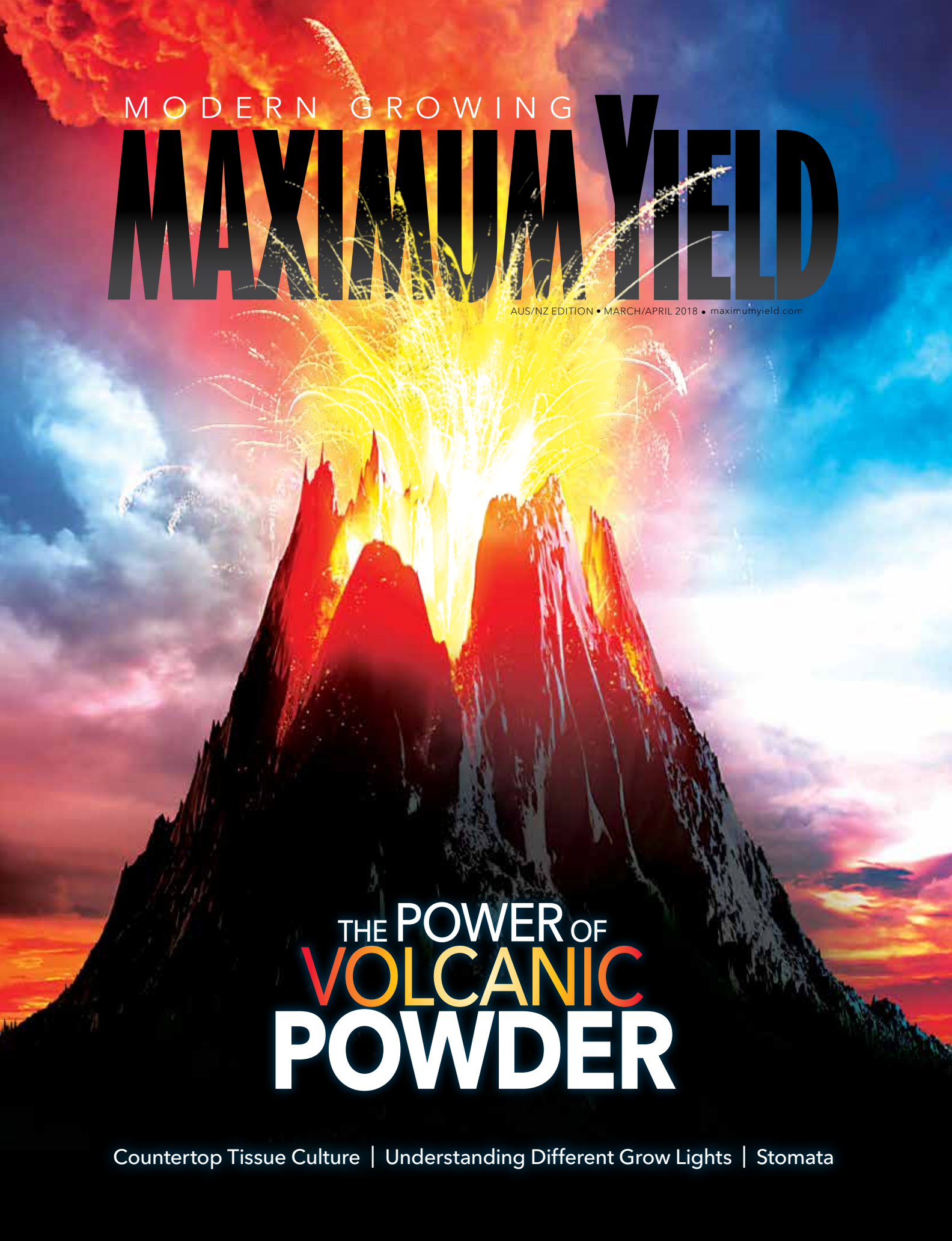

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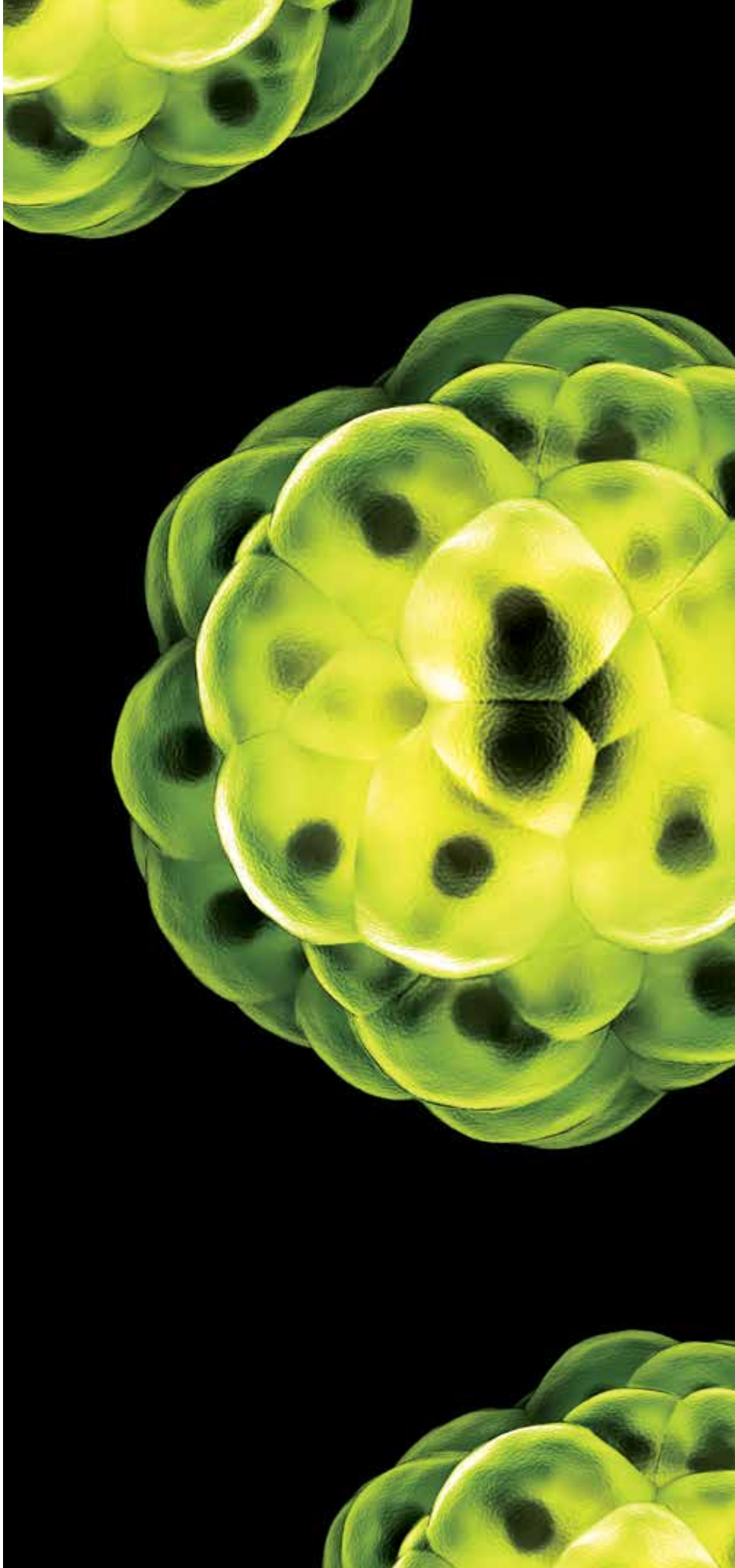

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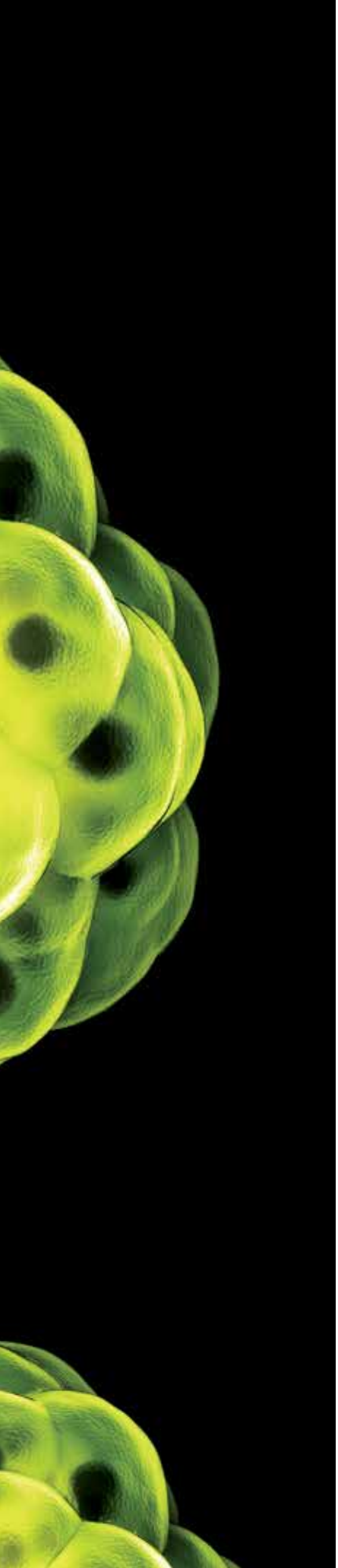

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from the editor

> "Knowing how your plants function will help you make better decisions when providing for them."

It's never a bad time to brush up on a few biology basics. As we've covered in recent issues with topics like methyl jasmonate (*Maximum Yield*, January/February 2018), plant biology is amazing. In this issue of *Maximum Yield*, we explore the process of how plants breathe (Story of Stomata on page 46) and tissue culture on page 38. Knowing how your plants function will help you make better decisions when providing for them, whether your garden is indoors or outdoors. Understanding plant biology will also help when considering more advanced procedures, like propagation through cuttings (page 58), or why some lights are more effective in certain situations than others (page 50).

Of course, the entire reason we grow our own food is to have a closer connection to it, and to produce healthier and tastier produce than what the global supply chain can offer. In Monica Mansfield's cover story Volcanic Power on page 28, she provides a few ideas on why using volcanic basalt powder can really add to your food by boosting your soil's mineral content.

For more tips and ideas, check out our Max Facts section starting on page 16, and our Good to Grow section on page 20 will point you in the right direction for all the grow gear you need to get your garden off to a good start.

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

MAXIMUM YIELD

VOLUME 15 – NUMBER 6
March/April 2018

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I personally wanted to thank you for all that you do for the industry! I work as a sales specialist for Greencoast Hydroponics and am an avid reader of your magazine each month and have the issues here on my counter for customers to learn more about the methods involved in this industry.

[I] have always referred to your "good to grow" sections of your issues and tried several products that came up.

Matt S.

Grow Tip Tweets

Keep water temperature no higher than 70 degrees and no lower than 60 degrees. The risk of root rot increases and oxygen is depleted at higher temperatures while cold temperatures can shock your plants.

via Green Planet
@gpgrown

Nitrogen deficiency in the soil could cause the leaves to lose their green color and could lead to unhealthy plants. Compost enriched with tea and coffee grounds, manure, and kitchen waste is an excellent source of nitrogen.

via The Garden Store
@thegardenstory

Rotating crops helps improve soil stability. Alternate between crops with deep roots and those with shallow roots.

via Humic Harvest
@HumicHarvest

Shop Shout Out

We'd like to give special shout-outs to The Green Room Hydroponics and Organics, Extended Seasons Indoor Gardening, Innovative Green Solutions, and Green Gopher Garden Supply for regularly sharing our posts with their Facebook followers. For a full list of shops that carry *Maximum Yield*, check out our distributors guide starting on page 66.

There's nothing like the sense of accomplishment that comes from growing something naturally and organically with your own bare hands.

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MONICA MANSFIELD After owning an indoor garden store for 5 ½ years, Monica sold the business and started a seven-acre homestead with her husband, Owen. Monica is passionate about gardening, sustainable living, and holistic health. She writes about these topics and her homestead adventures on her blog *thenaturelifeproject.com*.

DR LYNETTE MORGAN holds a B. Hort. Tech. degree and a PhD in hydroponic greenhouse production from Massey University, New Zealand. Lynette is a partner with Suntec International Hydroponic Consultants and has authored several hydroponic technical books. Visit *suntec.co.nz* for more information.

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Q

Hello,

I have a sealed growroom with CO_2 in my fruit cellar in my basement. I find the lights can get the room up to 31°C and wanted to know if I was to hook up a fan and draw the 4°C outside air in, would I be passively pushing the CO_2 out through small cracks? Your insight would be greatly appreciated.

Thanks!
David

A

Hello David,

Thank you for your question. Enriching a grow environment with CO_2 is a great way to boost growth rates and a garden's overall productivity. To operate a CO_2-enriched environment most efficiently, a grower needs to make some adjustments to the growroom's atmospheric conditions. As an example, a typical growroom with an enriched CO_2 level of 1,200 parts per million (ppm) will have an optimal operating temperature that falls in the 26-30°C range. This is roughly two to five degrees higher than the optimal operating temperature of a growroom without CO_2 enrichment.

