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MAXIMUM YIELD

MAR/APR 2019

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12

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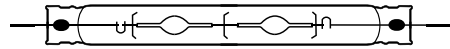
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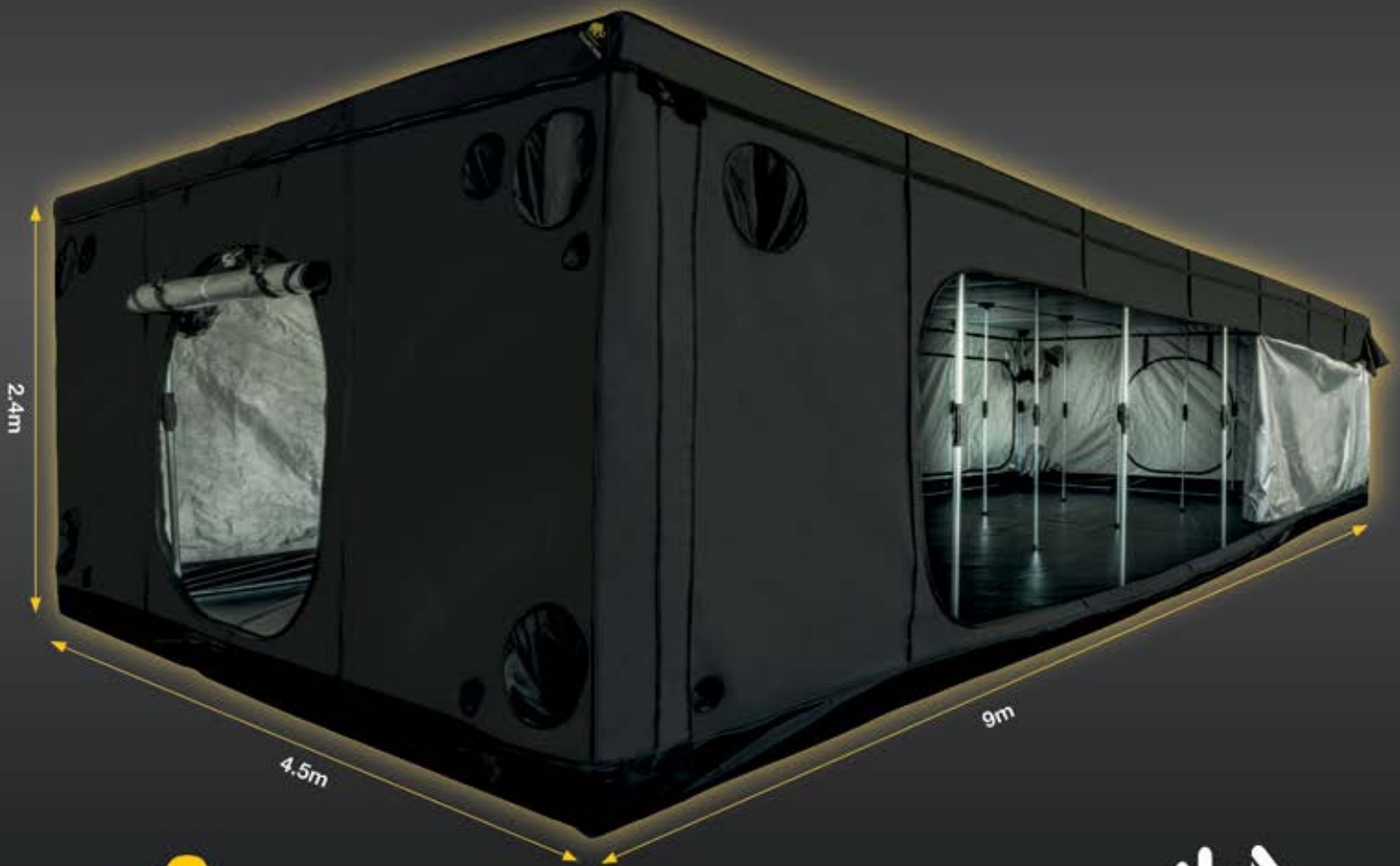


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Features

32 Optimising Greenhouse Climate

by Monica Mansfield

When dialling in the climate in your greenhouse, think about Goldilocks. The temperature shouldn’t be too hot or too cold, the air shouldn’t be too moist or too dry, and the air shouldn’t be too stagnant or too breezy.

40 Cultivating a Hydroponic Citrus Grove

by Dr. Lynette Morgan

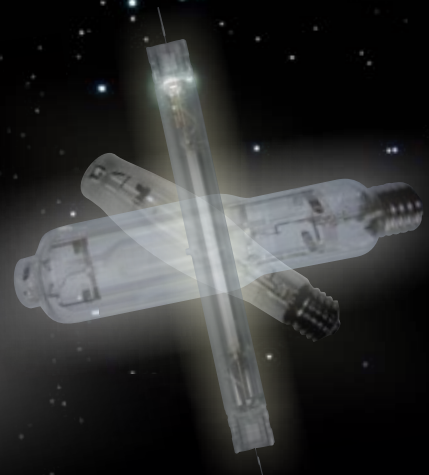
Many citrus varieties make for excellent indoor growing cultivars and reward horticulturists with some tasty fruits and fragrances.

