problems can be eliminated or greatly reduced by using an RO system."

Maintenance is yet another consideration and distinction between types of RO systems and membranes. Membranes are not permanent inserts. They need to be replaced at least every five years depending on use and sometimes as often as every one to two years. The better the system in place to pre-screen sediments and particles before entering the membrane, the longer the useful life of the membrane.

After passing through a membrane of either sort, water in an RO system then generally passes through another filter containing carbon or charcoal to remove any potential unwanted smells. It is then ready to be consumed or is suitable for use in plant production.

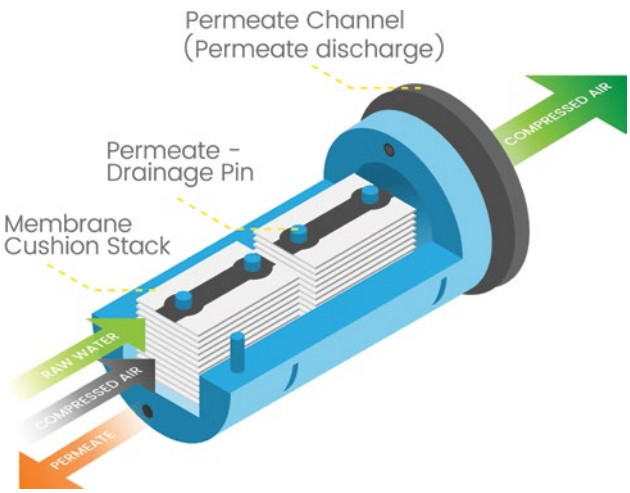
WHY REVERSE OSMOSIS IS USED IN HORTICULTURE

Plants are particularly susceptible to a wide range of contaminants often found in some water sources. In some cases those contaminants may negatively affect healthy plant growth and in worse case scenarios, the plants can absorb toxins that are then passed along to humans upon consumption of the affected plants.

In a wide variety of crop plants, contaminated water may lead to all levels of detriment to a plant. It may manifest itself as deformities, aesthetically displeasing plants (detrimental if the aim is to sell them) such as with salt buildup leading to burning of leaf margins, slow or stunted growth, and the possibility of plant senescence and ultimate death. High levels of solids/salts in irrigation water can also injure plant roots, which will in turn interfere with water and nutrient uptake. Water-borne bacteria that cause root rots and other fungal problems can be eliminated or greatly reduced by using an RO system.

In soil culture or in soilless media, the organic matter and some of the inert materials can act as a buffer to collect or absorb some of the contaminants that RO can help to reduce or eliminate. This does not mean no contaminants can or will be transferred, but less so than in growing systems, such as hydroponics, where the water comes into direct contact with the plant roots. For this reason, RO systems are heavily used in professional and commercial hydroponic operations unless frequent, routine water quality testing proves it's not needed.

Growers typically like RO systems because they allow for more accurate dosing of plant nutrients. If the irrigation water starts out with near-zero levels of particles and dissolved solids, such as with RO water, then it should have an electrical conductivity (EC) measure of zero. This means the grower does not have to guess which ions are already in the water that could bind with, and render useless, some of the added nutrients or act as a force multiplier and cause nutrient toxicity because of a buildup of any particular nutrient.

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"Growers typically like RO systems because they allow for more accurate dosing of plant nutrients."

Growers and homeowners alike need to beware of the potentially corrosive nature of RO-treated water. Some of the dissolved calcium and magnesium in hard, untreated water acts as a buffer against corrosion of pipes. With hardness removed from the water, treated water can eat away at copper or galvanized pipes much faster than if it were untreated. For this reason, growers need to make sure if they are irrigating with RO water that their watering lines can tolerate relatively pure water.

REVERSE OSMOSIS ALTERNATIVES

For growers and homeowners alike with water quality concerns, there are alternatives to RO water. A full water quality analysis by an unbiased professional or lab should be performed to determine what the potential contaminants are. It may be that an RO system is not even needed to purify water for irrigation or drinking. While test results from private companies selling or servicing water treatment equipment may be accurate, the follow-up recommendations from them may align better with their product lines and inventory than on your actual needs.

Various filters, compounds, or even light may be used as an alternative to RO treatment. The carbon filter that RO-treated water typically goes through may in fact be all that is needed to control water issues. Carbon filters control or reduce the presence of chlorine, pesticides, radon, and human-made volatile organics. Sediment filters can be used to control and exclude the presence of soil, sand, other solid particles, and even some biological contaminants like Giardia cysts. Private water supplies can be treated with small amounts of chlorine to control or kill bacteria, hydrogen sulfide, iron, and manganese. Water may even be treated by exposure to UV light to kill certain types of bacteria.

There are several other treatment options that don't require the addition of anything to the water, but rather control impurities by some mechanical or physical means such as aeration and distillation. Like RO systems, each of these potential alternatives have their respective pros and cons and should be investigated as to their likely effectiveness in your particular situation before using.

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While hydroponic crops are robust and quick growing, sometimes the taste quality can leave a lot to be desired. Lynette Morgan looks at how plant stress, and other factors, can improve the taste of crops grown hydroponically.

by Dr. Lynette Morgan

"AROMA

is an important aspect of sensory quality."

The compositional quality of hydroponic produce is something we don't often give that much thought to. It's easy to assume that all well grown, attractive, highly productive, and rapidly grown fruit and veg will automatically give a taste sensation we want to savour. Just as we expect that biting into a large, succulent red strawberry will give an incredible sensory burst of sweetness combined with that distinctive aroma. The reality doesn't always live up to expectations and sometimes that attractive berry can be insipid and lacking in any real flavour. The same is true for a wide range of plants commonly grown in hydroponics, while we can maximise yields, size, and appearance quality, nailing that intense, distinctive, home-grown flavour and aroma profile can be more challenging. This is because many of the compounds contributing to sensory quality are influenced by a diverse range of factors and aiming to just maximise yield may not necessarily give the optimum taste experience.

Aromatics

Whether it's fragrance from hydroponic blooms, the distinctive smell of crushed basil, or the Mediterranean scents of rosemary and oregano, aroma is an important aspect of sensory quality. Airborne volatile compounds, of which there may be many hundreds in each plant species, are detected by the olfactory nerve endings in the nose.

These sensations are then combined with taste receptors on the tongue to provide an overall flavour experience. However, while the tongue can detect flavour compounds in parts per hundred, we can usually detect volatiles in parts per trillion. In tomato fruit, more than 400 volatile aromatic compounds have been identified that contribute to the overall flavour experience of the fruit. In many aromatic herbs and plants we grow, it is the production and concentration of essential oils in the foliage and flowers which give the characteristic aroma and flavour. Hydroponic herbs such as basil, marjoram, mint, oregano, thyme, sage, and rosemary contain high concentrations of specific essential oils which we have come to associate with the distinctive aroma of each.

The Role of Stress in Flavour Profiles

Many of us have pleasant memories of great tasting and fantastically aromatic produce picked outdoors in the height of summer. There is some science behind this "summer flavour phenomenon" as it relates to plant physiology and it gives us insight into how plants respond to their environment. Plant stresses such as those experienced in summer include high light, lack of moisture, low humidity, warm conditions, salinity, and other issues that may all act to reduce plant growth and yields; however, they often have a positive effect on fruit flavour and aromatic compounds.