Assuming you are enriching your environment to around 1,200 ppm, the 31°C operating temperature isn't too far off the mark. An intake fan connected to a thermostat, or even an intermittent timer, would most likely be all that you need to control the operating temperature. When using an intake fan without an exhaust fan, the growroom will experience a positive pressure. When growrooms have a positive pressure, the air (CO_2 and all) within the growroom is forced out through cracks and crannies. For some growers, this can become an odour control issue because the air escaping contains the odours of the garden. If odour is not an issue for you, I would proceed with the intake fan installation (ideally teamed with some sort of thermostat or atmospheric controller). If odour is a concern, you may want to consider a single exhaust fan combined with a carbon filter, which, when operating, would create a negative pressure in the room and draw cool, outside air into the room through the cracks and crannies. I hope this helps.

Keep on Growing,
Eric Hopper

Eric Hopper's past experience within the indoor gardening industry includes being a hydroponic retail store manager and owner. Currently, he works as a writer, consultant, and product tester for various indoor horticulture companies. His inquisitive nature keeps him busy seeking new technologies and methods that could help maximise a garden's performance.

TEMPERATURE & PHOTOSYNTHESIS

Temperature affects a plant's ability to photosynthesise and plays a key role in fruit and flower development. An increase in temperature under CO_2 enrichment enables plants to properly process the additional CO_2 in the atmosphere and increase the rate of photosynthesis, which increases plant growth. Carbon dioxide levels of 1,200-1,500 ppm will equal an increased temperature range of 26.6-32.2°C

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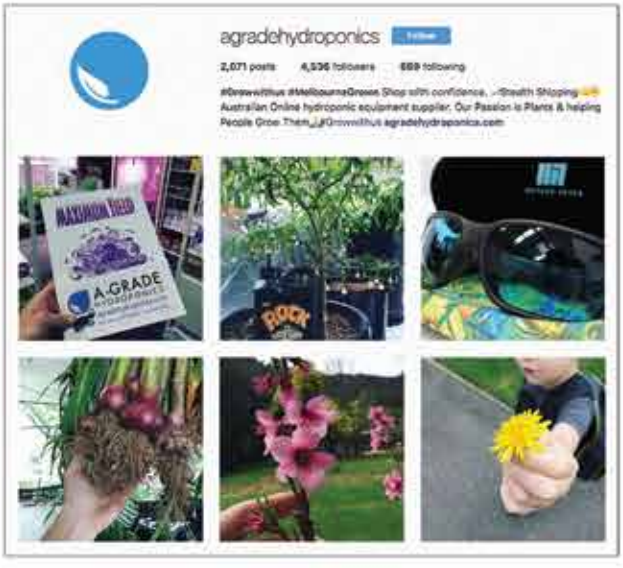

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Bacteria Help Plants Thrive in Saline Conditions

Salinity stress is a major issue faced by farmers, but new research has discovered why some plants handle salty conditions better than others: *Enterobacter cloacae*. These plant growth promoting rhizobacteria (PGPR), which grow in the soil or on the roots of plants, help the plant acquire necessary nutrients, modulate plant hormone levels, and protect the plant from pathogens. They found the PGPR influenced the production of proteins involved in stress response pathways. The research suggested that *Enterobacter cloacae* helped the plants produce more of certain cytoskeletal and cell cycle proteins to reinforce the cell structure and to ensure that cell division goes on.

– researchmatters.in

Breeding Less Selfish Crops Could Increase Yields

Over the past 10,000 years, we have bred selfish plants by focusing on each plant's individual characteristics and yields. That is, we optimised crop yields by selecting and cultivating only the strongest, most productive plants. However, a new study in *Ecology* suggests that farmers could increase yields by up to 35 per cent by cultivating more social traits in crops. "It's about imagining a new evolutionary strategy in plant breeding. What is good for individual plants is not necessarily good for the crop population in the field," says professor Jacob Weiner from the Department of Plant and Environmental Science at the University of Copenhagen, Denmark. "Traditional breeding chooses the plants that clearly give higher individual yields, but in general these plants use a lot of resources to compete with one another, which can potentially result in a poorer collective yield." So, instead of wasting time and energy competing, crops would share their resources more equally. Though individual yields may be smaller, the overall yield would increase.

– sciencenordic.com

Researchers Assess Interconnected Benefits of Urban Ag

A team of researchers led by Arizona State University (ASU) and Google have assessed the value of urban agriculture and quantified its benefits at global scale. The researchers estimated that existing urban ag areas show potential to annually produce 100-180 million tons of food; save 14-15 billion kilowatt hours' worth of energy; sequester 100,000-170,000 tons of nitrogen; and avoid 45-57 billion cubic metres of storm runoff. With intense implementation, the team estimated the overall annual worth of urban agriculture could be as much as $80-160 billion. "We've known there are benefits to having these small plots of land in our cities, but we found that the benefits extend well beyond having fresh food in the hands of those who will consume it," says lead author Nicholas Clinton of Google, Inc. "The global estimates that we provide are useful because they provide a benchmark for other researchers, but the societal benefits extend well beyond that because of the implementation of Google's Earth Engine platform," says Matei Georgescu, an ASU associate professor of geographical sciences and urban planning and a corresponding author of the paper. "Anyone on the planet who wants to know whether and how much urban agriculture can provide for their locality can now do so using open data and code provided with the paper." The findings were published in *Earth's Future*.

– sciencedaily.com

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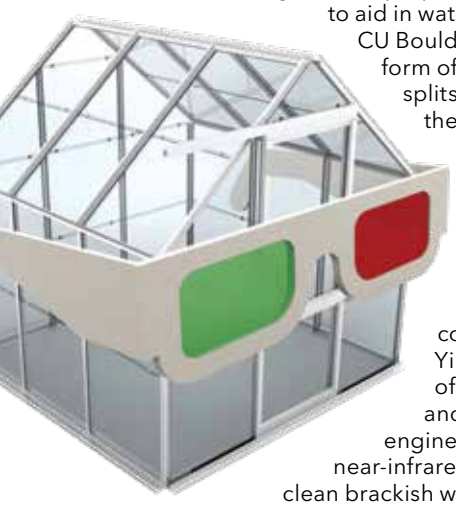
New Greenhouse Film Could Improve Photosynthetic Efficiency



University of Colorado (CU) Boulder engineers and Michigan State University's department of horticulture are working together to develop a new type of greenhouse film that could help solve food, energy, and water security challenges posed by population growth and climate change. The scalable, cost-effective material would split sunlight into photosynthetically efficient light and repurpose inefficient infrared light to aid in water purification. "The new CU Boulder technology will take the form of a semi-translucent film that splits incoming light and converts the rays from less-desired green wavelengths into more desirable red wavelengths, thus increasing the amount of photosynthetically efficient light for the plant with no additional electricity consumption," says Xiaobo Yin, an assistant professor of mechanical engineering and materials science and engineering at CU Boulder. "The near-infrared wavelengths can help clean brackish wastewater, allowing it to be recirculated in an advanced humidification/dehumidification interface and further reducing the greenhouse's energy footprint," says team leader, assistant professor Ronggui Yang. The thin material would be applied directly to the surface of greenhouse panels. The tech will be developed in a four-year research program funded by a US$2.45 million grant from the USDA.

– hortidaily.com

Study Uses Olive Mill and Paper Waste as Alternative Soilless Media

A study recently published in *Environmental Science and Pollution Research* looked at using olive stone and paper waste as substitutes for peat in soilless media for ornamental crop production. The scientists grew marigold, petunia, and matthiola in media made of various ratios of peat and the two alternatives to determine the substrate's physicochemical properties and effects on plant growth. The study indicated that olive stone waste can replace peat in quantities up to 30 per cent for marigolds and petunias and up to 10 per cent for matthiola, while the addition of paper waste onto of the olive stone waste is not recommended. It also suggested further research is needed.

– link.springer.com

Thought for Food Challenge Calls on Youth to Tackle Food Security

The Thought for Food (TFF) Challenge once again invites young innovators from around the world to develop new ideas and business concepts to tackle the challenge of sustainably feeding the world's growing population. The competition is open to everyone under the age of 35, and no pre-existing idea or business is required. From January 15 to May 4, 2018, participating teams develop new ideas through an independent online platform that offers training tools such as a design thinking lab and 12-week start-up bootcamp. Teams of three to five participants are formed and led through a series of exercises that help them identify an opportunity and develop an innovative solution. Ten finalist teams then pitch their ideas for the chance to win cash grants from TFF and its partners. The TFF Challenge culminates with the annual TFF Summit, which will be held in summer 2018. The TFF Challenge was established in 2012 to find new answers to the question: How do we feed nine-plus billion people by 2050? Previous entries to the competition have covered key areas such as vertical farming, logistics, breeding, ag tech, open data, aquaculture and livestock, food waste, synthetic biology, new proteins, and appropriate tech for smallholders.

– tffchallenge.com

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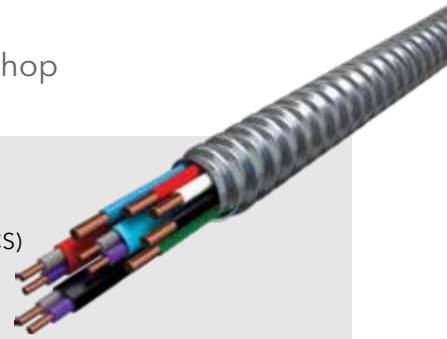

AFC Cable Systems MC Luminary MultiZone Cables

AFC Cable Systems announces a complete new line of MC Luminary MultiZone (UL type MC-PCS) Cables, the first products designed specifically for use in daylight harvesting applications. These cables are an expansion to AFC's popular line of MC Luminary Metal-Clad Cables, which combine electric lighting and control circuits under a single interlocked armour. The cables respond to daylight harvesting trends that seek to save energy and reduce power costs by dimming lights proportionally to the availability of natural light. One MC Luminary MultiZone cable can replace up to three traditional MC Luminary cables or three power and three control pair cables. The cables are offered with multiple PVC jacket colour options matched to the power conductor colours. Also offered are neutral per-phase constructions. By combining all required conductors and phases under one armour, MC Luminary MultiZone cables can replace up to six individual cable runs, increasing productivity and reducing costs. MC Luminary MultiZone cables are compliant with all applicable codes and UL standards, compatible with zero to 10 volt DC solid state lighting control systems, and digital signal compatible.

ExHale Original CO_2 Bag

The ExHale Original CO_2 Bag is designed for small to medium-sized growing spaces. These bags are ideal for gardeners who use grow tents or those growing in a roughly 4x4-foot area. In fact, the ExHale Original CO_2 Bag is guaranteed to provide CO_2 to a 4x4-foot space (or 128 cubic feet) for six months. Always remember, if your space is larger, simply add more ExHale bags.

Growlink Smart Irrigation Controller

The Growlink Smart Irrigation Controller has four sensor inputs and four relays and includes pre-set calibrations for stone wool and soil mediums. Sensor probes measure soil moisture, temperature, and electrical conductivity. Relays can be used to control values and pumps. The system works with all other Growlink products or as a standalone.

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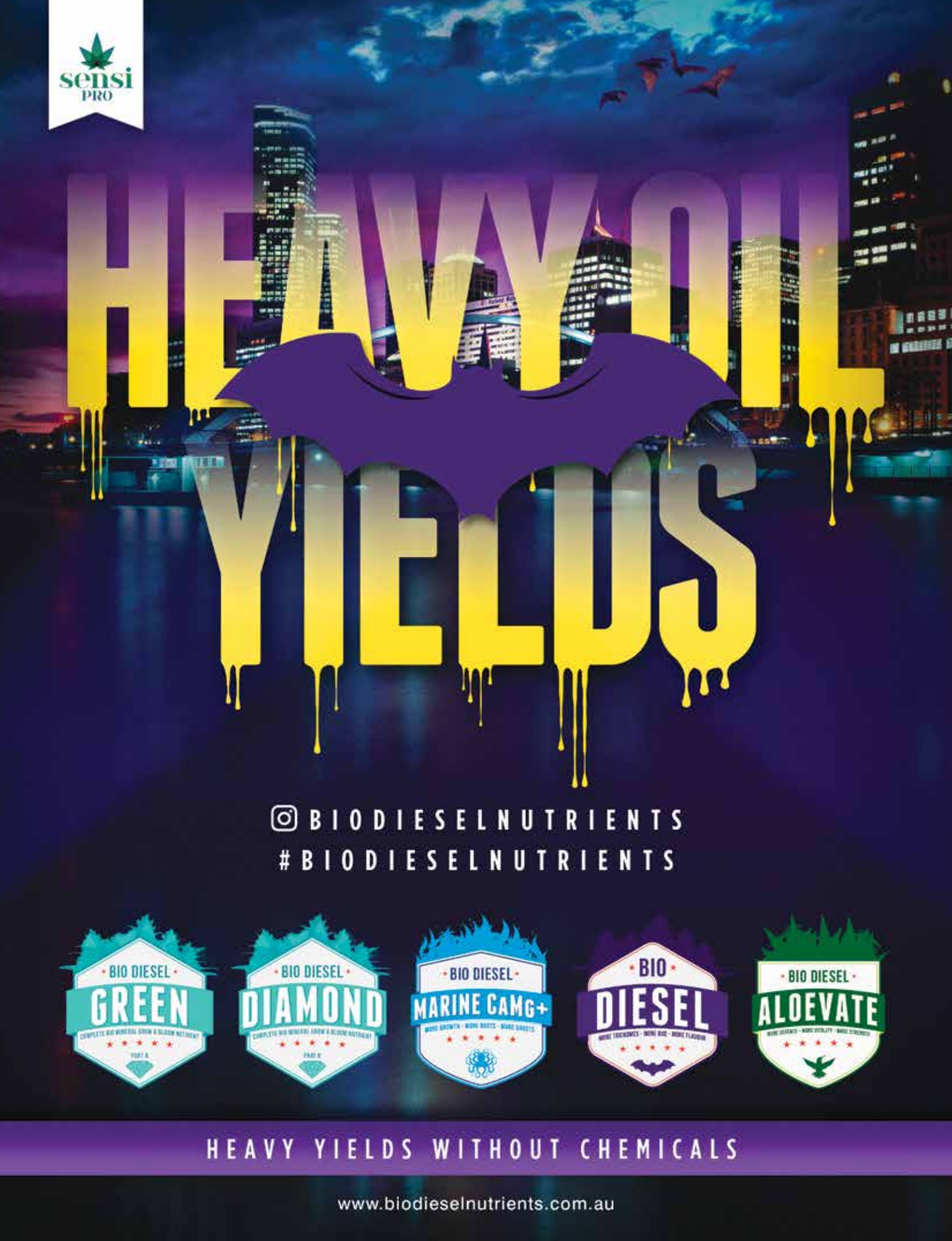
Terpinator is formulated to increase the concentration of terpenoids in aromatic plant oils and glands. The unique composition of Terpinator provides the basic building blocks that plants require to produce flavorful oils. By using naturally occurring plant and biological compounds, unique enzymatic pathways within a plant's body are utilized to enhance the production of terpenoids and plant oils. These glands are brought to their maximum potential and size using Terpinator along with a nutrient regimen. Terpinator also catalyses steps in a plant's normal metabolism that will protect and prolong fragrances of its dried fruits and flowers.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Massive Bloom Enhancer