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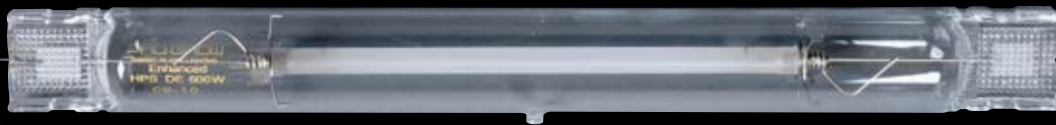


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“

No matter what technology we use to grow, how plants grow will never change.”

from the EDITOR

TG Toby Gorman

We're returning briefly to our roots in this issue of *Maximum Yield*. Over the past couple of years, we've focused on the innovation that has taken place in the indoor growing space. There has been a lot. From robotic bees to personal food computers, artificial intelligence to growing hydroponically in space, how we grow our food is constantly changing. These days, indoor farms that employ just a couple of robots and a cloud-based brain are at the leading edge of farming.

No matter what technology we use to grow, how plants grow will never change. The basic biology remains constant, as do the problems growers encounter, such as pests, nutrient deficiency, and pH control.

In this issue, we're featuring stories that every grower needs to know, starting with long time contributor Chris Bond's article "Understanding How Roots Uptake Water and Nutrients" on page 54. As Bond states, "Most folks know what plant roots are and have a vague notion of some of the basic functions they perform. Of course, roots offer an anchorage system to keep plants in place,

they store food for the plant in the forms of sugars, starches, and proteins, and roots send water and nutrients up into the plant. But not everyone knows just how the root system does these amazing things."

There is no better stage in the growing game to brush up on how roots work than the pre-veg seedling stage. We've got that covered in this issue, too, with Grubbycup's article "Caring for Delicate Pre-veg Seedlings" on page 36.

"After a seed has sprouted — but before it enters the preadolescence of vigorous vegetative growth — plants go through an oft-overlooked and frequently underappreciated seedling (pre-veg) stage. While the time spent in this stage is usually limited to a week or two, it can be fraught with opportunities for mistakes by unseasoned growers and is less forgiving of errors than mature plants," says Grubbycup.

It's never a bad time to revisit some of the basics.

As always, thanks for reading *Maximum Yield* and if you have any questions or just want to drop us a line feel free to contact us at editor@maximumyield.com. **MY**

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Featured Contributor

MM **Monica Mansfield** owned an indoor garden store for 5 1/2 years, 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.

Contributors

+ **Chris Bond**
Wiley Geren
Grubbycup
Kent Gruetzmacher
Philip McIntosh
Dr. Lynette Morgan
Bryan Traficante



A GRAFTING



Grafting is the act of taking a bud, shoot, or scion of a plant and inserting it into a groove, slit, or surface opening in a stem or stalk of another plant in which it will continue to grow symbiotically. Grafting has been practiced for thousands of years. Grafting has many purposes, from protection against disease to the creation of new fruit varieties. Grape varieties are often grafted onto different root stock to provide protection from disease and in-soil threats like fungi that one species might be adapted to, but the desired fruit crop is not.

Some grafts are within families such as apples, while some are more exciting. For example, tomatoes can be grafted onto potato plants to create a more productive garden plot. Grafting can only be successful if the grower manages to put the vascular tissues of the scion and the rootstock into contact with one another.

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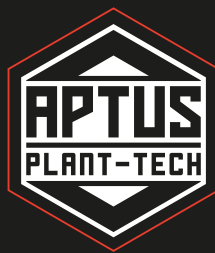
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@ I've learned so much reading *Maximum Yield* magazine, I eagerly wait for the monthly issues I get online and at the hydro shop.



@ I am a grower of forest seedlings by trade and find the articles in *Maximum Yield* add to my broader knowledge.



@ Your website gave me the courage to start growing! Love you guys, keep it up.



@ I love you guys I would be lost without you and your team of knowledge.



@ You helped me up my production last summer I was able to feed 900+ homeless out of a 20th of an acre.

Article Archives

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

Ask the Experts

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

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What proportion of plant hormones should we add for chili pepper plants?

*Thanks,
Surya P.*



Hello Surya,

The type of concentration of plant hormones (plant growth regulators) to use on chili pepper plants depends on what process you are trying to control. Plant hormones are not routinely used for the general production of greenhouse and hydroponic chili plants under normal growing conditions as the plant produces sufficient amounts of these for optimal growth, and there is a risk that incorrect application can actually have a negative effect and may even kill or severely harm plants. The main use of plant hormones on chili plants is under adverse growing conditions, such as high or low temperatures where application helps reduce flower drop thus increasing fruit set and yields. Under adverse growing conditions chili crops can have a significant reduction in growth and yields when high daytime temperatures (more than 30°C) coupled with warm nights cause abscission of flowers and poor fruit set which severely restricts yields.