Top: The pungency of chilies can be increased by raising the EC of the nutrient solution.
Middle: Hydroponic berry flavour is influenced by genetics, nutrition, and growing conditions.
Bottom: The essential oils in herb plants contribute to the distinctive aromatics of these crops.

Left: Cherry or cocktail tomatoes usually have the highest sugar or brix levels and intense flavour which can be boosted by increased EC levels.
Above: Large, succulent fruit don't always deliver the taste sensation we expect.

Rosemary plants, for example, which originate from a hot, dry, sunshine-filled climate, concentrate essential oils in the foliage under these conditions, however, when grown in a less stressful environment, flavour and aroma can be somewhat lacking. Plants grown under some degree of climatic stress such as intense light and reduced moisture also restrict their uptake of water; this concentrates many compounds within the plant tissue which are related either directly or indirectly to flavour and aroma. Field tomatoes, for example, are often grown with "deficit irrigation practices" to concentrate the dry matter, sugar compounds, and flavour in the fruit destined for processing or fresh consumption. This application of stress science applies to several fruiting crops, where increased brix (total soluble solids or sugars) is desirable. In hydroponics, we have traditionally aimed to provide the plant with more than sufficient water and nutrients, so all its requirements are fully met. However, application of slight moisture stress is a technique sometimes used by commercial growers to improve fruit compositional quality and to also restrict unwanted vegetative growth. Moisture stress in the root zone creates a higher osmotic potential, however, this can also be achieved by increasing the electrical conductivity (EC) of the nutrient solution. Electrical conductivity control is easier to measure and manage than imposing moisture stress in the highly restrictive root zone of most hydroponic crops, and is less likely to be taken too far, causing plant damage. Bringing EC levels in the root zone up just as the plant has passed the vegetative stage and has set the first fruit is a common practice in commercial hydroponic tomato crops. This has been shown to have a number of positive effects, such as improving not only the compositional quality in terms of flavour, sweetness, and volatiles, but to also prolong shelf life and firmness which are important post-harvest factors. Modern tomato hybrids bred for greenhouse and hydroponic production are particularly tolerant to high EC levels and respond well to this technique of quality improvement. Heirloom and older tomato varieties can also respond to increases in EC to maximise flavour, however, not to the same extent as commercial hybrids and they can become more prone to disorders such as blossom end rot when this is attempted. In hydroponic tomatoes, it has been found that the flavour profile, sugar, acid, and sodium content of fruit grown at an EC of 8.0 mScm-1 was far greater than fruit grown at an EC of 3.0.

"When grown in a less stressful environment, flavour and aroma can be somewhat **LACKING."**

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"Sensory quality in hydroponic produce encompasses a complex array of **FLAVOURS."**

Top: Hydroponic basil is a crop well known for its strong and aromatic flavour. **Below:** Grapes are another fruiting crop which responds well to stress applied to improve compositional quality.

However, increasing the EC to improve flavour via a higher percentage of dry matter in the fruit tends to give smaller fruit and lower yields. So, there is often a trade-off between flavour improvements and yield potential.

With hydroponic chili crops, EC levels as high as 8.0 mScm-1 have been applied to boost pungency with good results, however, different chili cultivars will respond differently to increases in EC and growers need to determine for themselves which will give the biggest 'kick' in their fruit. When using a higher EC to increases the pungency of chilies, it's best to do this by increasing only the macro nutrients in solution (nitrogen, phosphorus, potassium, sulfur, and calcium) and maintain the trace elements at normal EC strength levels. For crops such as onions, garlic, shallots, and chives, the strong flavour and aroma is derived from the presence of organosulfur compounds. In hydroponic allium crops, these distinctive flavours have been shown to be boosted by using higher levels of nitrogen and sulfur in the nutrient solution. Brassica crops such as watercress, arugula, cabbage, kale, and others also derive much of this distinctive flavour from sulfur containing compounds called glucosinoles. Manipulation of sulfur in the nutrient solution can help boost these flavours, which range from cabbagey to peppery, and pungent in watercress to sharp and nutty in arugula.

Increasing sulfur levels in hydroponics has also been shown to assist flavour or pungency in condiment herbs such as wasabi or horseradish, which contain mixtures of volatile compounds such as isothiocyanates which give them their flavour and heat.

Other stresses that may be applied during hydroponic plant growth to improve sensory quality are also those which concentrate volatiles and influence the water balance of the plant. Ample light not only ensures maximum rates of photosynthesis, which produce assimilates or sugars which are imported into fruit, but also acts to provide another stress factor, increasing the overall dry matter accumulated by the plant. Studies have also shown that full-spectrum light, including incorporation of some UV-B wavelengths, can improve the content of antioxidant compounds in plants such as spinach grown under protected cultivation. Low humidity, which speeds up the rate of moisture loss from the foliage, influences the water balance of the plant and the resulting osmotic adjustment gives a low level of continual stress and a concentration of volatile compounds within the plant. Warm conditions, with high rates of air flow, are also stressors in many plants which can all act to play a role in dry matter accumulation.

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"OTHER FACTORS

influencing flavour should not be overlooked."

Other Flavour Factors

While stress application to improve compositional quality is a useful tool for hydroponic crops, other factors influencing flavour should not be overlooked. These include basic plant production principals such as providing a well-balanced nutrient solution, increasing potassium for plants in fruit, and containing all the essential elements. With indoor gardens, attention to light levels and leaf area determine the amount of sugar available for importation into fruit, and with many crops the leaf-to-fruit ratio is vital to ensure not only fruit size but also quality. Crops such as tomatoes, grapes, melons, and berries may need fruit thinning to ensure all fruit can receive sufficient assimilate for optimal compositional quality.

Sensory Quality and Variety Selection

While growing conditions and manipulation of the root zone EC can play a major role in quality determination, genetics are also an important tool for hydroponic growers. Varieties of the same plant species can differ considerably in flavour and aromatic profile. It's a waste of energy putting a great deal of time and effort to boost flavour using cultivars which have poor flavour genetics in the first place. So, growers should select naturally high-flavoured or aromatic varieties to experiment with stress techniques to maximise this even further.

Flavour Quality Assessment

To determine if the application of plant stress has been used successfully and achieved flavour improvement, there are a couple of different evaluation approaches. Taste testing, or "sensory evaluation," is one method, however, it can be difficult to compare samples from crops grown months apart and flavour assessment is best carried out when there are two or three different treatment samples to compare at the same time. Having a number of different people assess the samples is also advisable and blind testing, where taste panellists don't know which sample is which, is also standard practice. For a more analytical approach, lots of fruit such as berries, grapes, tomatoes, melons, and others can have sugar levels (total soluble solids) directly measured using a portable brix meter (refractometer). While industry standards for brix exist for most fresh products — as a basic guide for tomatoes, a great tasting beefsteak tomato will have a brix of at least seven, smaller cocktail types a brix of more than 10, and a poor testing fruit often have brix levels below five. Most people can usually taste a difference of just one degree in brix, however, taste is somewhat subjective with human evaluation, while brix meters give hard and fast data. Hand-held brix meters are not expensive and can be easily obtained by growers who are keen to assess their flavour improvement techniques.