Massive is Green Planet's flagship bloom booster. The ingredients contained allow it to not only ensure the natural manufacturing process of carbohydrates and sugars continues to operate as nature intended, but it also gives your plants an extra dose, allowing them to surpass their potential. Think of it as supercharging the photosynthesis process. The processes in the plant that the Massive bloom formulation supports allow it to noticeably increase flower size, strength of aromatics, essential oils, dry weight, resistance to stressors, and all other natural plant processes.

Method Seven Cultivator HPS Plus+

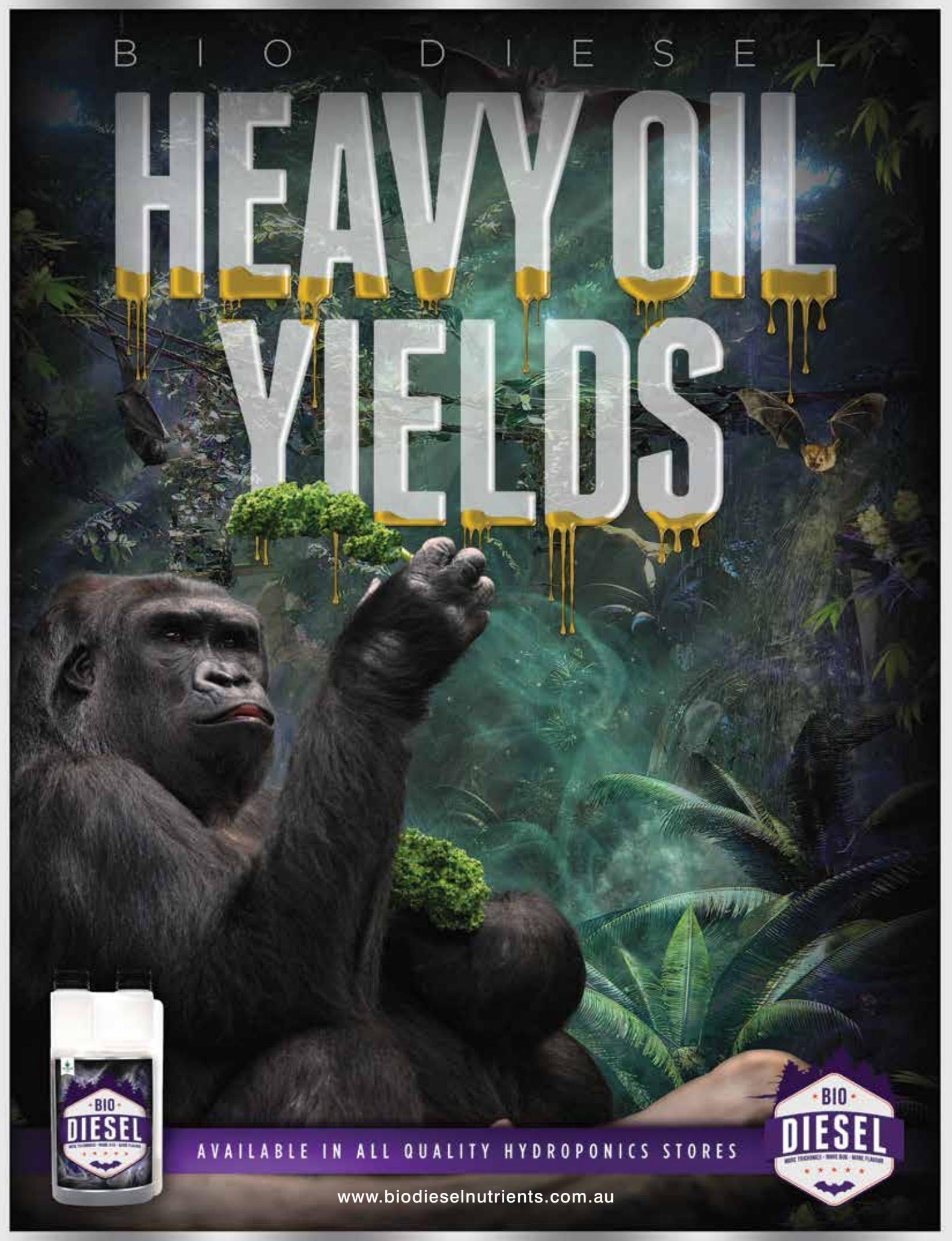
The Cultivator HPS Plus+ provides great value and exceptional colour balancing for HPS lighting. The proprietary lenses manufactured by Carl Zeiss Vision Lenses are polycarbonate with 100 per cent UV protection and a Flash Silver exterior lens coating. Like other premium eyewear and unlike typical value eyewear, these lenses are decentered (asymmetrical) to eliminate distortion that would otherwise occur with a curved lens. The Cultivator frame features a rubber nose pad, which holds the frames comfortably for hours, even in hot conditions. A microfibre pouch is included for proper cleaning and storage.

Fluence Bioengineering RAZR2

The RAZR2 array is ideal for tissue culture, seedlings, and cutting/cloning propagation as well as ornamental plugs and starter pots. It provides an average PPFD up to 160 µmol/m²/s over a 0.6x1.2-metre area with a 30.5-centimetre mounting height above canopy. The RAZR2 array includes 10 lighting modules, covers 7.4 square metres of canopy, and weighs just over 17.5 kilograms including the power supply enclosure. It typically consumes 600 watts per array. The RAZR2 is wet-location rated to easily integrate into commercial applications with little to no changes needed to the controlled environment or process workflow. Lower operating costs and improve cultivation environment with cool and efficient horticultural lighting that stacks layers upon layers with practically zero radiant heat and efficacy surpassing 2.3 µmol/J.

Growlink EC-1 Environment Controller

Monitor and control all aspects of your growroom from a single programmable controller. The Growlink EC-1 Environment Controller is designed for small room operation. It includes the new compact base controller and our new remote ESM1 Sensor Module, which measures temperature, humidity, VPD, CO_2, and light. It also comes with two Power Links that allow you to control any device.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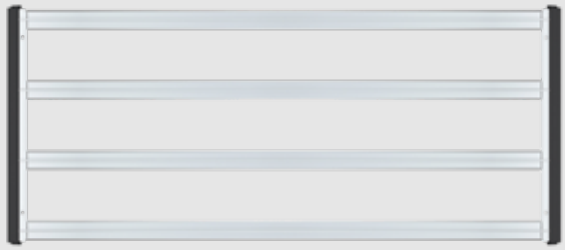

The RAZR4 array is ideal for full-cycle leafy green, basil, strawberry, and culinary herb production as well as early-stage vegetative growth for vegetables and ornamentals cultivation. It has an average PPFD up to 375 µmol/m²/s over a 0.6x1.2-metre canopy with a 12.7-centimetre mounting height above the plant canopy. The RAZR4 array includes five lighting modules, covers 3.7 square metres of canopy, and weighs about 16 kilograms including the power supply enclosure. It typically consumes 600 watts per array. The RAZR4 is wet-location rated to easily integrate into commercial applications with little to no changes needed to the controlled environment or process workflow. Lower operating costs and improve cultivation environment with cool and efficient horticultural lighting that stacks layers upon layers with practically zero radiant heat and efficacy surpassing 2.3 µmol/J.

Cole-Parmer Oakton Pocket Testers

The new and improved Oakton pocket testers from Cole-Parmer stand up to everyday use, harsh environments, and time. They are ideal for all professionals in the lab or out in the field who need to test water quality. An easy-to-replace sensor module and a dependable double-junction pH electrode sensor allow these pocket testers to stand up to the test of time. The new cap design stabilises the base to keep the tester standing upright, stores solution to keep the electrode hydrated, or works as a sample cup to calibrate or measure. Dustproof, waterproof (IP67 rating), and with a Valox® plastic body give these pocket testers have the ruggedness they need to work in harsh environments. A more intuitive interface makes reading measurements easy and reliable.

Fluence Bioengineering RAZR3

The RAZR3 array is ideal for full-cycle leafy green and microgreen production as well as propagation of vegetable and ornamental crops. It has an average PPFD up to 260 µmol/m²/s over a 0.6x1.2-metre area with an 20-centimetre mounting height above canopy. The RAZR3 array includes seven lighting modules, covers 5.2 square metres of canopy, and weighs just over 17 kilograms including the power supply enclosure. It typically consumes 600 watts per array. The RAZR3 is wet-location rated to easily integrate into commercial applications with little to no changes needed to the controlled environment or process workflow. Lower operating costs and improve cultivation environment with cool and efficient horticultural lighting that stacks layers upon layers with practically zero radiant heat and efficacy surpassing 2.3 µmol/J.

GeoPot Line

The GeoPot product line gives cultivators a single, extremely durable solution for all fabric-pot needs and growing environments. The pots' signature fabric and design help growers achieve optimal water and nutrient uptake, yielding rapid, optimal plant growth throughout each growth cycle. The GeoPot, a breathable fabric container constructed of the thickest non-woven polypropylene material available, allows air to easily reach your plants' root zones, delivering superior drainage and creating a healthier root environment. The porous material, available in black or tan to accommodate your growing environment, is reinforced with high-quality bonded-polyester thread. The GeoPot's innovative quad-stitched construction allows the container to withstand constant moisture and prolonged UV exposure while retaining its self-supporting form and structural integrity, even in challenging climatic conditions and during irrigation. The container's optional sturdy handles make it easy to quickly and safely move your plants. Available in a variety of styles.


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BY MONICA MANSFIELD

Give Your Veggies a Blast of Flavour and Nutrients

Many of today's picture-perfect vegetables lack the nutrition and flavour that make them truly great. Volcanic basalt powder, however, can help bring life back to your plate by boosting your soil's mineral content.


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> "SINCE VITAMINS and minerals are so important to our health, we need to get higher quantities of them into our food. This means we need to rebuild and heal our soil if we want to be truly healthy."

We live in a world where most consumers value pretty vegetables that lack nutrition and flavour. Our meals make for pretty photos on social media, but they are not as good for our bodies as they should be. With fewer minerals than they had 100 years ago, our food is now flavourless and our health is suffering. So, how do we fix this? It starts with replenishing our soil.

We once had rich, fertile soil. Unfortunately, in the past few hundred years, our agricultural practices have depleted our greatest asset. We have used up the soil's nutrients and minerals without putting them back, and have killed the soil life with synthetic chemicals.

These chemicals promised us larger, pest-free harvests, but we've paid a hefty price. Sure, our tomatoes are large, plump, and free of bug bites, but they taste bland and don't heal our bodies the way they once did.

MINERALS ARE IMPORTANT

Healthy soil equates to tastier food and healthier bodies. It is so profoundly simple that it is overlooked by the masses. In fact, many modern diseases are linked to mineral deficiencies. Dr. Linus Pauling, a well-respected, award-winning scientist said, "You can trace every sickness, every disease, and every ailment to a mineral deficiency."

It is easy to find evidence to support his claim. Vitamin C deficiency causes scurvy. Anemia can be caused by iron or B12 deficiencies. Vitamin D deficiency causes rickets. Osteoporosis can be caused by low levels of calcium, phosphorus, or vitamin D. Niacin deficiency causes pellagra. Potassium and magnesium soothe achy muscles. Pauling was convinced that vitamin C was valuable in treating colds, flus, infections, cardiovascular disease, cancer, and degenerative issues related to aging. Many cancer centres today use vitamin C therapy along with chemotherapy for treatment.