The application of foliar sprays of the NAA (Naphthaleneacetic acid) auxin can enhance fruit set and yields under these conditions and make the crop more profitable. One study has also found that use of NAA at foliar-applied rates of 20-40 ppm not only improved fruit set, but also increased plant height and the number of primary branches in chili plants. However, other studies show varying responses to applied plant growth regulators, so some experimentation may be required. Other plant growth regulators that may have an effect on chili pepper plants have been reported as being GA3 (Gibberellic acid) at 10 ppm, and triaccontanol at 5 ppm, which both had a similar effect to NAA by promoting greater fruit set and resulting yields under adverse environmental conditions.

*Dr. Lynette Morgan
Suntec International Hydroponic Consultants*



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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Weed-eating Ants Could Be Boon for Farmers

Research suggests harvester ants, which eat weed seeds, can help farmers manage weeds in their fields. Farmers can also save water and improve soil quality through less tilling, which preserves the ants. "These ants are naturally present in the fields," says Barbara Baraibar Padro, a postdoctoral scholar in plant science from Penn State. "They are able to remove a huge amount of weed seeds from the system, and if farms till less to preserve ants, it can benefit them." The research, conducted in Spain, and published in *Biological Control*, shows non-tilled fields had larger nests, leading to better weed management. Tilling less can help farmers save water, improve their soil, reduce the costs of fuel and labour, and help the ants that consume weed seeds. Harvester ants can also help farmers manage herbicide-resistant weed species such as rigid ryegrass.

– sciencedaily.com

Black Apples: Rare and Costly

When people think of apples they think of vivid reds, greens, yellows or a mixture of the three colours, but they can grow dark purple, almost black, as well. These rare apples are called Black Diamond and are only grown in the mountains of Tibet. They cost \$7.26 per fruit and are sold in high-end Chinese supermarkets in packs of six to eight. Black Diamond apples are a breed of Chinese Red Delicious that get their plum-like dark purple colour from the geographical conditions of Nyingchi, in the Tibet Autonomous Region of China. A Chinese company has set up a 123-acre orchard at an elevation of 10,170 feet above sea level. The reason these apples turn dark is the notable night and day temperature differences, and their exposure to intense sunlight and ultraviolet light which causes their skin to go from the characteristic deep red to dark purple.

– freshplaza.com

Pesticide Laws Need to Protect All Bee Species

New reports argue pesticide regulations designed to protect honeybees fail to account for potential threats from agrochemicals to the full range of bee species. With the human population on the rise, and as pollinators continue to suffer declines caused by everything from habitat loss to pathogens, regulators need to widen pesticide risk assessments to protect not just honeybees, but other species from bumblebees to solitary bees, says environmental sciences professor Nigel Raine, holder of the Rebanks Family Chair in Pollinator Conservation. "There is evidence that our dependency on insect-pollinated crops is increasing and will continue to do so as the global population rises," says Raine, who co-authored three papers recently published in the journal *Environmental Entomology*. Government regulators worldwide currently use honeybees as the model species for assessing pesticide exposure to insect pollinators. The papers call on regulators to look for additional models among solitary bees and bumblebees to better gauge health risks and improve protection for those species.

– sciencedaily.com



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Massive Mushroom Considered Largest Organism on Earth

A mega honey mushroom, thought to be one of the biggest living organisms on Earth, is much larger and much older than scientists first thought. First studied in 1992 in a Michigan forest, the massive mushroom, first thought to be 1,500 years old, is in fact closer to 2,500 years old and weighs more than 440 tons. Amazingly, it stretches across 70 hectares. The honey mushroom, which largely consists of an underground network of tendrils wrapped around tree roots, is heavier than three blue whales. While the Michigan fungus is large, it is outclassed by another honey mushroom from Oregon that is even bigger. There is also the Pando aspen in Utah, a forest originating from a single underground parent clone that is thought to weigh up to 6.6 tons. The honey mushroom is edible but isn't among the most flavourful fungi out there.

– independent.co.uk



The Five Healthiest Leafy Greens

Most know leafy greens are good to grow and good for you as well, but which are the healthiest? Kale is number one due to its many vitamins, minerals, and antioxidants. To benefit from all its properties it's best to eat it raw as cooking can reduce its nutrient profile. Second best are microgreens, which can contain up to 40 times more nutrients than their mature counterparts, including vitamins C, E, and K. Collard greens come in at number three and they are a great source of calcium as well as vitamins A, B9, and C. They are also one of the best sources for vitamin K. Ranking fourth is spinach, which is another fantastic source of vitamins A, K, and manganese. Cabbage is fifth thanks to its overall nutrient value, plus studies on animals have shown it protects against lung and esophageal cancer.