Left: Moisture restriction in a free-draining substrate is one way of improving compositional quality in hydroponic tomato crops. **Above:** Alliums are crops where the strong flavour and aroma are derived from organosulfur compounds.

Sensory quality in hydroponic produce encompasses a complex array of flavours from sweet, sour, salty, and bitter, which interact with a vast number of aromatic volatile compounds to give an overall taste experience. While indoor hydroponic gardens can provide a perfect environment for high yields of beautifully presented produce, flavour and aroma can be given a helping hand with the careful application of some well-timed plant stress. Understanding how stress, osmotic adjustment, and other plant processes influence that final sought-after flavour can lead to some interesting experimentation and great tasting results.

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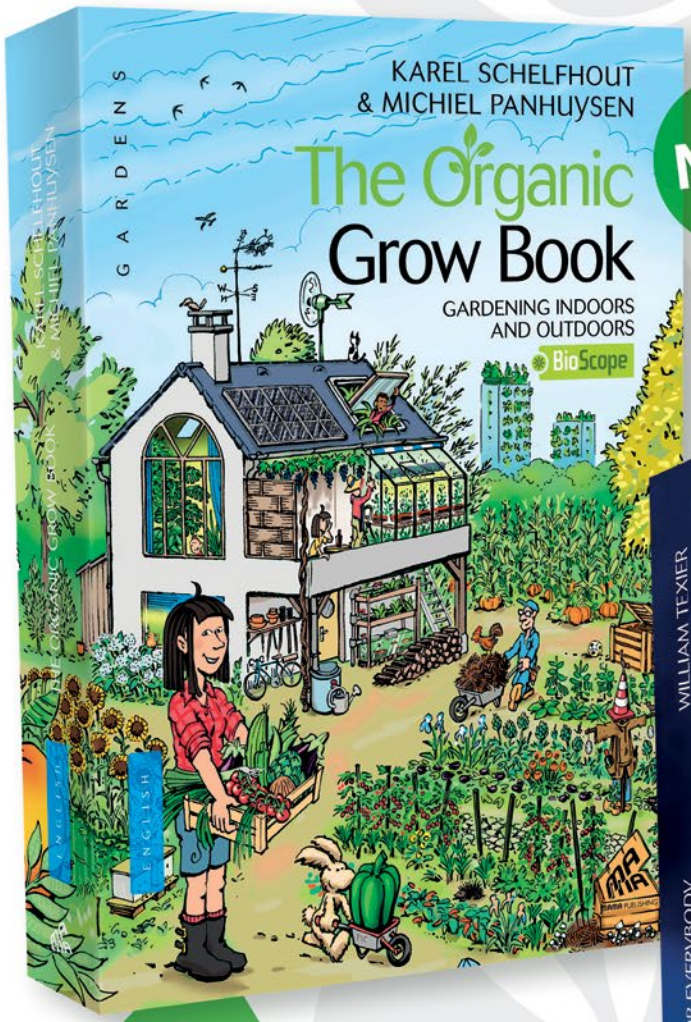

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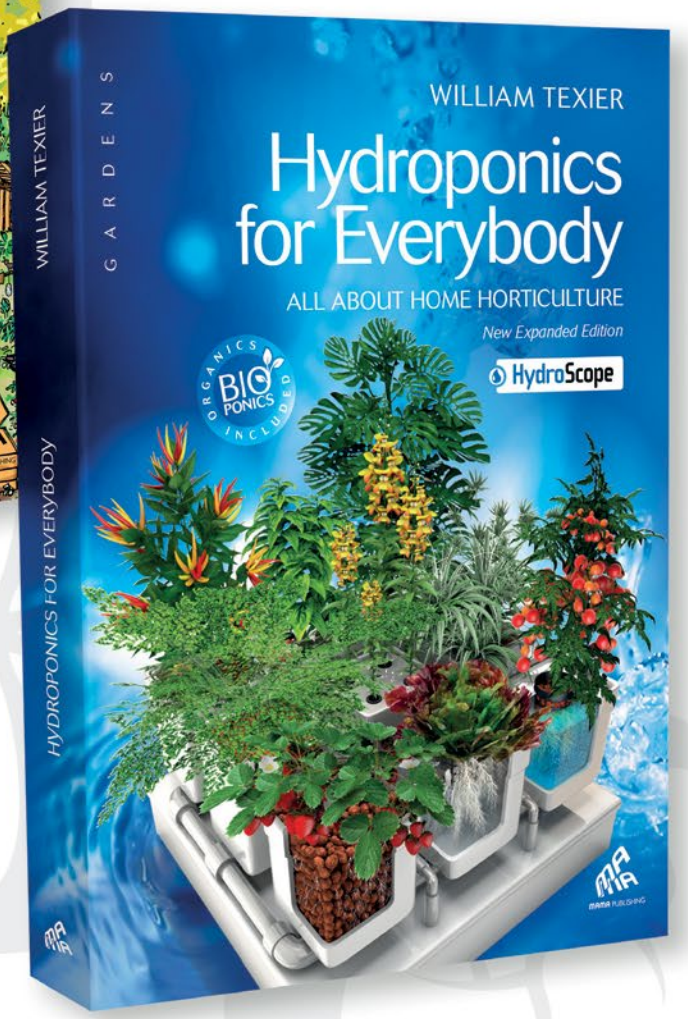

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HydroLogic takes more than 10 years of solving every water problem imaginable and scales that knowledge into HyperLogic, its new line of professional-grade industrial filter systems, purifying up to (and in some cases more than) a million gallons of water a day. We caught up with HydroLogic founder and president Rich Gellert to find out more about this interesting California-based company.

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What did you and your partners do before starting this company?

I'm the sole founder and owner of the company. Prior to HydroLogic, I was a grower obsessed with trying out every tool possible to produce consistently high-grade product. Pretty much everything that's happened since then has been my effort to leverage that passion to build a company that enables everyone to do the same. Now, we are taking that momentum to a commercial and industrial scale with HyperLogic's professional filtration systems.

How did you get into this industry?

I'm a grower myself. The quest for the perfect plant begins with realising most tap water isn't dialed in for optimal growth. I learned this the hard way and realised I needed much better technology than what was available in hydroponic retail stores at that time. I assembled some filtration systems with off-the-shelf parts that I needed for my garden and it worked out pretty well. Well enough, in fact, that all of a sudden, my buddies wanted the same garage-built filtration system for their own gardens. And then boom, it just exploded from there. It's funny because the conversations I'm having with guys with multi-million-dollar operations are not dissimilar from the ones I was having with people who didn't understand why their little garden was failing all those years ago.

When and where did the company begin?

Santa Cruz, California. It's famous for smart hippies so, makes sense some serious growers are here.

How does your company philosophy translate to opportunities?

Necessity is the mother of invention. I needed a better water filter, so I built one.