Since vitamins and minerals are so important to our health, we need to get higher quantities of them into our food. This means we need to rebuild and heal our soil if we want to be truly healthy. Minerals support plant health. When plants are grown in mineral-rich soil, they tend to have a higher brix measurement. Brix measures the total dissolved solids in plant juices, which include sugars and minerals. When plants have a high brix, they are healthier, taste better, and don't have issues with pests and disease. Pests and disease attack sick plants, not healthy ones.

WHAT IS VOLCANIC BASALT POWDER?

There are many techniques and amendments that can help you build up your soil, but one that stands out above the rest is using rock dust—specifically, volcanic basalt powder.

Rocks are minerals, and as these rocks break down over time, they create our soil. In fact, basalt is a major component in most soils around the world, especially in the ocean where underground volcanoes are continuously erupting.

Different types of rocks contain different types of minerals. Basalt is an igneous rock made from volcanic lava that has solidified and cooled. Igneous rocks are different in that they have not been changed by the environment, so none of their vitamins or minerals have leeched out. They contain all of the minerals just as they were when they came from the centre of the earth. Basalt in particular is special because, though it releases nutrients slowly over time, it breaks down faster than most rocks and contains hundreds of vitamins and minerals.


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"WE CAN EACH do our part to replenish the soil on our little plot of earth, and reap the benefits of delicious food and good health in the process."

BENEFITS OF BASALT

Two of the most prevalent minerals found in basalt are silicon and iron. Both are extremely valuable to plants and our bodies. Studies have found that basalt is highly effective in treating iron chlorosis in plants. Iron is essential for many of a plant's vital functions, including metabolism, development, nitrogen fixing, and chlorophyll production. Iron chlorosis will show up as yellowing leaves with green veins.

Just as iron affects chlorophyll, a plant's blood, it also plays an essential role in our blood. Our bodies use iron to transport oxygen from our lungs to our tissues via our blood. Without enough iron, we can become anemic and fatigued.

Silicon is the second most abundant element in the earth's crust. For this reason, healthy soil rich in organic matter probably won't need silicon supplementation. However, now that our soils have been depleted, there are many benefits to adding it back in. Silicon is the building block for a plant's strong, flexible cell walls. This allows plants to stand up to stressors like drought and extreme temperature change much more easily because the cell walls are able to expand and contract. The stronger, larger stems also allow plants to take up more water and nutrients, and give plants the strength to carry larger fruits. The tougher cell walls also make plants less desirable to munching insects looking for a snack. Insects don't like tough plant fibres just like we don't enjoy a tough steak.

Silicon has also been shown to ward off fungal infections such as powdery mildew, rust, and pythium. It even builds up in areas of infection on plant tissue to protect the plant from further disease. Silicon levels can truly make or break your plant's health.

Silicon plays a similar role in the human body. It is important for healthy and flexible bones, joints, collagen, skin, and nails. It increases the benefits of vitamin D, calcium, and glucosamine. It is vital that the food we eat has enough silicon to pass onto us if we want to feel and look our best.

HOW TO USE BASALT IN YOUR GARDEN

To access the hundreds of minerals present in basalt, you'll need to make sure you have plenty of microbial life in your soil. The beneficial microbes will extract the minerals from the basalt and feed them to your plants in a form they can use. One of the best ways to accomplish this is to always pair basalt with compost. You can mix basalt directly into your compost pile before you add it to your garden. For better results, add basalt to your compost when you start your pile and add it every so often to make sure there are plenty of minerals available to your plants when you finally add it to your garden. If you don't like to disturb your soil, you can add a layer of basalt to your garden and then cover it with a layer of compost. Compost tea is another effective way to increase microbial life in your soil, and pairs well with basalt.

When choosing your powder, make sure it has the texture of flour. The smaller particle size allows it to break down for your plants faster. A good rule of thumb is to use 4.5-6.8 kilograms of basalt for every 9.3 square metres. This application will last three to four years. You don't need to add basalt to your garden more often than this.

Although modern agricultural practices have depleted our soil, there is still time to repair the damage. Amending our soil with basalt is a great place to start. We can each do our part to replenish the soil on our little plot of earth, and reap the benefits of delicious food and good health in the process. The healthier the soil is, the better our food tastes, and the healthier we are. MY

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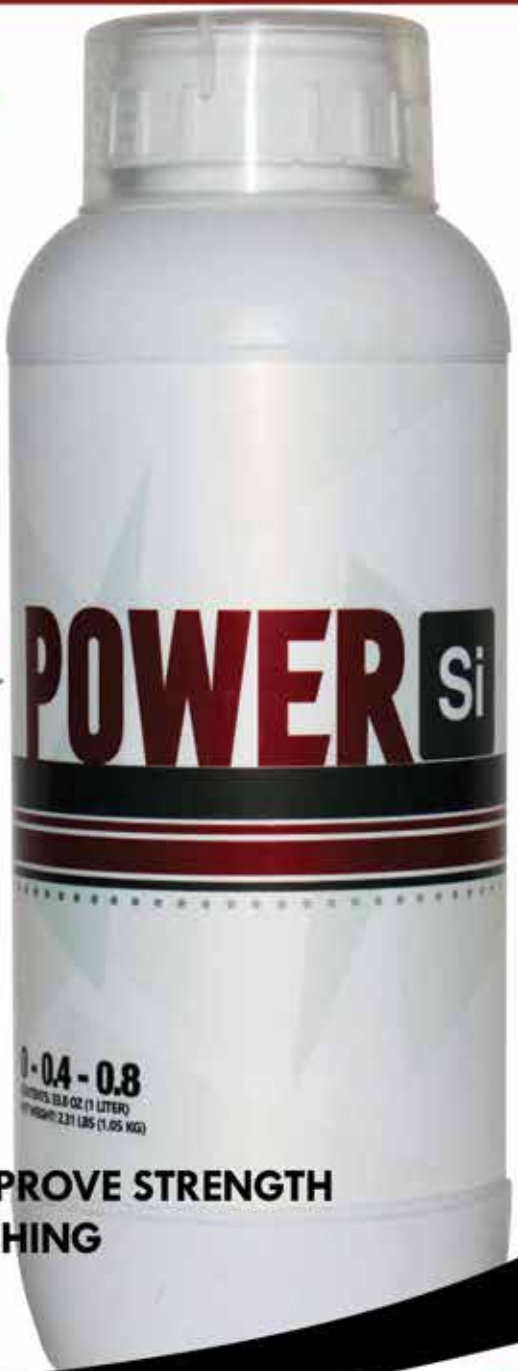

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COUNTERTOP TISSUE CULTURE

BY DR LYNETTE MORGAN

Just as hydroponics was once the tool of scientists until growers modified the technology for their own use, tissue culture is now being carried out in home kitchens, on spare countertops, or in modified indoor growing areas.

Tissue culture, or micropropagation, is a high-tech tool for the rapid multiplication of plant material. However, it is no longer primarily the domain of commercial labs with expensive equipment. Basic tissue culture is relatively simple and easily adapted to indoor gardens where artificial light and a clean, protected environment are readily available to facilitate the process. All growers need are steady hands and attention to aseptic procedures, and they'll be rewarded with rapid production of clones or the multiplication of difficult or slow-to-propagate species.

The term "tissue culture" describes a wide range of procedures that all involve taking small parts of plants, tissues, or cells and growing them inside sterile containers in which the environment can be carefully controlled. Some methods are highly advanced and more suited to being carried out in a lab as they require specialised equipment. These include cell suspension culture and protoplast culture. However, basic plant multiplication is relatively easy on most plant species.

The medium most commonly used in tissue culture is agar gel, which holds the plant material in place at the base of the flask. This gel substrate provides all the nutritional requirements of the new tissue as well as directs growth and development of the new plantlets by containing various hormones. The most commonly used hormones in agar gel are cytokinins to stimulate shoot development and auxins to stimulate new root development. An agar medium will also contain carbohydrates, such as sucrose or glucose; vitamins, such as thiamine (B1), nicotinic acid, and pyridoxine; and other compounds essential for the species being cultured.

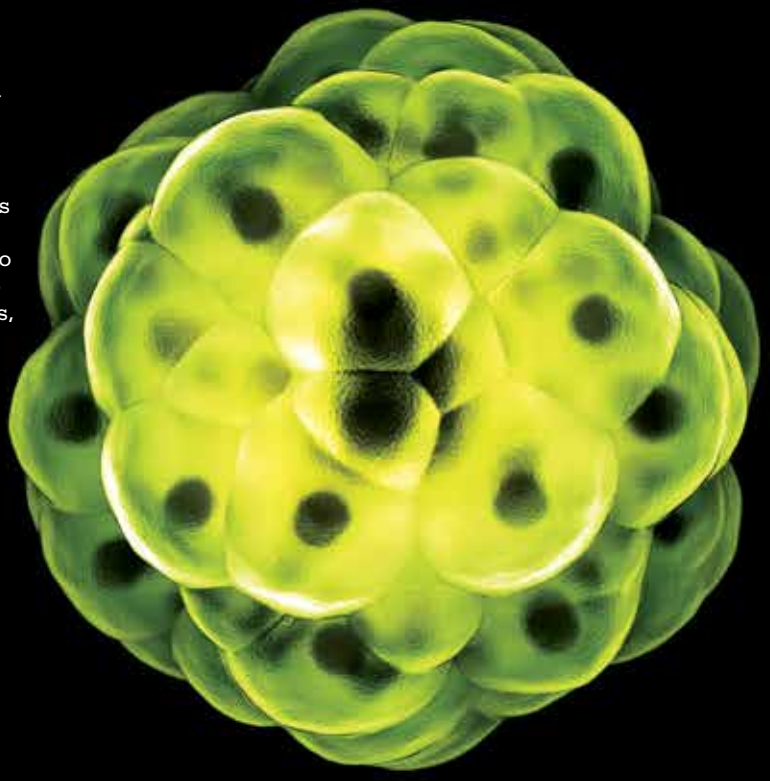
Advantages of Tissue Culture

For indoor gardeners who have a few prized plants that require propagation, tissue culture is a method worth considering. Growers who use vegetative propagation usually select their best plants to multiply, but a single plant can only provide a handful of cuttings, making bulking up numbers slow. However, using basic tissue culture methods, even a small grower can rapidly produce high numbers of clones from a single plant, either for their own use or for sale. New plantlets, once they have come through the culture process, can be easily shipped to other growers while still in their sterile tissue culture flasks. In fact, many orchid varieties can now be purchased as flasks of tissue cultured plantlets, which are ready to be shipped around the world to new growers, potted up, and grown on. Overall, it's a cost-effective way of buying and selling newer plant material. Tissue culture flasks can also be used to store or hold plantlets maintained in a sterile, disease-free environment in vitro as future propagation stock, taking up less space than mature specimens.

The Process

The most widely used tissue culture method is based on adventitious shoot formation, where a small piece of plant (root, leaf, stem, bulb scales, or similar) is taken and induced to produce many small shoots through the application of the correct plant growth hormone. Normally, such plant parts would not produce new shoots, let alone masses of them, but the conditions inside the tissue culture flask and the application of a plant growth regulator stimulates this growth to occur. These shoots, once sufficiently developed, are divided up into individual clumps and grown on in another flask where they are induced to form new tiny roots by application of another plant growth hormone. From there onwards, the young plant is grown on until it is large enough to leave the protected environment of the flask, be potted up, and grown on in a nursery situation.

The tissue culture media inside sterile flasks can also be used to germinate very small seeds or spores. Orchid seeds are so small, they appear like a fine dust and have embryos that are not fully developed. In the wild, these seeds are dependant on a symbiotic relationship with certain microbes in the bark of trees, which provide nutrition for germination. However, orchid seeds can be raised in tissue culture media that supplies the inorganic salts and sugars required for germination. Fern spores can also be raised in this way, and the use of tissue culture media and aseptic methods improves the rate of multiplication of ferns from spores.



"THE TERM 'tissue culture' describes a wide range of procedures that all involve taking small parts of plants, tissues, or cells and growing them inside sterile containers in which the environment can be carefully controlled."

Photo courtesy of Solan Nursery, Australia

Preparing plant material for tissue culturing.

Photo courtesy of Solan Nursery, Australia

Photo courtesy of Solan Nursery, Australia

Top: A commercial tissue culture lab growth room.
Bottom: Tissue culture vessels with agar medium in their bases.

The basic process of plant multiplication with tissue culture starts with healthy, well-grown stock plants from which the propagation material is taken from. In this example, we'll use African violet, as it is an easy-to-work-with plant used by many to develop their culturing skills before venturing onto more valuable species. The first step is to cut a mature leaf from the parent plant and sterilise this material by immersing it in a solution of diluted bleach. This kills any surface microbes that would otherwise contaminate the plant material inside the culture flask.

The leaf is then rinsed with sterilised water and further prepared inside a sterile still air cabinet, or "clean box," which is used whenever working with open flasks and transferring the plant material. In commercial tissue culture labs, a laminar flow hood carries out this role of preventing microbial contamination of the sterilised flasks and media by passing filtered air from the rear of the hood outward on a positive pressure gradient. In small or non-professional settings, a countertop cabinet can be made using a glass fish tank on its side, a large plastic container, or even a do-it-yourself cabinet made from plastic film stretched over PVC piping. These enclosed transfer boxes work well provided they are regularly sterilised by a misting spray of bleach solution or other disinfectant. The still air cabinet needs to have sufficient working space, and dimensions of 60x50x50 cantimetres is usually adequate for small propagators.