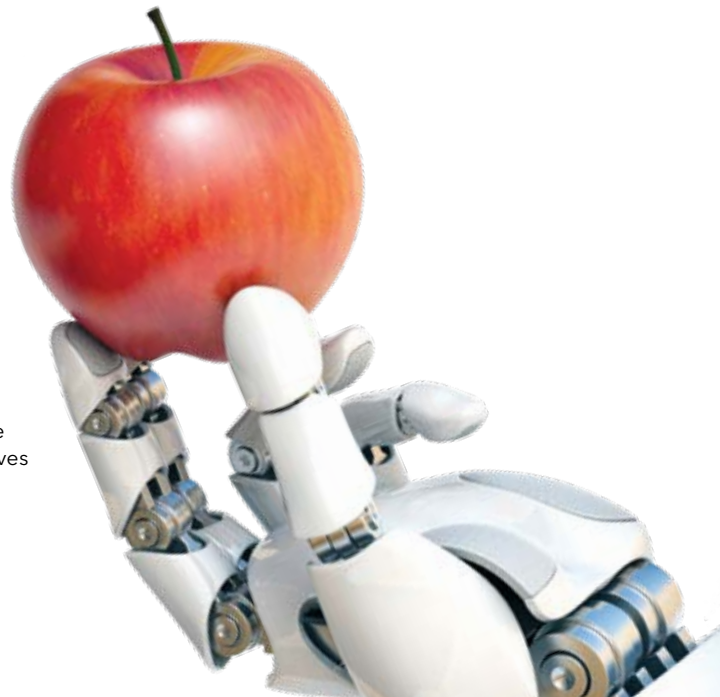
– healthline.com



How Robotics Will Influence Agriculture in 2019

More and more, farmers and cultivators are turning to technology to help maintain crop health and production. In 2019, robots, or agribots as they are sometimes called, will have more influence on the industry. Robots will help address the problem of a dwindling workforce while allowing farmers to work more efficiently. Harvest CROO Robotics develops crop-harvesting robots which have a workload capacity equivalent to 30 human workers. And despite fears robots are taking jobs, one agricultural researcher says that's not true. "The jobs have already been lost. What we're trying to actually do is increase the skill level that farm workers will have, where they'll become a fleet manager overseeing the autonomous vehicles," says Jonathan Gill. Soon, robots will be able to detect plant disease, saving farmers money. Using automation also gives growers more time to focus on the business of farming.

– freshplaza.com





Sometimes **Bigger** is Better



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1 | Nanolux DE Dual 600W DE 2K+6K

Nanolux's DE dual fixture (600Wx2) splits a 1,200W DE into two 600W lamp outputs, allowing the fixture to run both a 2K DE HPS lamp and the new double-jacketed 6K MH DE lamp. This commercial-grade fixture provides a very comprehensive PAR spectrum while pumping out 1,260 watts of the most powerful light. The spectral output of the 6K DE MH lamp combined with the 2K DE HPS lamp provides additional blue light that benefits your plant in the vegetative stage.

2 | Reiziger Grow Food A&B

Reiziger's Grow Food A&B is a full-spectrum nutrient designed without compromise to enhance the cultivation of all crop specific strains. Grow Food A&B is free of contaminants and derived from pure nutritive ingredients. It helps stabilise pH, guarding your crops against fluctuation stress and nutrient deficiencies. The balanced formula provides macro, secondary, and fully chelated micronutrients plus innovative and revolutionary patented phosphorus facilitates better absorption by the roots. Reiziger Grow Food A&B nutrients are designed for use in all hydroponic growing media, both recirculating and non-recirculation systems.

3 | Cyco Coco Coir

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

4 | Nutrifield Tank Control Range

Nutrifield is launching three new calibration solutions as part of their premium tank control range: the EC 2.77 calibration solution for calibrating electrical conductivity meters, and the pH 4 and 7 calibration solutions for calibrating pH meters. As with all their products, Nutrifield calibration solutions are made according to the highest quality specifications ensuring absolute consistency and accuracy for pH and EC calibration. It's recommended that gardeners calibrate their devices regularly to ensure the best results for their plants.

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5 | Fritsch Pulverisette 19

Optimised for cannabis production, the Pulverisette 19 boasts a high throughput of up to 60 pounds per hour. With a variable speed motor, it can work at a range of 300-3,000 RPM, quickly cutting through cannabis. It's efficiently designed so material is automatically moved and cut into increasingly fine samples by the shearing forces between the knives. The negative pressure in the cyclone ensures continuous flow through the cutting rotor. The Pulverisette 19 is designed with minimal dead space, and exchangeable sieve cassettes make for easy operation and cleaning.

6 | Hortitek Defender 800W Ballast

Hortitek has recently released the world's first magnetic 800W ballast. Being the first of its kind, extensive research and development was undertaken to ensure efficiency and performance. The Defender 800W magnetic ballast has been optimised to provide higher PPF and more efficiency than any 1,000W magnetic ballasts, while emitting less heat. With superior slotted case design for improved passive cooling, high-spec internal components for maximum output and efficiency. It also has an Inbuilt circuit breaker safety switch.

7 | Cyclo Kleanse

Cyclo's Kleanse is a salt-clearing agent formulated to solubilise most micronutrients, cationic nutrients, or metals in a growing environment. Kleanse can be utilised during the growth and bloom period to flush the root system from accumulated mineral salts, while feeding the microbial life in the substrate with needed carbohydrates. It's used throughout the vegetative and flowering periods of plant growth to provide a clean rhizosphere that aids in mineral uptake. Cyclo Kleanse is a unique and purposefully formulated cleansing agent for use with the Cyclo Platinum Series line of plant nutrients.