"NECESSITY IS THE MOTHER OF INVENTION."

What did you first produce?

A 100-gallon-per-day reverse osmosis system I called "The Stealth-RO" because it was a stealthy operation in my garage and it's mainly all black in colour.

What were some of your struggles as you started the business?

Space. I was working out of my garage. When I outgrew that, I rented a shipping container I kept in my side yard. Next, I shared the soil room with Santa Cruz Hydroponics, then eventually my own warehouse, and today we operate out of a state-of-the-art, 20,000-foot facility. I also did everything myself…wore all the hats for the first year or so.

How did you overcome them?

Bit the bullet and spent the money on a larger space and hired one employee!

How did you gain market share and recognition?

Well, believe it or not (former Maximum Yield co-owner) Linda Jesson convinced me to do my very first trade show in San Francisco in 2006. That thrust me into the market immediately. I also did a lot of advertising with and wrote educational articles for *Maximum Yield* magazine.

Then there were countless hours on the road visiting stores and spreading the gospel of water filtration. Demand for our products grew quickly. HydroLogic has been dedicated to refining these water filters on so many levels: efficiency, conservation, ease of us, not to mention price. But I'm most proud of how we've nailed down our customer service pipeline. We make sure our customers are taken care of and I believe our reputation and market share speaks to that.

Has your company moved or expanded since the beginning?

We have done nothing but grow in the past few years, so yeah, we've had to increase our physical footprint at least three times in the past half decade. It's not really slowing down for us either. The water out there isn't getting any cleaner; unfortunately, it's the opposite.

What is your current product line?

We sell everything from personal scale to municipal scale water filtration systems. Our most popular hobby line is still the Stealth-RO, which remains the best-selling hydroponic water filter in the world. But it's been amazing to watch the commercial department grow so quickly in the past few years. We build all of the commercial systems from scratch, completely customised to the operation's source water chemistry.

Where do you distribute?

USA, Canada, Mexico, Europe, Central and South America.

"QUALITY COMES FIRST, ALWAYS."

How many people now work for the company?

Twenty extremely hard-working, dedicated clean-water enthusiasts.

What are your company's strengths?

The HydroLogic crew is a smart, nimble group. We all wear a lot of hats and therefore share a lot of common strengths, especially as it pertains to understanding water-related issues.

What are some of your proudest moments?

Coachillin' Cannabis Business Park. A 165-acre campus grow facility comprised of an education centre, demonstration farms, a brewery, and restaurant. We supply the entire park's water via our industrial reverse osmosis systems.

What significant things have you learned so far about the industry?

Primarily that prosperous businesses have a tight formula for success and the contributors to that formula are legitimate, seasoned experts. There are no shortcuts or gimmicks to make an operation fly. If you want premium-grade product on an industrial scale, one weak link, one unconsidered variable that shouldn't have existed, can throw the entire program under a bus. Don't be that guy, do your homework.

What have you learned about starting and growing a company?

You can't build a business on inferior products or service, hoping to make it better in the future. You must love what you do enough to understand every possible thing about it and be willing to make the investment to upgrade the current formula. Quality comes first, always.

What words of wisdom can you share about the business, the industry, or the future of the industry?

There's so much potential out there, the possibilities can become overwhelming. *Focus*. Become an authority in your niche. Know more about the thing than the current guru knows about the thing. Be able to speak fluently about it with one person or an auditorium full of people. You need to be that good, because this is a competitive industry, for sure.

Share your favourite story from a day on the job.

In one day, I sold a million dollars worth of water filtration. This was a moment when I really had to pause and take stock on how far the company has come from its humble beginnings in my garage.

What makes your employees so awesome?

We take our business very seriously, but my employees do a great job of keeping the vibe light around the office. We also do a free lunch Friday where everyone eats together, plus after-hours gatherings where we just hang out and have fun together!

Please feel free to include anything further you'd like to share.

My team and I are genuinely excited to see what challenges and opportunities are up next for Hydro and HyperLogic.

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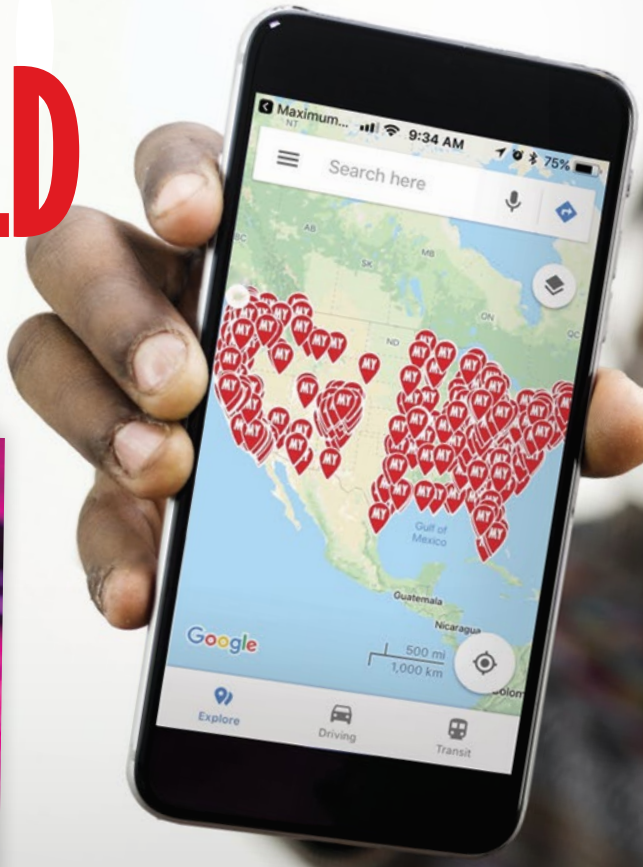

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Somersby NSW 2250
(02) 4340 0339

The Grow Shed
4/22 Alliance Ave.
Morisset NSW 2264
(02) 4972 6872

The Grow Shop
5/5 Forge Dr.
Coff's Harbour NSW 2450
(02) 6651 9992

The Petshop Boyz
Unit 1/ 5-7 Channel Rd.
Mayfield West NSW 2304
(02) 4960 0708
petshopboyz.com.au

TN Hydroponics
1/43 Chadderton St.
Cabramatta NSW 2166
(02) 9724 5692

Tweed Coast Hydroponics
2/58 Machinery Dr.
Tweeds Head South NSW 2486
(07) 5524 8588

Uncle Wal's Gardenland
31 Cres. Ave.
Taree NSW 2430
(02) 6550 0221

VN Hydro
8 Robert St.
Belmore NSW 2192

Warrawong Hydroponics Centre
240 Cowper St.
Warrawong NSW 2502
(02) 4274 8001
warrawonghydro@hotmail.com

Westside Lighting & Electrical (Ezi Range)
PO Box 274
Mascot NSW 1400
1 800 661 475