"THE MOST commonly used hormones in agar gel are cytokinins to stimulate shoot development and auxins to stimulate new root development."

Inside the clean box, the sterilized leaf is cut into one- to two-centimetre pieces and transferred to the agar medium inside a culture flask or jar (baby food jars are recommended for this). The gel-like agar needs to be purchased pre-made or prepared ahead of time. The agar-based medium is prepared by mixing together the liquid medium, agar powder, and other ingredients; placing the mixture into the flasks or jars; and heat treated in either the microwave or a pressure cooker for a certain length of time. All tools and utensils such as scalpels, forceps, and knives must also be sterilised in this way. Isopropyl alcohol or ethyl alcohol is also used to flame cutting blades before they are used on plant material to ensure no microbes contaminate the plant tissue.

Once the pieces of leaf have been placed into the culture jars and sealed (the lid must be closed before the jar is removed from the clean box cabinet), they are left to generate new shoots. During this period, African violet leaves first form small bumps. Over two to four weeks, these develop into a mass of tiny shoots, a process that is promoted by the hormones in the tissue culture agar medium. The jars are often kept on shelves with lights positioned 23-30 centimetres above them. Cool-white fluorescent propagation lights are ideal, as they don't create a heat buildup inside the flasks. An ideal lighting period of 16 hours per day and temperature control is also important for this process.

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Top: Plantlets contained in tissue culture vessels.
Bottom: Plantlets being removed from the tissue culture growth medium to a potting medium.

"USING BASIC tissue culture methods, even a small grower can rapidly produce high numbers of clones from a single plant."

Once many new shoots have formed, these are transferred to a new flask with a fresh culture medium that does not contain shoot promoting growth regulators. (Instead, this second medium often contain auxins, which allow the shoots to elongate further and roots to rapidly form.) The mass of shoots can be extracted from the jar using sterilised forceps and a sharp knife. They can then be divided or pulled apart into many individual plantlets. These divisions are then transferred into the new culture medium to develop for a few weeks under lights. This process is similar for many plants that are propagated from leaves.

Once the young plantlets inside the flasks are sufficiently developed, they are taken from the culture flask and carefully hardened off. (The plantlets inside the jars or flasks have been protected with warmth and high humidity, so they are initially very tender.) This process applies both to growers who have purchased flasks of plantlets from a tissue culture lab and those who have carried out their own micropropagation. The hardening off process is carried out using hydroponic methods; that is, using sterile soilless media under low-level natural or artificial fluorescent lighting in a protected environment. The plantlets are removed from the culture jar or flask, and any excess agar medium is washed away. The young plant can then be potted into small containers or trays of sterile media. Fine-grade perlite or perlite/vermiculite mixtures work well for this process, as does stone wool and similar hydroponic media. The plantlets of most species can then be placed in a high-humidity tent, in a plastic bag for small pots, or under intermittent misting to retain humidity as the plant adjusts to normal growing conditions. Initially, only distilled or RO water should be given for the first few days, then a dilute quarter-strength seedling nutrient can be applied. Young plants typically require four to six weeks to harden off sufficiently. As they grow, light levels are increased, the humidity can be gradually lowered, and the nutrient can gradually increase in strength.

Materials and Supplies

For those new to tissue culture, a basic starter kit can be purchased from some suppliers and, increasingly, from hydroponic retailers. Kits are a good way to initially develop culturing skills, as all the hard work of sourcing agar medium ingredients, suitable jars or flasks, and other equipment has already been done. For those who are a little more DIY, many online retailers selling home tissue culture supplies can provide specific tissue culture agar mediums for different plants species and procedures, such as shoot multiplication, root development, and growing on plantlets. This removes the complicated step of formulating an agar medium for home propagation.

Tissue culture methods may seem a little complex and challenging at first, but once the basics of preparing plant material and a good understanding of aseptic methods have been developed, the process can be highly rewarding. Not only can favourite or carefully selected plants be cloned rapidly in high numbers, but more advanced methods can germinate difficult seeds or spores, produce virus-free planting stock, and play a vital role in ongoing plant breeding and improvement programs. Small-scale tissue culture is also well-suited to an indoor garden environment where artificial lighting and carefully controlled conditions can be provided to grow new plantlets from tiny pieces of excised tissue. MY

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UNDERSTANDING DIFFERENT GROW LIGHTS

by Chris Bond

Cost, available grow space, and the type of crops being grown all factor into which type of light will best suit a grower's needs. Chris Bond provides insight into the wide variety of grow lights available on the market today.

Most indoor plant growers are aware that plants need different types of light for good growth and high yields. We, as human beings, see light in the wavelengths that comprise the visible spectrum (remember Mr. ROY G BIV?). Plants use light in this range, but also need the light that occurs at both higher and lower wavelengths: ultraviolet (UV) and microwaves. It is an oversimplification of the concept, but in general, plants need more light from the blue side of the spectrum during their seedling stage and when developing foliage, and they require light from the orange to red side of the spectrum while in blooming and fruiting phases.

When considering the different types of grow lights available on the market, understanding efficiency, both in energy consumption and photosynthetic benefits, is key. Knowing the difference between different types of grow lights, their features and benefits, as well as their limitations can help the grower to decide which will work best for their growroom set-up and situation.

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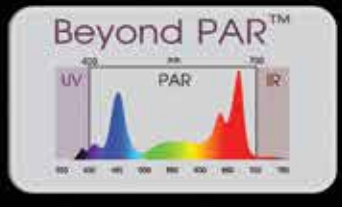

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"**HIGH PRESSURE** sodium (HPS) lights have been a common choice among indoor growers for many decades and are still the most common type of grow light used in the commercial greenhouse industry."

HPS

High pressure sodium (HPS) lights have been a common choice among indoor growers for many decades and are still the most common type of grow light used in the commercial greenhouse industry. They emit light mostly in the yellow to red range of the spectrum, 565-700 nanometres (nm). For reference, yellow light occurs at wavelengths between 560 and 590 nm, orange at wavelengths between 590 and 625 nm, and red at wavelengths between 625 and 700 nm.

High pressure sodium lights usually last for spans of time around 10,000 hours (though bulbs should be changed after 18 months of use even if they have not been used for the full 10,000 hours as the quality and quantity of light diminishes over time), and burn between 25 and 30 per cent efficiency. The remaining energy emitted from the bulbs is released as heat, making the surface of these bulbs extremely hot (some studies have shown surface temperatures of HPS lights as high as 450°C). High pressure sodium lights should not be placed in contact or very close to crops, as they will burn the foliage. For safety reasons, they should not be in contact with anything flammable such as some types of shade material or paper.

It should also be noted that in most large, commercial growing facilities like greenhouses, they are used as a supplement to natural light. Growers that opt to use HPS light as the sole source of artificial light are not giving their plants anything useful from the blue range of the spectrum.

HID

High-intensity discharge lights (HID), also known as gas or discharge lights, are commonly manufactured as metal halide (MH) or sodium vapour light (HPS lights are also HID lights, but they are excluded here since they were discussed above). These work by passing electricity through a gas-filled tube. High-intensity discharge lights offer the brightest light of any lights discussed in this article, so they offer the added benefit of allowing crops to be easily inspected. They were used by growers for many years since they are about 10 times more efficient than traditional incandescent lights, which are inefficient, burn hot, and offer little in the way of blue light.

High-intensity discharge lights, while more efficient than incandescent lights, still emit a lot of heat. Among the HID light choices, HPS lights are roughly equivalent in terms of energy efficiency compared to MH bulbs, but they are more efficient in their photosynthetic value. Metal halide bulbs offer better light on the blue side of the spectrum than HPS do. High-intensity discharge lights also require large, bulky, and often costly fixtures to operate them, though the bulbs themselves are relatively inexpensive. They are not typically the grow light of choice for most hobbyist growers or growers who operate in relatively small growrooms. The technology, however, is old by today's standards, and most current research is being directed towards light emitting diodes (LEDs) and sulphur plasma technologies.

If HID lights are a practical or more economically viable solution in a certain situation, a combination of both MH and HPS lights may be advisable if the crops being grown are blooming or fruiting crops as opposed to foliage crops like edible greens. These can be operated at the same time or alternated, depending upon the stage of growth; better results will likely result by using both in tandem. Though HID bulbs are not interchangeable with one another, conversion lamps have been available for some time, which allow you to achieve the spectral output of an MH lamp in an HPS fixture. Also, there are double-ended MH lamps that have been recently introduced to the market that can be used as a direct replacement in a compatible HPS fixture.

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LEDs

Light emitting diodes (LEDs) have become the grow light of choice for many professional and hobbyist growers alike. These products can emit light in wavelengths ranging from 250 nm to more than 1,000 nm. Most plants require wavelengths of light ranging from the blue section of the spectrum at about 450 nm to the far-red end of the spectrum at about 730 nm at different times of their development. Light emitting diodes have the capability of having their spectra manipulated to efficiently capture the nuances of the emitted wavelengths.

These lights are also favoured because of their long life and efficiency. They have been shown to last more than 50,000 hours, with efficiency usually ranging from a low of 38 per cent to a high of more than 50 per cent. They are also extremely useful for growers because some LED lights can emit light in specific ranges of wavelengths to support plants during their vegetative and blooming phases. Light emitting diodes do not require the addition of any kind of reflector, as the light is directly emitted towards the plants and not dispersed like other types of grow lights.

A 2014 study conducted by researchers at Purdue University showed that LED lighting was more effective for development of commercially viable bedding plants than HPS lighting. This study included popular annuals such as geraniums, impatiens, petunias, salvia, and others.

The main obstacle for growers is the relative high cost of LEDs. The cost of LEDs, however, is dropping as they continue to be produced in higher volumes by more manufacturers. A current study released this year in the journal *HortScience* cites that it still costs five to 10 times as much to set up a new LED grow light system as compared to a new HPS system.

Another drawback of LED lighting is one of its selling points. Because far less light is lost or scattered with LED beams, it is not necessarily the best choice of lighting for larger operations. These lights can be thought of as more surgical, while HID lighting is designed for saturation. Small grow operations will likely see more benefit with a switch to LEDs than their larger counterparts.

Sulphur Plasma

Sulphur plasma lights are the new kid on the block in the world of grow lights. Their high cost will keep them out of the hands of the casual grower for a while until market factors kick in based on their effectiveness for supporting plant growth. Many units currently sell for thousands of dollars each.

> "**LIGHT EMITTING** diodes have the capability of having their spectra manipulated to efficiently capture the nuances of the emitted wavelengths."

The amount of peer-reviewed literature on this new technology useful for the layman is scant, so it is difficult to glean an unbiased review of their performance. Of all the possible options in grow lights, the sulphur plasma light is touted to emit light in frequencies and wavelengths closest to that of the sun. It is the only grow light that emits lights via microwaves. Its efficiency has been reported by some European researchers as high as 70 per cent.

Final Considerations

Don't forget about the inverse-square rule when placing your grow lights. The amount of light that is scattered or lost grows exponentially larger the higher the lights are suspended over the crops. Every time you double the distance between your light source and your plants, they receive one-fourth of the amount of light than when you started. This is important when considering a type of grow light that produces a lot of heat, which needs to be kept away from crops to avoid burning of foliage.

Ultimately, whichever light is chosen for optimal growth, remember that all plants still need a daily period of darkness to complete their normal cycles. The amount of darkness a plant experiences provides cues to the plant regarding when to flower or when to produce vegetative growth (photoperiodism).

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How Plants Breathe: The Stimulating Story of Stomata

by Shannon McKee | Evolutionary wonders, stomata are vital to plant health. Knowing how they work and what they do for the plant is important knowledge for every kind of grower.

Take a second and just breathe. Think about how you are bringing air full of oxygen into your lungs through your mouth. Now, take a drink of water and think of how that water travels through your mouth down toward your stomach. You don't have to think about the air and water going to the right place unless something goes wrong and it slides down the wrong tube.

You may not consider the fact plants have a mouth, but they do. Plants have many tiny openings called stomata, which is "mouth" in Greek. These microscopic openings are found on the surface of your plants and they play a significant role in your plants' survival.

STOMATA BASICS

When you think about how plants draw in the things they need to live, you probably focus on the roots and how they bring in water and nutrients from the soil. The roots are a critical system, but there's another way that plants bring in the essentials and that's through their stomata. Stomata are found on the leaves of the plant in the highest concentration, but they're also located along the stem and other parts that are above the soil. Having a large number of stomata around the entire plant improves the potential of the plant surviving.

These tiny openings in the surface of the leaf and other parts of the plant are where gases are exchanged. These stomata open and close to bring in the carbon dioxide the plant needs to live and release oxygen that other organisms, like us, need to breathe in to live. Bringing in the carbon dioxide, which is crucial to the photosynthesis process, is like the inhaling part of the process for us. The carbon dioxide is converted by sunlight shining on the plant into sugar that's used for the plant to grow. The stomata also exhale as they release water molecules, and this process is called transpiration. Transpiration is necessary for cooling the plant, bringing in more carbon dioxide, and helping to improve the amount of nutrients the plant brings in.