8 | Bio Diesel Aloevate

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

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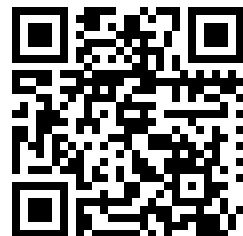
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9 | Lucius LED 150W Grow Light

The Lucius LED 150W grow light is designed to efficiently provide maximum levels of light with minimum power consumption. The 150W Lucius LED grow light can achieve 1,200 $\mu\text{mol/s}$ (highest point before light saturation) without emitting excessive heat. Whereas, gardeners using HID light systems struggle to operate at that level due to heat emission. By using innovative LED technology, cultivators can ensure maximum light is achieved while eliminating the risk of burning plants.

10 | Humboldt's Secret Plant Enzymes

Plant Enzymes, a supplement from Humboldt's Secret, is a highly concentrated enzymatic formula with a guaranteed content of 7,000 units per millilitre of active enzyme. Plant Enzymes clean roots by breaking down cellulose, dead root material, and salt buildup. This product is especially helpful for those growing in coco, deep water culture, and aeroponics and requires only one millilitre per gallon. It's available in sizes from eight ounces to 55 gallons. Plant Enzymes works in all grow media.

11 | Bio Diesel Green Diamond A&B

Another excellent Bio Diesel product, Green Diamond is a two-part grow and bloom base that's specially designed for hydroponic and coco fibre grow environments. It's a complete base that's rich in all micro- and macronutrients required for fast growth and flowering. It's packed with natural chelates and organic plant metabolites, along with pure minerals of the highest quality. Bio Diesel has also added additional trace elements, B vitamins, fulvic acid, and other bio stimulants that work exceptionally well in hydroponic and coco fibre media.

12 | Cyclo Platinum Series Swell

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Optimising

GREENHOUSE CLIMATE

by Monica Mansfield



THE GOLDILOCKS GREENHOUSE



When dialling in the climate in your greenhouse, think about Goldilocks. The temperature



shouldn't be too hot or too cold, the air shouldn't be too moist or too dry, and the air shouldn't be



too stagnant or too breezy. Here's how to get everything just right.

Greenhouses are an excellent way to extend your growing season. They allow you to enjoy a warm oasis and eat fresh vegetables throughout the winter. However, if your greenhouse's climate is not dialled in, you'll have nothing more than a hot house full of shriveled plants with moisture dripping from the walls. When growing in a greenhouse, you take on Mother Nature's job of creating the correct temperature, humidity, and air flow. Optimising the climate in your greenhouse is essential, and there are many options and techniques to help you create this ideal environment.

Temperature

Greenhouses capture heat efficiently, even in the cold winter months. Your goal is to keep the temperature in the proper range for growing. In the summer, you'll want to maintain your daytime temperature at about 24-29°C and nighttime temperature at about 15-24°C. In the winter, keep temperatures between 15-20°C during the day and as low as 7-10°C at night. The exact temperatures you maintain depend on the crops you grow and their preferences.

Many factors influence the temperature in your greenhouse, including light, outside temperatures, and air flow. Four methods commonly used for cooling your greenhouse are shading, evaporative cooling, fogging systems, and thermal mass reservoirs.



“THE EXACT TEMPERATURES YOU MAINTAIN DEPEND ON THE CROPS YOU GROW AND THEIR PREFERENCES.”

While shading is effective at reducing temperature, it also reduces the amount of light reaching your plants by 50-60 per cent, which can inhibit growth rates. Sometimes, however, this trade-off is necessary to ensure your plants' survival. To create shading, you can purchase shade cloth, paint-on materials, or adhesive compounds that can be applied directly to the glass for a more permanent solution. There are also roll-up screens made of wood, aluminum, vinyl, or plastic that come with pulley and rope systems to allow for adjustment based on light and outside temperature. You can grow trees and plants next to the greenhouse as a source of shade too. You can even grow trees or trellis grapes inside your greenhouse to supply shade to other plants. The large size of the grape leaves have the additional benefit of acting as a natural evaporative cooling system.

Evaporative cooling systems, also known as swamp coolers, turn hot air into a cool breeze by passing air through a soaked screen, pad, or spray of water. These systems are most effective in environments with low humidity as they add moisture to the air.

Fogging and misting systems are also often used to cool greenhouses. These two systems are similar in that they both spray water to cool the air. The main difference being the size of the water droplets. Foggers create a very fine mist, while misters spray larger water droplets. These systems can be put on a controller to spray water when temperatures get too high. While effective, the main drawbacks to these types of systems are excess humidity causing fungal issues within the greenhouse and clogged emitters from water with high mineral content.

You can also control temperature by keeping a black reservoir filled with water in your greenhouse. During the day, the water will absorb heat. When it cools down at night, heat is released and warms up the greenhouse. This is the principle of thermal mass at work. You can even put your tank to good use and grow fish while you're at it. As a rule of thumb, fill your reservoir with two to three gallons of water per square foot of greenhouse space. Finally, if you need to increase temperatures in the winter, you can use heaters or even wood stoves.