Wollongong Hydroponic Centre
318 Crown St.
Wollongong NSW 2500
(02) 4225 8773

NORTHERN TERRITORY

Darwin Hydroponics
5/8 Andrews St.
Berrimah NT 0828
(08) 8947-2576

Katherine Hydroponics Centre
17 Rundle St.
Katherine NT 0850
(08) 8972 1730

Top End Hydroponics
1785 Leonino Rd.
Darwin River NT 0841
(08) 8988 6076

QUEENSLAND

Advanced horticultural Supplies - Gold Coast
6/68 Blanck St.
Ormeau QLD 4208
0435 255 856
adhs.com.au

Advanced Horticulture Supplies - Noosaville
Shop 3 11 A Venture Dr.
Noosaville QLD 4566
(07) 5641 1256
adhs.com.au

Allgrow Hydro
13 - 58 Bullock Head St.
Sumner Park QLD 4074
(07) 3376 7222

Aqua Gardening
Unit 3, 4 Billabong St.
Stafford, Brisbane QLD 4053
(07) 3354 1588

Aqua Gardening
Shop 3/73 PIckering St.
Enoggera QLD 4051
(07) 3354 1588

Aquatic Oasis
Unit 2/33 Smith St.
Capalaba QLD 4157
(07) 3245 7777

Billabong Hydroponics
Lot 1 Billabong Crt.
Childers QLD 4660
(07) 4126 3551

D-Bay Hydroponics Shop
5/404 Deception Bay Rd.
Deception Bay QLD 4508
(07) 3204 8324

E.T. Grow Home
Unit 1/4 Windmill St.
Southport QLD 4215
(07) 5591 6501

Eye Lighting Australia Pty Ltd.
PO Box 306
Carole Park QLD 4300
(07) 3335 3556

Frans Hydroponics
Shed 3 1191
Anzac Ave. Kallangar QLD 4503
(07) 3285 1355

Gold Coast hydroponics
42 Lawrence Dr.
Nerang QLD 4211
(07) 5596 2250

Grow Hydro
22 Mining St.
Bundamba QLD 4304
(07) 3816 3206

H2 Gro Pty Ltd
2 Sonia Crt.
Raceview QLD 4305
(07) 3294 3253

Home Grown Hydroponics
4/9 Barnett Pl.
Moledinar QLD 4214
(07) 5571 6666

Hyalite Varsity
5/11 John Duncan Crt.
Varsity Lakes QLD 4227
(07) 5593 7385

Hydrocenter Hydroponics
46 Spencer Rd.
Nerang QLD 4211
(07) 5527 4155

HydroMart Hydroponics
1/23 Victoria St.
Capalaba QLD 4157
(04) 3127 8211

Hydroponic Roots & Shoots
Lot 3 Herberton Rd.
Atherton QLD 4883
(07) 4091 3217

Hydroponics & Garden Supplies
93 Cook St.
Portsmith QLD 4870
(07) 4035 5422

Hydroponics Today
PO Box 785
Stanthorpe QLD 4380
(07) 4683 3133

Indoor Solutions
Unit 2/79 Oxford Tce.
Taringa QLD 4068

J&K Hydroponics
387 Progress Rd.
Wacol QLD 4076
(07) 3271 6210

KY Garden
3/31 Argyle Parade
Darra Brisbane QLD 4076
(07) 3375 9098

Logan Hydroponics
13/22, Allgas St.
Slacks Creek QLD 4127
(07) 3299 1397
loganhydroponics.com.au

North Queensland Hydro Supplies
Shop 2B/20-22 Fleming St.
Townsville QLD 4810
(07) 4728 3957

Northern Hydroponics
383 Mulgrave Rd.
Cairns QLD 4870
(07) 4054 5884

NQ Hydroponics
1/31 Casey St.
Aitkenvale, Townsville QLD 4810
(07) 4728 3957

Pioneer Hydroponics
194 Doyles Rd.
Pleystowe QLD 4741
(07) 4959 2016

Simply Hydroponics Gold Coast
42 Lawrence Dr.
Nerang QLD 4211
(07) 5596 2250

Slacks Creek Hydroponics
#13/22 Allgas St.
Slacks Creek QLD 4217
(07) 3299 1397

Sunstate Hydroponics
7/10 Fortune St.
Geebung QLD 4034
(07) 3265 3211

Sunstate Hydroponics
10/13 Kerryl St.
Kunda Park QLD 4556
(07) 5445 3499

Town & Country Hydroponics
Shop 1/8585 Warrego Hwy.
Withcott QLD 4352

Tumbling Waters Hydroponics
2 Clarkes Track
Malanda QLD 4885
(07) 4096 6443

Walsh's Seeds Garden Centre
881 Ruthven St.
Toowoomba QLD 4350
(07) 4636 1077

SOUTH AUSTRALIA

Adelaide Hydro
Shop 3.267 Goodwood Rd.
Kings Park SA 5034
(08) 7230 5907
adelaidehydro.com.au

Advanced Garden Supplies
3/8 Bredbo St.
Lonsdale SA 5160
(08) 8382 1191

Amazon Aquariums & Gardening
Unit 5 16 Research Rd.
Pooraka SA 5095
(08) 8359 1800

Ascot Park
753 Marion Rd.
Ascot Park SA 5043
(08) 8357 4700

Barry's Hardware
Saints & Main North Rd.
Salisbury Plains SA 5109
(08) 8281 4066

Back Street Traders
Unit 6/8 Lindsey Rd.
Lonsdale SA 5160
(08) 8322 4383

Bloomin' Hydroponics
5/535 Martins Rd.
Parafield Gardens SA 5107
(08) 8281 6395

Bolzon Home & Garden
103 Tolley Rd.
St Agnes SA 5097
(08) 8265 0665

Chocablock Discount Variety Store
15-17/1220 Grand Junction
Hope Valley SA 5090
(08) 8396 3133

Complete Hydroponics
1581 Main North Rd.
Salisbury East SA 5109
(08) 8258 4022

Country Hydro
434 Saddleback Rd.
Whyalla SA 5600
(08) 8645 3105

D & W Dependable Hardware
45B Kettering Rd.
Elizabeth South SA 5112
(08) 8287 6399

Every Thing Hydro
Shop 2/494 Main North Rd.
Blair Athol SA 5084
(08) 8260 3335

Festive Hydro
2 Kreig St.
Evanston Park SA 5116
(08) 8523 5100

Fulham Gardener Nursery
597 Tapleys Hill Rd.
Fulham SA 5024
(08) 8235 2004

Future Garden Concepts North
Shop 2 21-23 Kreig Rd.
Evanston Park SA 5116
(08) 8523 5100

Futchatec Distribution
4 Symonds St.
Royal Park SA 5014
(08) 8447-1122

Glandore Hydroponics
644 South Rd.
Glandore SA 5037
(08) 8371 5777
www.glandorehydro.com

Greener than Green
52 - 54 Cliff Ave.
Port Noarlunga South SA 51
(08) 8386 2596

Greenhouse Superstore Lonsdale
35 to 37 Aldenhoven Rd.
Lonsdale SA 5160
(08) 8382 0100