STRUCTURE OF STOMATA

Stomata have a very straightforward structure. There are two guard cells on either side of the opening, and it is the opening itself that's called the stoma. The guard cells open and close the stoma depending on the conditions surrounding it. Light levels, temperature, and other cues influence when the stomata are opened and closed. During the morning hours when the sun rises, the guard cells fill up with water and when they are completely full, the stoma opens. At this point, there's the exchange of gases and the release of the water molecules.

Plants that are in dry, warmer climates are at risk of drying out from too much water loss from open stomata. It's a very careful balancing act for plants to keep the stomata open to bring in carbon dioxide and release the water molecules while keeping them closed for water retention. Some plants have evolved enough to leave their stomata open a slight bit to allow for the exchange of gases, while minimising the amount of water that's lost out of the opening.

Stomata can be grouped into different types based on the number and characteristics of the surrounding cells. Examples of different types of stomata include:

- GRAMINEOUS STOMATA: The guard cells are narrow in the middle and wider at the ends. The subsidiary cells are parallel to the guard cells.
- ANOMOCYTIC STOMATA: Possess irregular shaped cells, similar to epidermal cells, that surround each stoma.
- ANISOCYTIC STOMATA: Features include an unequal number (three) of subsidiary cells surrounding each stoma. Two of these cells are significantly larger than the third.
- DIACYTIC STOMATA: Stomata are surrounded by two subsidiary cells that are perpendicular to each stoma.
- PARACYTIC STOMATA: Two subsidiary cells are arranged parallel to the guard cells and stomatal pore.

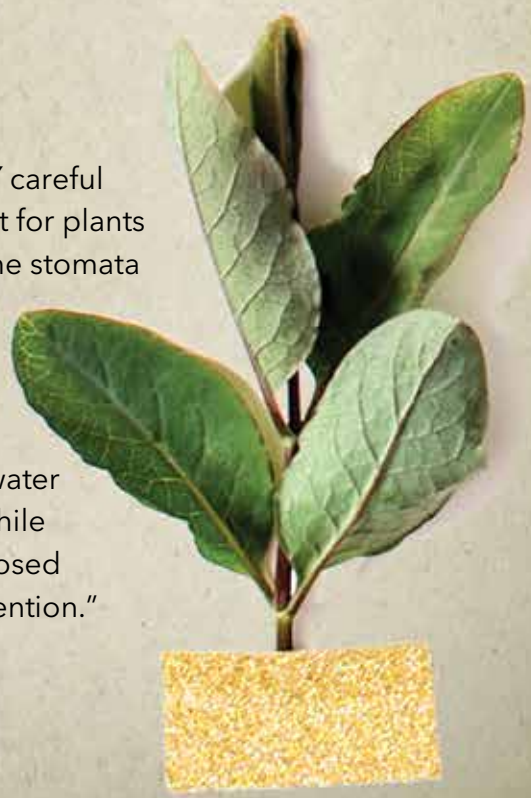
STOMATA PROBLEMS

Your plant's stomata are vital to the health of the plant, and when stomata are unable to perform their job, the plant suffers. One way you may be negatively impacting the stomata is by overcrowding your plants to where they're unable to adequately function, as there's little air circulation among the leaves with too many plants in too small a space.

Some diseases and fungal problems can also impact your stomata. Powdery mildew is one that can negatively impact your stomata to the point where your plant may die if not treated. The fungus, which gives the leaves the look of having a layer of powder on them, will block the stomata and the sunlight being absorbed by the leaves. This layer means carbon dioxide isn't being adequately brought into the plant, so the process of photosynthesis is affected.

Stomata may not be a mouth in the same sense as our mouths, but they have a function that's just as important. Knowing what stomata are can help you to be mindful of how fascinating plants are in taking in carbon dioxide and turning it into oxygen that you can breathe. Plus, it's helpful to understand so that overcrowding and diseases don't block your plants from reaching their full potential. MY

> "**IT'S A VERY** careful balancing act for plants in keeping the stomata open to bring in carbon dioxide and release the water molecules while keeping it closed for water retention."



OFF TO A GOOD START

There are many benefits to using starts, but there are a few things you should keep in mind to ensure your garden thrives a few months or years down the road. Grubbycup makes a few suggestions to make sure your starts are successful.

BY GRUBBYCUP

While many plants can be directly seeded into the garden, others benefit from getting a head start in smaller containers that they will be grown to maturity in. These "starts" are either prepared or purchased in advance of final planting, and may be from seed, rooted cutting, or via other propagation method. Starting from seeds is usually a less expensive option, but many people find the convenience and reliability of purchasing packs of starter plants to be worth the difference in price. A benefit of starting plants from cuttings (clones) is the starts will be copies of a plant with known characteristics. Some plants have to be started from cuttings. Cavendish bananas and other seedless plants have to be vegetatively propagated (started from cuttings), as they lack the ability to propagate sexually (they lack fertile seeds).

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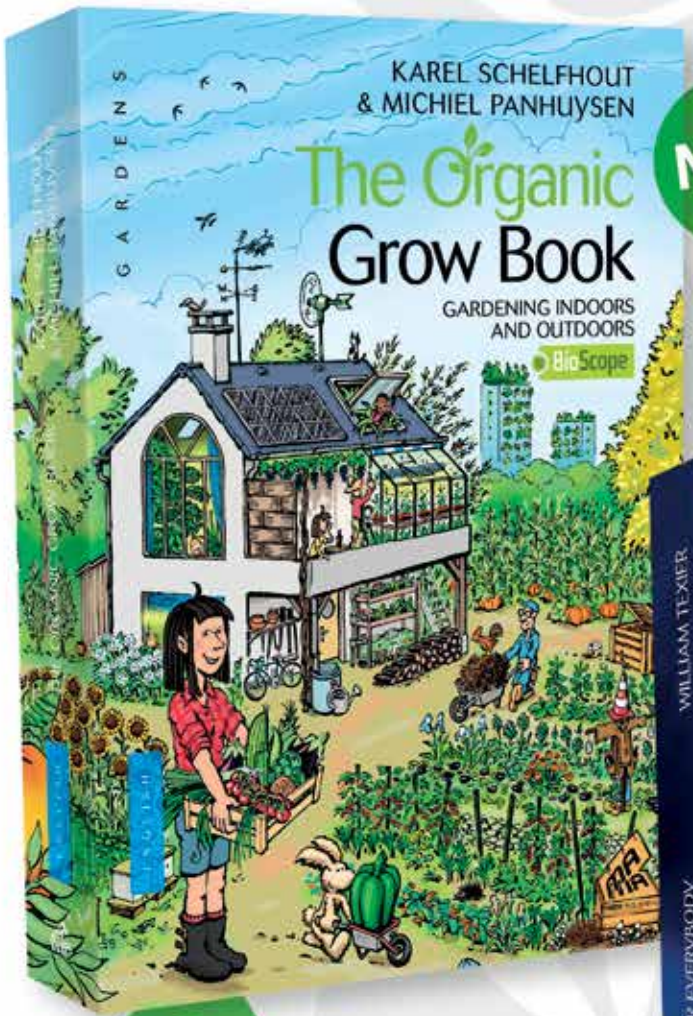

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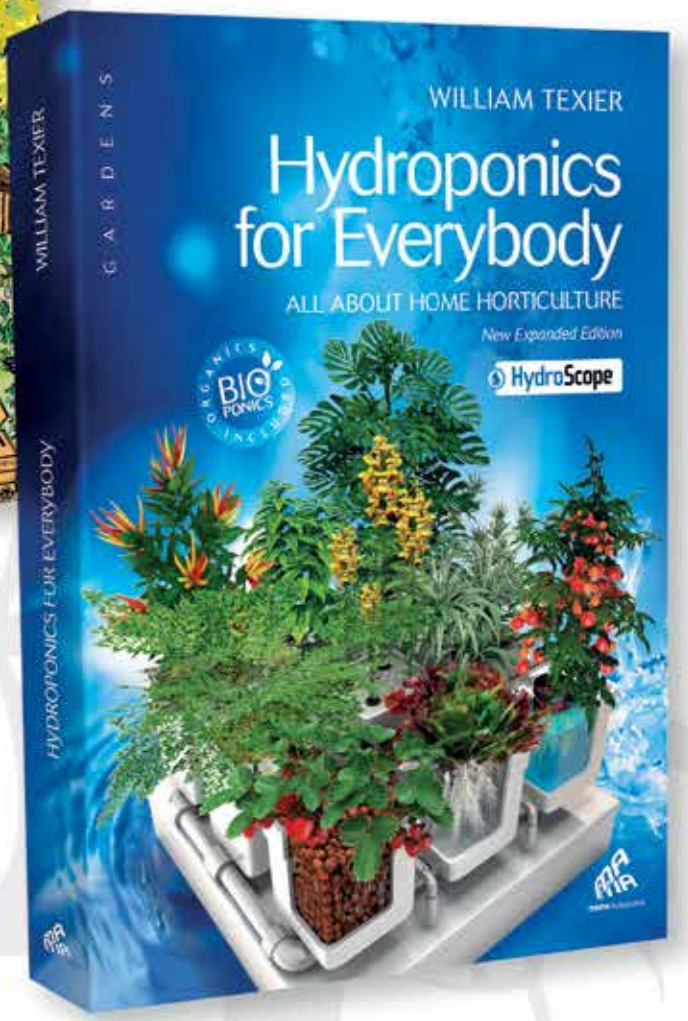

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START THE RIGHT PLANTS

Keep in mind starts eventually (hopefully) grow into full-sized mature plants. While this may sound obvious, it means that while shopping for starts, one is also shopping for future full-sized plants. Climate requirements, light, and available space should be taken into account when selecting which starts to try.

Garden zones are assigned to plants to help gardeners choose which plants are suitable for their climate. Another method of finding plants suitable for a given area is to observe what other local gardeners are successful with. Experiment to find favourites and take note of any particularly enjoyable varieties. Garden zone information should be available on the plant's identification tag, on the back of the seed packet, or from the plant/seed's source.

Even in the appropriate gardening zone, there are still light requirements to consider for a given space. In an outdoor setting, shade from other objects can reduce the number of full sun hours a space receives. Pay attention to a given space throughout the day to determine how many hours of direct sunlight it gets. Less than three hours of direct sun is considered "full shade," three to six hours is either "partial sun" or "partial shade," and six or more hours is "full sun." Light requirements are often found on the backs of seed packets or on the plant labels of starts. For indoor gardens, some partial shade plants can be grown successfully at the periphery of the primary growing area.

"A BENEFIT OF STARTING PLANTS FROM CUTTINGS (CLONES) IS THAT THE STARTS WILL BE COPIES OF A PLANT WITH KNOWN CHARACTERISTICS."

PLAN AHEAD

Prospective starts should be seasonally appropriate. Summer flowering annuals tend to be planted in the spring. It would make little sense to plant a summer flowering annual in late fall shortly before a killing frost. Most plants have a listing for the ideal planting months, with perennials generally being more forgiving of slightly out of season plantings than annuals.

Information about the expected mature size of a plant variety is frequently available for gardeners from a variety of sources. A plot of overcrowded plants tends to yield less than properly spaced one would even with the greater number of plants. The number of starts should be related to the proper number of plants desired. As a safety precaution, many gardeners start more plants than they intend to finish. This allows for a cushion in case some don't sprout or root. It is much easier to get rid of a few extras if needed than to go back in time and have started more in the first place.

To select from available starts for use, inspect the starts carefully. The seedlings or rooted cuttings used should appear healthy and vigorous. While it is true many plants can be nursed back to health from a rough start, beginning with inferior starts sends a garden off on the wrong foot.

"MANY GARDENERS START MORE PLANTS THAN THEY INTEND TO FINISH. THIS ALLOWS FOR A CUSHION IN CASE SOME DON'T SPROUT OR ROOT."

FIVE INDICATORS TO BE WARY OF:

1. Too tall and lanky for its size. Seedlings grown without sufficient light will stretch in an attempt to find better light. This can lead to weak stems and top-heavy foliage.

2. Pale leaves. Leaves that are light in colour compared to a healthy plant may be suffering from a nutrient deficiency.

3. Underdeveloped or overdeveloped roots. Cuttings should be well-rooted before planting but not overly root-bound.

4. Any observed insects on or around the starts should be identified to prevent introducing unwanted guests to the garden. A single cutting can carry enough eggs for some baneful insects to start a colony. To safeguard against this, some gardeners quarantine new arrivals for a couple weeks before installing them in the garden proper, even if there are no visible insects present.

5. Soft, discoloured, or weak stems. While it is common for seedlings to be tender and easily damaged until they become established, soft stems (particularly near soil level) may be an indication of a wilt or other fungal infection. Usually the result of overwatering, these infections are usually fatal in starts, so time spent fighting it is generally better spent obtaining new starts.

THE BEST STARTS SHOULD HAVE:

1

Visible new growth. Look at the growing sites for recent foliage development. Healthy growth is an indication of a healthy plant.

2

Strong stems and full foliage. Well-lit and well-cared-for plants tend to be stocky with plenty of leaves.