Ventilation and Air Flow

Air flow is essential for temperature control and fresh air exchange. Without fresh air, there will not be enough carbon dioxide for photosynthesis unless you install a CO₂ generator. Even with a generator, you'll need fans to move air within the greenhouse to help prevent fungal disease.

Vents, exhaust fans, and oscillating fans can be used for fresh air exchange and circulation. You can also install roof vents that need to be opened and closed throughout the day depending on the temperature. Roof vents are often operated by hand, but you can automate them with a thermostat controller to eliminate the manual work.

Exhaust fans can also be set on a timer so air is exchanged as often as once per minute. If it is cold outside, you will want to exchange the air less often, about a few times per hour. You can also hook your fans up to a thermostat, so air is exchanged when temperatures start to rise. Mount these fans high on the end walls and make sure they have a protective hood so that rain is not blown into the greenhouse.

Ceiling fans or oscillating fans keep air circulating within the greenhouse. This will control humidity levels and strengthen your plants' stems, just as the wind strengthens plants outdoors.

Finally, if you are going low-tech, you can install screened doors on the ends of your greenhouse to create cross-ventilation and prevent stagnant air.

Humidity

Humidity levels should be maintained between 70 and 85 per cent. When levels begin reaching 90 per cent and higher, growth slows, fungal diseases start to occur, and early bolting becomes a problem. Keep in mind it can be a challenge to measure humidity levels when air is constantly circulating. Placing multiple hygrometers around your greenhouse can help you get a more accurate reading.

If humidity gets too high, you can add a dehumidifier to dry it out. You might also try pruning your plants. Leaves perform a process called transpiration in which they release moisture into the air from pores on their surface, so reducing the foliage should help reduce humidity levels. Proper ventilation and air circulation are also important keys to managing humidity levels in a greenhouse. So, open doors or vents to reduce humidity. Controlling your temperature will also help to manage moisture levels as heat dries up moisture. If you live in an arid environment and need to increase humidity, you can do this by spraying the floor with water or installing a misting system.

Greenhouses can make a wonderful addition to your garden as long as they are managed properly. When you control your temperature, air circulation, and humidity, you can take advantage of extended growing seasons and eat fresh year-round. 🍷

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Caring for delicate Pre-Veg seedlings

by Grubbycup

When it comes to nurturing seedlings, gardeners need to be careful given how fragile plants are in the early development stage. Below are some tips for growing healthy pre-veg seedlings.

After a seed has sprouted — but before it enters the preadolescence of vigorous vegetative growth — plants go through an oft-overlooked and frequently underappreciated seedling (pre-veg) stage. While the time spent in this stage is usually limited to a week or two, it can be fraught with opportunities for mistakes by unseasoned growers and is less forgiving of errors than mature plants.

Anatomy of a Seedling

Inside a seed is a miniature, undeveloped plant, packaged in a protective shell. A seed can survive without light or additional moisture for months (sometimes years) in a state of suspended animation under conditions that would kill the same plant in any other life stage. Seeds should be kept in a cool, dark environment away from moisture or high humidity for long storage periods. Before sprouting, some seeds require a moist period of lowered temperatures to simulate winter in a process called stratification.

Seeds sprout when environmental conditions are favourable and moisture enters through small holes in the seed coat called micropyles. The moisture causes the dehydrated plant to swell, and hydraulic pressure bursts the seed coat from the inside. Food stored in the endosperm feeds the sprout until it has developed the ability to photosynthesize. The sprout sends down a root (radicle) to draw in moisture and nutrients, then sends up and unfurls a single seed leaf (cotyledon) in the case of monocots (monocotyledonous plants), or a pair of seed leaves in the case of dicots (dicotyledonous plants).

Plants with only these first seed leaves are commonly called “sprouts.” Meristem cells are among the most important to new development as they are undifferentiated and can further develop into a variety of specialised cells depending on location and need. The apical meristem at the tip of the radicle develops into the root system, while the apical meristem between the seed leaves develops into the first growth tip. Once the first true leaves start to appear, the plant is considered a seedling.



Once sprouted, the plant goes from one extreme to the other; from its most durable stage to its most vulnerable.

Starting Seedlings

Seedlings can wither and die in a matter of hours without proper moisture. They don't have an extensive enough root system to reach very far within the growing medium to take advantage of large containers, and as such are frequently started in smaller containers, then transplanted as they increase in size. Nursery pots sized to fit 1020 trays are a common choice, as are plastic beverage cups.

Seedlings planted directly outdoors should be well marked and protected from flooding or other traumata. Markers or garden maps can be helpful in ensuring each mature plant can be identified if multiple varieties of the same type of plant are grown. While it can be obvious to visually tell the difference between a squash sprout and a tomato sprout, telling the difference between similar tomato varieties can be difficult before fruit set, so keeping a record is handy.