Greenhouse Superstore Royal Park
4 Symonds St.
Royal Park SA 5014
(08) 8447 5899

Gro Pro Hydro
3 Kelly Rd.
Willaston SA 5118
(08) 8522 7761

Ground-Up Service Nursery
3 Copinger Rd.
Pt. Pirie SA 5540
(08) 8264 9455

Gully Hydro
32 Famechon Cres.
Modbury North SA 5092
(08) 8264 9455

Hackham Garden & Building Supplies
32 Gates Rd, Hackham SA 5163
(08) 8382 4754

Harvest Time Hydroponics
Shop 3/146-148
Findon Rd. Findon SA 5023
(08) 8244 0222

Hindmarsh Hydroponics
39a Manton St.
Hindmarsh SA 5095
(08) 8346 9461

Highland Grow & Flow
14/1042 Grand Junction Rd.
Holden Hill SA 5088
(08) 8395 4455

Hong Kong Hydro
13 Research Rd.
Pooraka SA 5095
(08) 8260 2000

Hush Hydroponic Wholesalers
25 Charlotte St.
Smithfield, SA 5114
(08) 8254 1585

Hydro Heaven
Kane Motors-Hunt Rd.
Mount Barker SA 5251
(08) 8391 1880

Hydro Sales & Service
1 Salisbury Cres.
Colonel Light SA 5041
(08) 8272 2000

Hydro Technics
321 South Rd.
Croydon SA 5008
(08) 8241 5022

Hydro Technics North
22 Peachey Rd.
Elizabeth West SA 5113
08 8252 7988

Hydro Warehouse
181 Seacombe Rd.
South Brighton SA 5048
(08) 8377 1200

Hydro Wholesalers
181 Seacombe Rd.
South Brighton SA 5048
(08) 8377 1200

Hydro World
40 Folland Ave.
Northfield SA 5085
(08) 8262 8323
hydroworld.com.au

Koko's Hydro Warehouse
Unit 2/2 McGowan St.
Pooraka SA 5095
(08) 8260 5463

Larg's Bay Garden Supply
239 Victoria Rd.
Largs Bay SA 5016
(08) 8242 3788

Martins Rd. Hydro
5- 353 Martins Rd.
Parafield Gardens SA 5107
(08) 8283 4011

Mitre 10 Dr. In
152 Hanson Rd.
Mansfield Park SA 5012
(08) 8445 1813

New Age Hydroponics
135-137 Sir Donald Bradman Dr.
Hilton SA 5033
(08) 8351 9100
newagehydro.com

Owen Agencies
17-19 Railway Terr.
Owen SA 5460
(08) 8528 6008

Palms & Plants
175 Salisbury Hwy.
Salisbury SA 5108
(08) 8285 7575

Professional Hydro
4/522 Grange Rd.
Fulham Gardens SA 5024
(08) 8353 0133

Professional Hydro
Shop 5/645 Lower North East Rd.
Paradise SA 5075
(08) 8365 5172

Professional Hydroponics
113 Maurice Rd.
Murray Bridge SA
(08) 8532 3441

Rob's Garden Centre
Shop 3/364 North East Rd.
Windsor Gardens SA 5087
(08) 8369 2498

Seaton Hydroponics
129 Tapleys Hill Rd.
Seaton SA 5023
(08) 8268 2636

Soladome Aquaculture & Hydro
44 Chapel St.
Norwood SA 5067
(08) 8362 8042

South Coast Hydroponics
6/25 Gulfview Rd.
Christies Beach SA 5165
(08) 8384 2380

State Hydroponics & Homebrew Supplies
174 Semaphore Rd.
Exeter SA 5019
(08) 8341 5991

Tea Tree Gully Hydro
32 Famechon Cres.
Modbury North SA 5092
(08) 8264 9455

Two Wells Hardware
86 Old Port Wakefield Rd.
Two Wells SA 5501
(08) 8520 2287

Urban Grow Solutions
1/111 Main Sth Rd.
O'Halloran Hill, SA 5189
(08) 8322 0040

Waterworld Home & Garden Supplies
9 Aldershot Rd.
Lonsdale SA 5160
(08) 8326 2444

Warehouse of Garden
89 Helps Rd.
Burton SA 5110
(08) 8280 3314
warehouseofgarden.com.au

West Garden Centre
Peachey Rd.
Elizabeth West SA 5113
(08) 8255 1355

TASMANIA

Advanced Hydroponics
26 Mulgrave St.
South Launceston TAS 7249
(03) 6344 5588

Aqua Hydroponics
Rear 45 Burnett St.
New Norfolk TAS 7140
(03) 6294 9233

Ezy Grow
625 East Derwent Hwy.
Lindisfarne TAS 7015
(03) 6243 9490

Garden World
717 West Tamar Hwy.
Legana TAS 7277
(03) 6330 1177

Green Acres Hydroponics
46-48 Bingalong Rd.
Mornington TAS 7018
(03) 6245 1066
sales@greenacreshydroponics.com.au

Growers Choice
225 Main Rd.
Derwent Park TAS 7009
(03) 6273 6088

Hydroponics Systems
131 Main Rd.
Moonah TAS 7009
(03) 6278 3457

Hydroponic World
322 Bass Hwy.
Sulphur Creek TAS 7316
(03) 6435 4411

Lifestyle Gardens
167 Gilbert St.
Latrobe TAS 7307
(03) 6426 2003

Organic Garden Supplies
17 Don Rd.
Devonport TAS 7310
(03) 6424 7815

Tasmanian Hydroponic Supplies
99 Lampton Ave.
Derwent Park TAS 7009
(03) 6272 2202

The Hydroponic Company
69 Charles St.
Moonah TAS 7009
(03) 6273 1411

The Hydroponics Company
289 Hobart Rd.
Kings Meadow TAS 7428
(03) 6340 2222

VICTORIA

99 Garden Services
Unit 31 12-20 James Court
Tottenham VIC 3012
(03) 9314 8088

AAA Lush Hydroponics
2-4 The Arcade, Junction Village
Melbourne VIC 3972

Albury Hydroponics/ Cappers Hydroponics
62 Thomas Mitchell Dr.
Springvale VIC 3171
(02) 6024 4029

All Seasons Hydroponics
3 Springvale Rd.
Springvale VIC 3171
(03) 9540 8000

A-Grade Hydroponics
60/148 Chesterville Rd.
Cheltenham VIC 3189
(61) 422 064 904

Aquamatic
299 Monbulk Rd.
Monbulk VIC 3793
(03) 9756 6666
aquamatic.com.au

Banksia Greenhouse and Outdoor Garden
530 Burwood Hwy.
Wantirna VIC 3152
(03) 9801 8070

Barb's Hydro and Nursery
15 Wallace Ave.
Interverloch VIC 3196
(03) 5674 2584

Bayside Hydroponics
5/9 Rutherford Rd.
Seaford, VIC 3198
(03) 9775 0495

Belgrave Hydroponics
5/ 60-68 Colby Dr.
Belgrave Heights VIC 3160
(03) 9754 3712

Brew 'N' Grow
4 - 479 Nepean Hwy.
Edithvale VIC 3199
(03) 9783 3006

Casey Hydroponics
12 The Arcade St.
Cranbourne VIC 3977
(03) 5996 3697

Casey Hydro
78 Spring Square
Hallam VIC 3803
(03) 9796 3776

Central Hydro
Factory 3/9 Mirra Court
Bundoora VIC 3083
(03) 9466 7635
centralhydroponics.com.au