3

Clear labelling. At the very least, it should clearly identify the plant. Many plant tags include some growing information as well.

4

Good drainage. Roots sitting in stagnant water can lead to a variety of unwelcome fungal infections, and proper drainage is one of the best preventatives.

5

The potential to produce something desirable. Even better than fresh vegetables from the garden are favourite fresh vegetables from the garden. Consider personal preferences when selecting from the flowers and vegetables appropriate for the garden zone.

Starting a garden with appropriate and healthy starts can help set a strong foundation for the season's growth and final harvest. A few minutes of care when selecting which plants to try can improve chances of gardening success. MY

[Hydro Meal]

PLANNING 101

by Eric Hopper

Every garden is unique, so a one-size-fits-all nutrient scheme isn't always the best for hydroponic set-ups. In this article, Eric Hopper lays out the basics of how to design a feeding regimen that's perfect for your plants.

Hydroponic horticulture is one of the most efficient and productive ways to grow plants. A hydroponic garden's accelerated growth rate is fuelled by the combination of the maximisation of available nutrients and the delivery of oxygen to the roots. In other words, hydroponic gardening supplies a plant with everything it needs when it needs it, and the plant is therefore able to achieve optimal growth.

The nutrients delivered to the plants via the hydroponic system are the main catalysts for faster growth. Hydroponic nutrients differ from organic compounds in the soil in that they are already broken down into a form that can be easily and quickly absorbed by plants. Providing the plants with essential elements and maintaining the proper nutrient concentration are both crucial when trying to maximise the overall performance of a hydroponic garden.

There is a plethora of hydroponic nutrients and nutrient additives available to hydroponic horticulturists. In fact, it can be downright overwhelming for a newbie to wade through all the information about each individual fertiliser. The good news is a gardener does not need a degree in chemistry to build an effective hydroponic feeding regimen. A general knowledge of how the nutrients are labelled, the various types of nutrients available, and when to use what type of nutrient is all a grower needs to build a successful fertiliser regimen.

Labels on Hydroponic Nutrients

One of the first things a grower will notice when he or she goes to purchase a hydroponic nutrient/fertiliser is the various numbers and ingredients listed on the label. There are regulations in place that dictate how and what must be included on a fertiliser label. Aside from the brand name and the name of the registrant or licensee, hydroponic nutrient labels usually contain the grade, the guaranteed analysis, and the product derivatives.

The Grade

The grade is essentially the abbreviated representation of the guarantees for total nitrogen (N), phosphorus (P), and soluble potassium (K). These numbers are always separated by a hyphen. For example, if a fertiliser's N-P-K is 20-20-20, the 20-20-20 is considered the grade on the fertiliser label. The grade gives growers the ratio between the three key nutrients found in the fertiliser.

Guaranteed Analysis

The guaranteed analysis is the listed breakdown of percentages of elements contained in a fertiliser. The guaranteed analysis includes the available percentage of nitrogen, phosphate, soluble potash, calcium, magnesium, sulphur, boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium, and zinc. Nitrogen is usually broken down further into the total percentages of ammoniacal nitrogen, nitrate nitrogen, and other determinable forms of nitrogen.

Product Derivatives

Most hydroponic nutrient manufacturers will include a derivative statement on the fertiliser label. The fertiliser's product derivatives are usually listed right below the guaranteed analysis. The product's derivatives can appear as a name of a chemical compound (e.g. ammonium nitrate) and/or as an organic ingredient (e.g. bat guano).

Start with a Base Fertiliser

The first thing a hydroponic gardener needs in his or her feeding regimen is a base fertiliser. The base fertiliser is exactly what its name implies: a foundation for the entire feeding regimen. Base formulas contain all the essential elements, which means they have all of the elements needed for basic survival and general health. Most base fertilisers are split into "grow" and "bloom" formulations, with their nutrient ratios specific to that particular stage of growth. Put another way, the grower will need "grow" base fertilisers for the vegetative stage of growth and "bloom" base fertilisers for the flowering stage of growth. There are a wide variety of base nutrients available in one-, two-, or three-part formulas, all of which contain the essential building blocks for plant nutrition. Although base fertilisers are generally labelled as such, a grower could examine the label to figure out the grade of the fertiliser and, from that, determine what type of fertiliser it is. Quality base fertilisers will contain a substantial amount of N-P-K along with a variety of micronutrients.

Don't Forget the Calcium

Calcium is a vital nutrient for plant health and a tricky aspect of the base formula. Most base fertilisers contain only a small amount of calcium because it is assumed that the gardener's water supply will contain calcium. A grower who has little calcium in his or her water supply or who is using reverse osmosis water may need to add a specific calcium supplement. Although calcium supplements are generally sold separately from the actual base fertilisers, it is so important to basic plant functions that a grower should consider it as part of the base formula for a feeding regimen.

> "As with other aspects of gardening, building an optimal fertilizer regimen requires experimentation."

Nutrient Additives

In general, the feeding regimen's nutrient additives should be considered icing on the cake. Although nutrient additives can make a big difference in the performance of a garden, they are not as important as establishing a good base fertiliser. It is only after a solid base fertiliser is established that a grower can truly reap the rewards of nutrient additives.

Additives are designed for more specific functions. For example, during the vegetative stage, many hydroponic gardeners like to supplement root enhancers. These root enhancers will not only increase the structural integrity of the plant (which better prepares it for large fruits or flowers), but they will also aid in keeping the roots healthy in the hydroponic system. Most root enhancers are enzyme formulas or microorganism-based supplements designed for use in the vegetative and early flowering stage. Some, however, some can be used throughout the entire life cycle of the plant. Additives that contain natural growth hormones, such as kelp, are another popular choice for the vegetative stage of growth.

A hydroponic gardener can't walk into a hydroponic retail shop without seeing a few different flowering or blooming nutrient additives. In fact, there are so many specific additives for the fruiting/flowering stage that they can be categorised into three groups: flower initiators, mid-flowering additives, and ripening additives. Many hydroponic growers will use a combination of blooming additives as the fruiting/flowering stage progresses. Flower initiator additives help the plants quickly transition from vegetative to flowering growth. Mid-flowering additives are designed to be used during the mid-stages of flowering. Finally, ripening additives are designed for use in the later stages of flowering to, as the name suggests, help accelerate the ripening process and boost yields.

Other additives that hydroponic growers commonly incorporate into their feeding regimens to help maximise performance include carbohydrates, enzyme formulas, amino acids, humic/fulvic acids, beneficial microbes, and vitamins.

The best way a grower can determine which additives to use along with his or her base fertiliser is through experimentation. This can be a time-consuming venture, but at the end of their grow cycles, horticulturists will be able to determine which additives helped them meet their goals and which did not. A good parts per million (ppm) or electrical conductivity (EC) meter are must-have tools for hydroponic gardeners experimenting with building a feeding regimen and can help growers keep the nutrient solution within a desired range of nutrient concentration.

> "It is only after a solid base fertiliser is established that a grower can truly reap the rewards of nutrient additives."

pH Buffers

Although most pH buffers are not actually nutrients and will not contribute to the nutrient content of the solution, they are still necessary when building a successful feeding regiment. For plants to be able to uptake nutrients from the solution, the pH needs to be kept in a particular range. For most hydroponic systems, a pH of 5.5-6.2 is ideal for nutrient uptake. As the pH fluctuates farther away from the desired range, specific nutrients will become unavailable to the plant. Over time, this can cause a series of problems, including nutrition lockout and/or nutrient deficiencies.

> "Although most pH buffers are not actually nutrients and will not contribute to the nutrient content of the solution, they are still necessary when building a successful feeding regimen."

Building a customised hydroponic nutrient regimen is like making your own unique recipe for gardening. A base nutrient will provide the plants will everything they need to survive, while nutrient additives are designed to help the plants thrive during particular stages of growth. As with other aspects of gardening, building an optimal fertiliser regimen requires experimentation. However, one of the exciting aspect of becoming a hydroponic grower is this honing-in on the specific nutritional needs of your plants. Every garden is different. Sure, every garden shares the same basic needs, but the growing space, the grower, and the plants themselves make each situation unique. Over time, these slight adjustments to a feeding regimen will equate to faster growth rates, increased quality, and more consistent yields. MY

Phone Number 1-888-771-GROW | Website: *dormgrow.com* | Years in business: Eight | Company motto: Grow Green with G8LED Technology!

Started by electrical engineers who took an interest in indoor gardening, G8LED manufactures and tests high-quality grow lights to give customers optimal results in their growrooms. Robert H., managing director, explains how the company has been expanding its market share year after year, and why customers are at the root of this success.

Tell us a little about how G8LED started.

G8LED was started by electrical engineers turned indoor growers who took their industry experience and applied it to the science of indoor growing. We took our design through several iterations over eight years to bring the most innovative indoor grow lighting technology in the highest yielding grow light system.

How has the company grown over the years?

From our humble beginnings, we expanded grassroots-style through word-of-mouth referrals from our indoor gardening contacts. For the first few years, we experienced a fierce resistance to LED grow lights because of subpar products being sold in the market. Customers were not able to get the results they were looking for and were skeptical of all LED grow light brands. We knew we could formulate a superior product, so we kept improving our design and working with expert growers in a positive feedback loop that propelled the G8LED design to what it is today—a highly efficient system that results in healthy growth and maximum yields.

What is your company's philosophy?

We believe that customers hold the answers to our success. We always listen to customers and make our decisions based on their feedback. If something is not good for the customer, in the long run, it will not be good for us, either. We follow this philosophy and it has helped us attain a great deal of success. We get a large percentage of our business from repeat customers and referrals.

What products does your company distribute and where?

Our G8LED indoor grow lights come in different sizes and with a couple variations to give customers flexibility in their growroom designs. We sell worldwide and ship to more than 130 countries.

How are the products your company distributes unique?

G8LED indoor grow lights are unique in their design. For example, the G8-600 Veg/Flower is a powerful indoor growing machine with the growing power of 1,000 watts of HID lighting while only using 390 watts of power. The G8-600 uses G8LED technology to produce high-quality buds while operating at low temperatures. Eight built-in fans make indoor temperature control easy while helping you save big on your monthly electrical bills. Having gone through several iterations and starting with so much input at the early stages of design and growth, we were able to formulate a highly efficient and effective design that produces healthy growth and maximum yields for the indoor grower.

What products are you seeing the most demand for?

The G8-900 LED grow light is the most popular amongst commercial growers and the G8-450 LED grow light is the most popular amongst hobby growers.

What else can you tell us about the G8-900 LED?

The G8-900 Veg/Flower Light provides the growing power of 1,200 watts of HID lighting, but only uses only 540 watts of power. We use an optimal eight-band formulation made with the weighted average of the different wavelengths of light necessary for peak photosynthesis. The formulation has everything needed for peak performance without any extra wavelengths that waste energy and reduce efficiency.

Can you share some advice for new growers looking at buying your products?

Do your homework before you invest in your indoor grow project. Ask a lot of questions. Your investment should pay off and that's what our technology does. We get emails every day from novice and expert growers alike who ask many intelligent questions about our products. We are happy to work with customers to get all their questions answered. While our customers are going through the learning process, we learn more about our customers' concerns and needs.

What does G8LED do to further the grow literacy of the masses?

Our site has a wealth of information for anyone interested in indoor growing. We listen to our customers and they tell us their concerns, then we try to provide the information to them throughout our website. It's a win-win strategy.

What else should people know about G8LED?

We are truly thankful for all the love and support from our customers. Grow Green with G8LED Technology! MY

"WE BELIEVE THAT CUSTOMERS HOLD THE ANSWERS TO OUR SUCCESS. WE ALWAYS LISTEN TO CUSTOMERS AND MAKE OUR DECISIONS BASED ON THEIR FEEDBACK."

Achieving Milestones: CO2Meter

CO2Meter is a team of gas measurement specialists based in Florida that has been designing and manufacturing gas detection and monitoring devices for more than 10 years. In addition to offering portable and fixed devices, the company also offers sensors for OEMs that can be incorporated into its designs. While CO2Meter services a variety of industries, including the agricultural, food and beverage, HVAC, and science sectors, the company has seen a lot of new potential in the indoor gardening market. Here's what they've learned along the way.

CO2Meter.com
CO2 Measurement Specialists

Web: *co2meter.com* **Phone:** 1-386-872-7669
Address: 131 Business Center Dr. Ormond Beach, FL 32174
Years in Business: Nine

Before starting CO2Meter, CEO Irene Hicks led international teams in the fields of gas detection—mainly the mining industry—and president Ray Hicks owned and operated several businesses in the robotics and optics sectors. Together, the pair saw a gap in the devices offered for gas detection and monitoring for carbon dioxide (CO_2), so they used their combined business experience to create their own company in a new business segment.

CO2Meter was established in 2006 in Ormond Beach, FL, in a small garage. It has since grown to occupy more than 740 square metres of warehouse space. "Our growth is a direct result of the increased use of and education surrounding CO_2, especially when it comes to indoor growing. This space is where microbrewing was 15 years ago," says Josh Pringle, vice-president of business development.