Dos and Don'ts for Pre-Veg Seedlings

- Overwatering can be as detrimental as giving too little water. Aside from the potential to drown the plants if kept in stagnant water, an abundance of moisture or humidity can lead to a fatal fungal infection known as "damping off," which is generally considered untreatable once infected.
- Seedlings require light to grow, but high-intensity discharge lighting can be detrimental. Of particular risk is heat damage, which can not only overheat the plant directly, but can cause indirect damage by drying out the grow medium.
- Their small size means they are more susceptible to physical attacks and mishaps than established plants. Even a single insect bite that would go practically unnoticed on a larger plant can put an end to a tender seedling.
- Errors in nutrient solutions are magnified when dealing with seedlings. Nutrient solutions for seedlings should be kept mild and simple. They are not tolerant of overfeeding and are particularly susceptible to nutrient burn and negative reactions from intense additives.

“Seeds sprout when environmental conditions are favourable and moisture enters through small holes in the seed coat called micropyles.”

- Particularly in the case of moving indoor-grown seedlings to the outdoors, hardening off can help reduce the stress from a change of environments. One approach to hardening plants is taking them outside during the mildest part of the day for an hour for the first day, and for an additional hour each consecutive day (two hours on the second day, three hours the third day, etc.) for a week to 10 days. By giving the plants time to acclimatise from their (hopefully) idyllic indoor conditions to the harsher realities of outdoor life, the shock of the experience can be mitigated and the stress reduced. Hardening off is generally not required when moving to a milder environment, so outdoor plants can be moved indoors (after a quarantine period) with relative safety.
- Similar to hardening off, if the seedling will be grown under harsher high-intensity discharge indoor lighting, it is less stressful to gradually increase the intensity over a period of time than making a harsh transition to the new environmental conditions. This can be accomplished by first moving to the periphery of the lit area for a few days before placing directly under the lighting fixtures.

It behooves a gardener to take particularly good care of their seedlings, as they are the tender starts to robust mature plants. Healthy seedlings enjoy a more vigorous growth spurt from transitioning into adulthood, whereas sickly starts can take additional time to recover from their retarded development before maturing. 🌱





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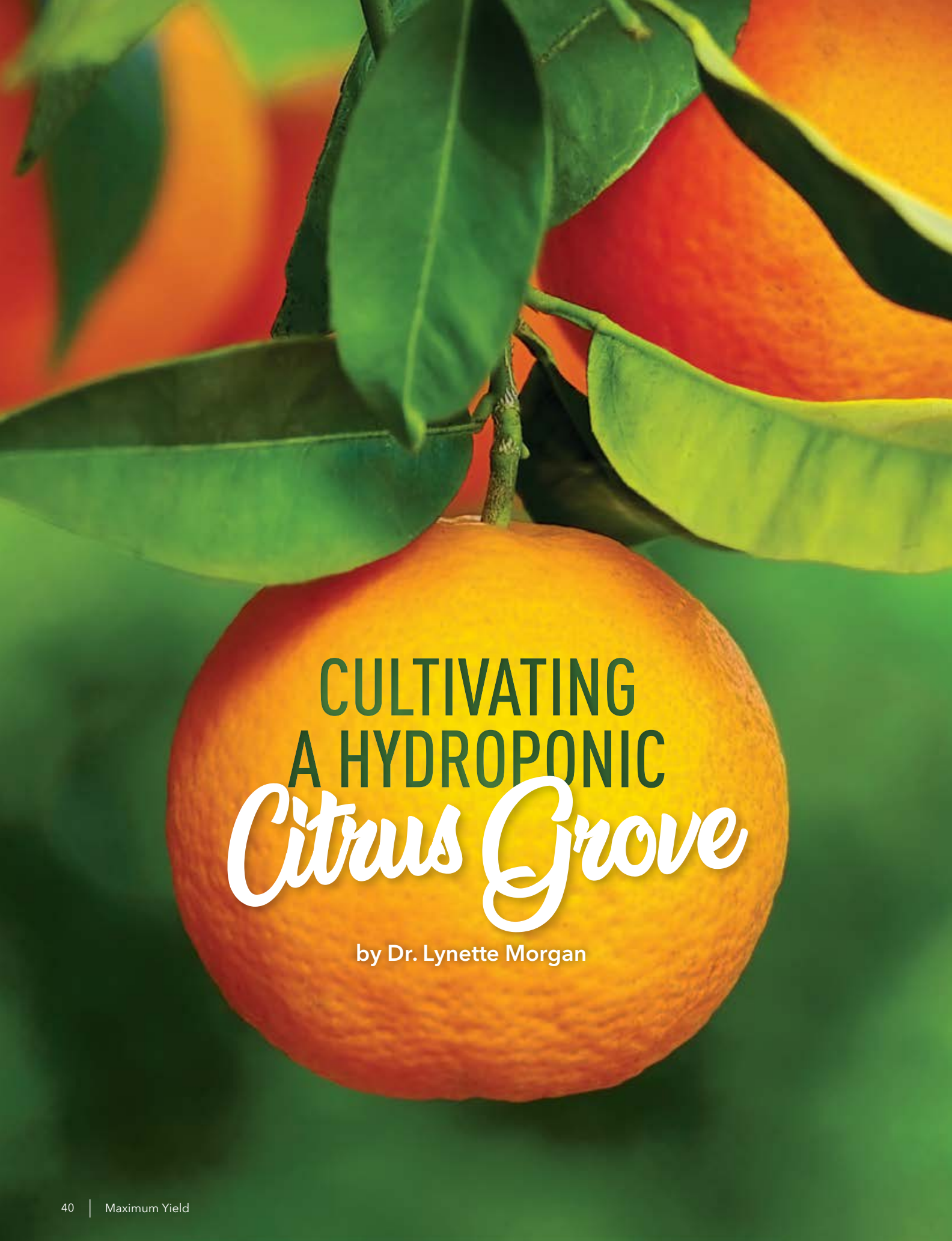