Chronic Hydroponics
31 Anderson St.
Templestowe VIC 3106
(03) 9646 8133

Crown Garden Supplies
8 Glencapel Crt.
Hillside VIC 3037
(04) 5996 6344

Discount Hydroponics
18 Princes Hwy.
Doveton VIC 3177
(03) 9792 2966

Echuca Hydroponic Nursery & Supplies
23 Ogilvie Ave.
Echuca VIC 3564
(03) 5480 2036

Echuca Pump Shop
128 Ogilvie Ave.
Echuca VIC 3564
(03) 5480 7080

Epping Hydroponics
10 Dilop Dr.
Epping VIC 3076
(03) 9408 4677
eppinghydroponics.com.au

Excel Distributors Pty Ltd
2/41 Quinn St.
Preston VIC 3072
(03) 9495 0083

F.L.O.W. Plants and Environments
66B Chapel St.
Windsor VIC 3181
(03) 9510 6832

Fastway Hydroponics
Unit 2/444 Geelong Rd.
West Footscray VIC 3021
(03) 9314 1119

Fruits of Nature Pty Ltd T/A Westside Hydroponics
202 Main Rd.
Ballarat, VIC 3350
(03) 5338 7555

Gardensmart/ AutoPot Systems
810 Springvale Rd.
Braeside VIC 3195
(03) 9701 8811

Global Hydroponics
10 Knight Ave.
Sunshine VIC 3020
(03) 9356 9400

Greenleaf Hydroponics
9a Church St.
Traralgon VIC 3844
(03) 5176 0898

Greenleaf Hydroponics
Factory 7, Ind. Pk. Dr.
Lilydale VIC 3140
(03) 9739 7311

GreenLite - Ringwood
291 Maroondah Hwy.
Ringwood VIC 3134
(03) 9870 8566

Grow 4 XS
Rear 24 Simms Rd.
Greensborough VIC 3088
(03) 9435 6425

Growlush Australia
830-850 Princes Hwy.
Springvale VIC 3171
(03) 9546 9688
www.growlush.com

Guerrilla Gardens
factory 1/4 Wren Rd.
Moorabbin VIC 3189
(03) 9912 6090
guerrillagardens.com

Holland Forge Pty Ltd.
68-70 Rodeo Dr.
Dandenong South VIC 3175
(03) 9791 8800

Hydroware
1/54 Lara Way.
Campbellfield VIC 3061
(03) 9357 8805

Hyalite Airport West
Unit 4/504-506 Fullarton Rd.
Airport West VIC 3042
(03) 9331 5452

Hyalite Bayswater
4/19 Jersey Rd.
Bayswater VIC 3153
(03) 9720 1946

Hyalite Global
10 Knight Ave.
Sunshine N VIC 3020
(03) 9356 9400

Hyalite Westend
3 Third Ave.
Sunshine VIC 3020
(03) 9311 3510

Hydroponic Central
110 Dynon Rd.
West Melbourne VIC 3003
(03) 9376 0447

Hydroware
1/54 Lara Way
Campbellfield VIC 3061
(03) 9357 8805

Indoor Garden Company
29 Glasgow St.
Collingwood VIC 3066
(03) 9416 1699

Inner City Hydroponics
155 Dardbin Rd.
Thornbury VIC 3071
(03) 9480 1078

Impact Distribution
PO Box 2188
Salisbury Downs VIC 5108
(08) 8250 1515

JB Lighting
492 - 500 Neerim Rd.
Murrumbeena VIC 3163
(03) 9569 4399

Just Hydroponics Deer Park
Shop 11, 29/39 Westwood Dr.
Deer Park (Ravenhall), VIC 3023
(03) 8390 0861
justhydroponics.com.au

Just Hydroponics Geelong
Shop 1, 22 Essington St.
Grovedale (Geelong) VIC 3216
(03) 5421 6046
justhydroponics.com.au

Just Hydroponics Hoppers Crossing
3, 8 Motto Ct.
Hoppers Crossing VIC 3931
(03) 8742 2830
justhydroponics.com.au

Just Hydroponics Mornington
Shop 4, 14 Latham St.
Mornington VIC 3029
(03) 5973 6281
justhydroponics.com.au

Latrove Valley Home Brew Supplies
PO Box 802
Morwell VIC 3804
(03) 5133 9140

Living Jungle
345 Sommerville Rd.
Footscray West VIC 3012
(03) 9314 0055

LTM Co
12/87 Hallam South Rd.
Hallam VIC 3803
(03) 8712 2421

Magick Brew
205a Bayview Rd.
McCrae VIC 3938
(03) 5981 1160

Melton Hydroponic Supplies
18/10 Norton Dr.
Melton VIC 3194
(03) 9746 9256

Midtown Hydroponics
Factory 1, 821B Howitt St.
Wendouree VIC 3355
(03) 5339 1300

Mirror Paints
110 Dynon Rd.
W. Melbourne VIC 3003
(03) 9376 0447
mirrorpaints.com.au

Monster Crop Hydroponics
567 Waterdale Rd.
Heidelberg West VIC 3081
(03) 8528 3474

One Stop Sprinklers
1 Burwood Hwy.
Wantirna VIC 3152
(03) 9800 2177

Pakenham Hydroponics
1/27-31 Sharnet Circuit
Pakenham VIC 3810
(03) 5940 9047

Pam's Home Brew & Hydroponics
61 McArthur St.
Sale VIC 3850
(03) 5143 1143

Pakenham Hydroponics
1/27-31 Sharnet Circuit
Pakenham VIC 3810
(03) 5940 9047

Prestige Hydroponics Pty. Ltd.
S 2.10 Level 2, 343 Little Collins St.
Melbourne VIC 3000
(61) 4187 81083

Revolution Harvest
9/177 Salmon St.
Melbourne VIC 3000
(04) 0242 5451

Shepparton Hydroponics
87A Archer St.
Shepparton VIC 3630
(03) 5831 6433

Simple Grow
12 Blackfriar Pl.
Weterill Park VIC 2164
(02) 9604 0469

Simply Hydroponics
5/ 411-413 Old Geelong Rd.
Hoppers Cros. VIC 3029
(03) 9360 9344