These days, CO2Meter offers more than 100 different devices and 35 types of sensors for a variety of gas-monitoring applications. The numerous devices provide options for a variety of gases to measure, data logging, portability features, and monitoring different gas concentrations. "Our expert technical representatives assist customers in selecting the best device for their needs," says Josh, adding 35 per cent of sales

have been international, reaching more than 100 countries in the last 24 months. "With approximately one-third of our business shipping internationally, CO2Meter is uniquely positioned to not only offer solutions for gas detection and monitoring, but for learning from our global partners so that we make future product enhancements and technological advances. All our new devices begin with the feedback of our customers needs and wants."

CO2Meter's most popular product for indoor growers is the RAD-0501, a day/night CO_2 controller that can be used in greenhouses, growrooms, and other places such as grow tents where elevated CO_2 levels are used to maximise plant growth. Growers simply set minimum and maximum CO_2 levels on the RAD-0501 and the device will maintain optimal CO_2 levels from tanks, burners, or generators. When the minimum CO_2 level is sensed, power is supplied from the RAD to the CO_2 generator or regulator via the built-in European 110-240 VAC 5A piggyback power cord. The RAD-0501 also has a built-in photo sensor that overrides the CO_2 control and shuts off the CO_2 when it senses darkness. "Photo-sensor control such as this saves dollars and energy by ensuring growers are only supplying CO_2 during the light cycle when it is needed," explains Josh. "Best of all, this CO_2 monitor and controller is easy to install and use. Simply mount the unit inside a greenhouse (all cables and hardware are included), plug it into a standard wall jack, plug in your CO_2 generator or regulator, and the RAD-0501 is ready to maximise your yields."

CO2Meter's unique business philosophy is a large part of their success. "We are uniquely positioned to use our experience in multiple industries to drive innovation and success for our customers throughout the business segments we service," says Josh. "We define ourselves as cost-effective. We believe every device that ships is our next opportunity to satisfy a customer and build a loyal brand following. The ideals of great devices, at good prices, with premier customer support, are hallmarks that the company will always follow."

Most of CO2Meter's growth has to do with its many strengths, which include quality devices, superior technical knowledge and support, unwavering integrity, and the ability to offer cost-effective solutions for growers of all levels. It's all led Josh and the rest of the team to learning a lot along the way. "In this business, I've learned a lot. The three major things that stand out the most are: 1) Accurate, quality gas measurement devices do not need to cost tens of thousands of dollars; 2) Most people want a solution but do not know how to find or create one; and 3) Education is the key component for the industry moving forward."

Along with its physical location and number of product offerings, the team at CO2Meter has also grown immensely, with 15 full-time and two contract employees now on board. Growing the team is something Josh considers one of his proudest moments so far. "Growing the business and adding employees is always frightening and rewarding, but finding, training, and retaining good people, which is an important factor in any business, makes anything possible. When the team is trained properly, motivated to succeed, and has a clear vision for the future, most business problems don't even appear."

> "When the team is trained properly, motivated to succeed, and has a clear vision for the future, most business problems don't even appear."

Other proud moments CO2Meter has had so far include landing major corporate customers or achieving sales milestones, but Josh says the proudest moments are always the ones that happen when customers contact them to tell them how well a device worked or that one of their devices saved their life. "It's hard to beat those moments," Josh says. "I think one of my favourite moments on the job is the phone call I received from a middle-school student. He and his mom called to share some news with me about the science fair project he had been working on. He was measuring the CO_2 change in plant growth and I had spent some time helping them purchase the correct sensor for the project, as well as offering some guidance about the set-up and design. He called to tell me he had won a Google Prize for his experiment. Not only was it a great feeling to know he had succeeded, but more importantly, at that point I realised students today are studying the effects of gases and will be able to affect change in the future."

For growers and entrepreneurs entering this sector who are just starting out, Josh has the following advice to share: "Things change every day in this business segment, whether you are trying to control CO_2 for growth, or you've been instructed by a fire marshal to have a life safety device in your facility to monitor for hazardous levels of CO_2. Be open about your business. Lean on others to help you understand the pitfalls in business that you can avoid. Accept that you aren't an expert in everything and that you can learn from others. The only constant is change, so be flexible and willing to learn."

Top left: Josh Pringle at recent trade show events.
Top right: Melyssia Santiago, CO2Meter director of sales, with Andy Sistrunk of Persimmon Hollow Brewing.

distributors

retail stores listed alphabetically by city in each state

ACT

South Pacific Hydroponics
#2 - 84 - 86 Wollongong St.
Fyshwick ACT 2609
(02) 6239 2598

South Pacific Hydroponics
70 Oatley Crt.
Belconnen ACT 2617
(02) 6251 0600

NEW SOUTH WALES

24/7 Hydroponics
151 Wine Country Dr.,
Nulkaba NSW 2325
(02) 4990 4291
admin@simplydvine.com.au

99 Trading
57 Hoskins Ave.
Banks Town NSW 2200
(02) 9790 1525

Accent Hydroponics
Unit 1/5 Clerke Place,
Kurnell NSW 2231
(02) 9668 9577
accenthydroponics.com

ASE Hydroponics
Factory 10/45 Leighton Pl.
Hornsby NSW 2077
(02) 9477 3710

Ballina Hydro
19 Cessna Cres.
Ballina NSW 2478
+61 (07) 3354 1588

Criscete Hydroponics and Organics
Unit 2/15 Kam Close
Morisset NSW 2264
(02) 4973 5779

Dubbo Hydro & Tobacconist
42c Victoria St.
Dubbo West NSW 2830
(02) 6885 1616

Earth & Colour Vertical Gardens and Hydroponic Supplies
1/43 CorporationCircuit
Tweed Heads South NSW 2486
(07) 5523 9565
earthandcolour.com.au

Favgro Hydroponics Growers
107 Glenella Rd.
Batehaven NSW 2536
(02) 4472 7165

Felanza - Hydroponics
140 Princess Hwy.
Arncliffe NSW 2205
(02) 9556 1494

General Hydroponics
7/14 Sunnyholt Rd.
Blacktown NSW 9676
(02) 9676 8682

Grow Your Own
Unit 6/34 Alliance Ave.
Morisset NSW 2264
(02) 4973 5179

Holistic Hydroponics Pty. Ltd.
Unit 21/322 Annangrove Rd.
Rouse Hill NSW 2155
+61 (04) 8803 8807

Home Grown Aquaponics
8A-8B 13 Hartley Dr.
Thornton NSW 2322
(02) 4028 6388
home-grown.net.au

Hong Hung
D5 303 The Horsley Dr.
Fairfield NSW 2165
(02) 8764 1083

Hunter Hydro
2/44 Alliance Ave.
Morisset NSW 2264
(02) 4972 6872

Hyalite Kingsgrove
1/4 Wirega Ave.
Kingsgrove NSW 2208
(02) 8068 5896

Hyalite Moorebank
6/376 Newsbridge Rd.
Moorebank NSW 2170
(02) 9824 3400

Hyalite Villawood
2/21 Birmingham Ave.
Villawood NSW 2163
(02) 9723 7199

Hydro Experts
34/2 Railway Parade
Lidcombe NSW 2141
(02) 8041 7959
info@hydroexperts.com.au
hydroexperts.com.au

Hydro Masta
100 Station Rd.
Seven Hills Sydney NSW 2147
(02) 8812 2845

Hydro Place
1/68 Nelson St.
Wallsend NSW 2287
(02) 4965 6595

Hydro Shop Pty Ltd
Unit 1/5-7 Channel Rd.
Mayfield West NSW 2304
(02) 4960 0707

Hydro Supplies
57 Flinders St.
Darlinghurst NSW 2010
(02) 9326 0307

Hygrow Horticulture (Greenlite)
252 Oxford St.
Bondi Junction NSW 2022
(02) 9369 3928

Indoor Sun Shop
745 Victoria Rd.
Top Ryde NSW 2112
(02) 9808 6511

Indoor Sun Shop
Unit 2/109 Junction Rd.
Moorebank NSW 2170
(02) 9822 4700

International Fans
PO Box 120
St. Mary's NSW 2760
(02) 9833 7500

Kyper's Tools and Hydroponics
Stuart & Tincogan Sts.
Mullumbimby NSW 2482
(02) 6684 4928

Lismore Hydro
1/106 Canway St.
Lismore NSW 2480
(02) 6621 3311

Lismore Hydroponics
Rear of 28 Casino St.
South Lismore NSW 2480
(02) 6621 3311

Lux Cuttings
Shop 2/273 Anzac Parade
Kingsford NSW 2032
(02) 9663 0473

North Coast Hydroponics
2/5 Wallis Ave.
Toormina NSW 2452
(02) 6658 7932
northcoasthydro.com.au

Northern Lights Hydroponics
6/46 Through St.
South Grafton NSW 2460
(04) 3110 5882

Northern Nursery Supplies Pty Ltd
14-16 Nance Rd.
Kempsey NSW 2440
(02) 6563 1599

Nowra Hydro
68 Bridge Rd.
Nowra NSW 2541
(02) 4423 3224

Nutriflo Hydroponic Systems
19/5 Daintree Pl.
Gosford West NSW 2250
(02) 4323 1599
nutriflo.com.au

Outside in Hydroponics & Organics
2/595 Main Rd.
Glendale NSW 2285
(02) 4956 5676

Parkview Plants
250 Princess Hwy.
Nowra South NSW 2541
(02) 4423 0599

Port Pumps and Irrigation
20 Uralla Rd.
Pt Macquarie NSW 2444
(02) 6581 1272

Quik Grow
510a Great Western Hwy.
Pendle Hill NSW 2145
(02) 9636 7023

Quick Grow
823 King Georges Rd.
S. Hurstville NSW 2221
(02) 9546 8642

Quik Grow Pty Ltd.
490 Parramatta Rd.
Petersham NSW 2049
(02) 9568 2900

Richmond Hydroponics
Unit 3/84 Bells Line of Rd.,
North Richmond NSW 2754
(02) 4571 1620
richmondhydroponics.com.au

Simple Grow
Hassall St. & Windem
Wetherill Pk NSW 2164
(02) 9604 0469

South Pacific Hydroponics
84-86 Wollongong St, Fyshwick
NSW 2609
(02) 6239 2598

Sydney Garden Supplies
187 Waterloo Rd.,
Greenacre NSW 2190
(04) 1460 9241

The Green Room Hydroponics & Organics
2/6 Davids Close
Somersby NSW 2250
(02) 4340 0339

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

Home Grown Aquaponics
13/8a-8b Hartley Dr.
Thornton NSW 2322
(02) 4028 6388

Warrawong Hydroponics Centre
Shop 2B - 72 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
0478 735 165
darwinhydroponics.com

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
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
26 Spencer Rd.
Nerang QLD 4211
(07) 5527 4155

HydroMart Hydroponics
4/12 Natasha St.
Capalaba QLD 4157
(07) 3823 3169 & (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
+61 (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 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
(61) 8 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) 82682636

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, S.A 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

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

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
045 996 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

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 3021
+61 (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

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.
5 Hi-tech Pl.
Rowville Vic 3178
(03) 9764 1372

HW HYDROWARE

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

Hyalite Airport West
Unit 4/504-506 Fullarton Rd.
Airport West 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 5108
(08) 8250 1515

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

JUST HYDROPONICS

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

JUST HYDROPONICS

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

JUST HYDROPONICS

Just Hydroponics Hoppers Crossing
3, 8 Motto Ct.
Hoppers Crossing Vic 3931
+61 (03) 8742 2830
justhydroponics.com.au

JUST HYDROPONICS

Just Hydroponics Mornington
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by Philip McIntosh

10 facts on...

TWOSPOTTED SPIDER MITES

Of all garden pests, the **TWOSPOTTED SPIDER MITE** may be the most feared. These little critters are hard to get rid of and can wreak havoc on your crop.

THE TWOSPOTTED spider mite *(Tetranychus urticae)* is quite possibly the most hated–and feared–of all plant pests.

ALTHOUGH THE creatures themselves are small (0.4-0.5 mm) and difficult to see, their distinctive webs and sometimes swarming behaviour can give them away. A hand lens is recommended when inspecting plants for their presence before they get too abundant.

RELATED TO their fellow arachnids, the spiders (no surprise), there are more than 1,200 species of mites and they all look pretty similar.

SPIDER MITES must be studied closely to be sure of the exact species identification. The twospotted spider mite is generally pale but variable in colour with two dark spots on the dorsal side.

SPIDER MITES are a challenge to treat with pesticides because of their tendency to be on the underside of leaves and the rapid onset of resistance. Insecticides are generally ineffective and miticides may require multiple applications before control is achieved.

THE WEBS of spider mites are much finer than most spider webs and in severe infestations, mites can be seen moving about en masse over the webs.

BESIDES THE red predatory mite, there are other predatory mites as well as midges and beetles available as biological control agents.

SPIDER MITES like to hang out on the undersides of leaves where they use their piercing mouth parts to suck the sap out of plants. This damages chlorophyll, causing pale speckling of the leaves.

DO NOT mistake the red predatory mite *(Phytoseiulus persimilis)* for the twospotted spider mite. Red predatory mites are beneficial, able to eat several adults and many spider mite eggs in a day. Red predatory mites are more solitary than the twospotted variety and seem to move about frantically on surfaces.

SPIDER MITE infestations can arise quickly at low relative humidity (20-40 per cent) when temperatures are above 29°C. Overhead watering helps keep humidity up and can wash mites off of leaves.

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