Smart Hydro Garden
3/4 Lacy St.
Braybook VIC 3019
(03) 9318 8110

St Albans Hydroponic
55 St Albans Rd.
St Albans VIC 3021
(03) 9366 7788

Sun-lite Hydroponics
23B Wood St.
South Geelong VIC 3220
(03) 5222 6730

Sunray Hydro
157 Tenth St.
Mildura VIC 3500
(03) 5023 6422

Supply Net International P/L
PO Box 171
Highbury VIC 5089
(08) 264-3600

The Hydroponic Connection
5/393 Dorset Rd.
Boronia VIC 3155
(03) 9761 0662

Urban Hy
1/59 Gilbert Park Dr.
Knoxfield VIC 3180
(03) 9764 9400

Valley Hydro and Home Brew
166 Argyle St.
Traralgon, VIC 3844
(61) 3 5164 2297

Vic Garden Pty
31B Slater Parade
Keilor East VIC 3033
(04) 3160 5025

Waterworks Hydroponics
Unit 1, 5 Brand Dr.
Thomastown VIC 3074
(03) 9465 1455

Westside Hydroponics
202 Main Rd.
Ballarat VIC 3350
(03) 5338 7555

WESTERN AUSTRALIA

Accent Hydroponics
Unit 2/141 Russell St.
Morley WA 6062
(08) 9375 9355

Aqua Post
Unit 2B 7 Yampi Way
Willetton WA 6155
(08) 9354 2888

Aquaponics WA
Lot 12 Warton Rd.
Canning Vale WA 6155
(08) 0064 0222

Bloem
PO Box 1816
Subiaco WA 6008
(08) 9217 4400

Bunbury Alternate Growing Supplies
8/13 Worcestor Bend
Davenport WA 6230
(08) 9725 7020

Creative Grow Store
1/95 Dixon Rd.
Rockingham WA 6168
(08) 9528 1310

Great Southern Hydroponics
Shop 1, 21 Hennessy Rd.
Bunbury WA 6230
(08) 9721 8322

Greenfingers World of Hydroponics Maddington
Shop 1, 6-8 Emerald Rd.
Maddington WA 6109
(08) 9452 0546

Greenfingers World of Hydroponics Midvale
22 Elliot St.
Midvale WA 6056
(08) 9274 8388

Greenlite Hydroponics
4/91 Wanneroo Rd.
Tuart Hill WA 6060
(08) 9345 5321

Growsmart Hydroponics
47768 South Coast Hwy.
Albany WA 6330
(08) 9841 3220

Hydro Hill Hydroponics
9/35 Biscayne Way
Jandakot WA 6164
(08) 6461 6816
hydrohill.com.au

Hydro Nation
41A Rockingham Rd.
Hamilton Hill WA 6163
(08) 9336 7368

Hydroponic Xpress
295 Warton Rd.
Canning Vale WA 6155
1 800 640 222

Hydroponic Solutions
1/1928 Beach Rd.
Malaga WA 6090
(08) 9248 1901
hydroponicsolutions.com.au

Hydroponic Warehouse
Unit 7/627 Wanneroo Rd.
Wanneroo WA 6065
(08) 9206 0188

Hydroponica
317 Guildford Rd.
Maylands WA 6051
(08) 9371 5757

Isabella's Hydroponics
66 Jambanis Rd.
Wanneroo WA 6065
(08) 9306 3028

Johnson's Nursery Garden Centre
30 Blencowe Rd.
Geralton WA 6530
(08) 9921 6016

Neerabup Organic & Hydroponic Supplies
Unit 1, 21 Warman St.
Neerabup WA 6031
(08) 9404 7155

One Stop Hydroponics
11 B Beechboro Rd. S.
Bayswater WA 6053
(08) 9471 7000

Perth Hydroponic Centre
Shop 4, 171-175 Abernathy Rd.
Belmont WA 6104
(08) 9478 1211

Reptile and Grow Store
Unit 7 - 117-119 Dixon Rd.
Rockingham WA 6168
(08) 9527 2245
reptileandgrow.com

Richo's 4 Hydro
Unit 7/22 Franklin Ln.
Joondalup WA 6027
(08) 9301 4462

Southwest Hydroponics
Lot 29, Pinjarra Rd.
Mandurah WA 6210
(08) 9534 8544

The Grow Room
1/1451 Albany Hwy.
Cannington WA 6107
(08) 9356 7044

The Great Indoors
Unit 1/25 Gillam Dr.
Kelmscott WA 6111
(08) 9495 2815

The Watershed Water Systems
150 Russell St.
Morley WA 6062
(08) 9473 1473

The Watershed Water Systems
2874 Albany Hwy.
Kelmscott WA 6111
(08) 9495 1495

The Watershed Water Systems
1/146 Great Eastern Hwy.
Midland WA 6210
(08) 9274 3232

Tolesas
No. 6 Abbey Rd.
Armandale WA 6112
(08) 9497 3527
tolesasgrowsmart.com.au

Tru Bloomin Hydroponics
7/36 Port Kembla Dr.
Bibra Lake WA 6163
(08) 9434 5118

Water Garden Warehouse
14 Drake St.
Osborne Park WA 6017
(08) 9443 7993

NEW ZEALAND

Easy Grow New Lynn
3018 Gt North Rd.
New Lynn, Auckland
(09) 827 0883

Easy Grow Manukau
15/69 Wiri Station Rd.
Manukau, Auckland
(09) 263 7560

Guru Gardener
14 Molesworth St.
New Plymouth
(06) 758 6661

Otaki Hydroponics
1083 S.H. 1 South Otaki
(06) 364 2206

House of Hydro
221 Waiwhetu Rd.
Lower Hutt, Wellington

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FACTS ON

MITOCHONDRIA

by Philip McIntosh

Cells require energy. Enter the organelle often referred to as the "powerhouse of the cell," **the mighty mitochondrion.**

MITOCHONDRIA ARE small, round to oblong organelles only found in eukaryotes. They don't look like much on the outside, but they have a complex structure consisting of a double membrane system with a large surface area for housing enzymes.

TO UNDERSTAND the role of mitochondria, it is helpful to know something about energy transformations in cells. Energy is required to perform the myriad molecular tasks that keep a cell alive and functioning.

GLUCOSE IS often thought of as an energy source. This is only true because of the action of mitochondria, which ultimately are responsible for generating the cell's true energy currency.

THIS TRUE cellular energy currency is adenosine triphosphate, better known as ATP.

ANYWHERE A small energy "kick" is required (to assist an enzyme in its action, for example), one of the three phosphate (PO_4^{3-}) groups on an ATP molecule is removed and added to some receiving substrate molecule.

THE DONATION of the phosphate group changes the ATP to adenosine diphosphate (ADP). The receiving molecule has been phosphorylated.

THE PHOSPHATE molecule can be removed from the substrate and added to an ADP to convert it back into ATP once again. It is this specific and highly localized on-off exchange of phosphate groups that releases energy to drive chemical reactions within the cell.

ATP IS a big deal, and that is where mitochondria come in. In plants, the glucose resulting from photosynthesis is split into two pyruvate molecules. Pyruvate then enters the mitochondria where it is transformed by dozens of orchestrated reactions to generate 30 ATP molecules for every starting glucose molecule.

AN IMPORTANT phase of the ATP production process occurring inside mitochondria is the citric acid cycle (a.k.a. the carboxylic acid cycle or Krebs cycle), the elucidation of which led to a Nobel Prize for Hans Krebs and Fritz Lipmann in 1953.

MITOCHONDRIA are able to fuse and, like chloroplasts, they contain their own DNA and multiply in a way that looks a lot like bacterial fission. According to endosymbiont theory, both mitochondria and chloroplasts are derived from prokaryotes that were taken up by host cells in the early days of life on Earth.

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