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CULTIVATING
A HYDROPONIC
Citrus Grove

by Dr. Lynette Morgan

A close-up photograph of a citrus fruit, likely an orange or grapefruit, with vibrant green leaves. The lighting is bright, highlighting the texture of the fruit and the veins on the leaves. The background is a soft, out-of-focus green.

Often overlooked
in hydroponic
growing, many
citrus varieties
make for excellent
indoor growing
cultivars and reward
horticulturists with
some tasty fruits
and fragrances.

Fragrant, zingy, and an essential culinary ingredient, citrus is not a crop to be left out of the hydroponic realm. While we may be more used to thinking of expansive orchards of spreading citrus trees grown in sun-drenched climates, with a little modification citrus can be a valuable and productive specimen for the indoor garden. By selecting high quality, grafted, and dwarf varieties of citrus, a thriving crop can be grown all year indoors, avoiding the limitations of cold outdoor environments and the risk of frost damage. As an added bonus, citrus flowers are highly fragrant and the glossy, deep-green leaves make an attractive display within any hydroponic system.

Citrus Types

While a wide range of citrus is grown commercially using hydroponic methods, these are largely long-term outdoor systems with drip irrigation. Some citrus such as Makrut lime (also called k-lime), grown largely for its fragrant leaves, are produced in greenhouses where heating is applied to extend the harvest season. With a smaller indoor garden, the objective is to maximise yields and fruit quality, while at the same time growing a healthy and attractive tree. To achieve this, investing in dwarf, grafted trees of known cultivars is the best option, as although citrus can be grown from seed, the characteristics of the resulting tree are highly unpredictable. The time to first flowering is often many years and fruit is generally inferior and lower yielding than that of named varieties on grafted plants. There are even some types of grafted trees with two or three different types of citrus grafted onto the one root stock, making more efficient use of valuable growing space. Grafting tends to produce superior trees and crops as the root stock provides additional vigour and disease resistance. Citrus trees are great specimens for restricted spaces as many varieties, such as lemons and limes, tend to fruit relatively young and while still quite small in stature. They can also be pruned and trimmed to restrain excessive vegetative growth and kept compact, while at the same time, still be highly productive. If grown with a restricted root zone volume in limited-sized pots, the height and spread of the tree can be minimised and citrus can even be grown as fruiting bonsai specimens.

Hydroponic Citrus Varieties

The most commonly grown citrus for hydroponic production are the smaller types of lemons and limes; however, there are some more unusual citrus types which offer a unique opportunity to grow a tree crop indoors. These include the tiny-fruited orange kumquat, the limequat, the Australian finger lime (*Citrus australasica*), blood limes, the strangely shaped Buddha's hand citrus, and the uniquely flavoured calamansi. The Australian finger lime, often called citrus caviar, is a relatively new specimen on the culinary scene which is currently being prized by chefs worldwide and one which is likely to become a valuable commercial hydroponic crop. Finger limes are a relative of citrus, native to Australia, but available from some citrus nurseries in the US. The fruit are elongated and finger like, and are split open to reveal rounded lime green, tart, and juicy vesicles which resemble caviar. Finger limes require warm growing conditions and are frost sensitive outdoors, thus well suited to the year-round protected climate of an indoor garden.



Left: Young fruitlets need high levels of potassium under hydroponic production. **Middle:** The uniquely shaped 'double' leaves of the Makrut lime are used in Asian dishes. **Top:** Citrus flowers are attractive and highly fragrant. **Bottom:** The knobby fruit of the Makrut lime.

“There are even some types of grafted trees with two or three different types of citrus grafted onto the one root stock, making more efficient use of valuable growing space.”

For hydroponic production, suitable varieties of common citrus types include Meyer and Yen Ben lemons, Tahiti, Key and Mexican limes, mandarins, and sweet Washington navel oranges. Makrut lime is another small citrus tree ideally suited for indoor hydroponic production which produces a double crop of highly fragrant leaves which are finely sliced and used in Thai and other Asian dishes as well as small, knobby green fruit which provide aromatic zest and juice. The advantage of Makrut lime is not only that the fresh leaves are far superior to the dried version, but the plant is often only grown for its valuable foliage and doesn't necessarily need to flower and set fruit.

Start with Plants from a Good Nursery

For a new hydroponic planting, obtaining relatively young plants from a reputable nursery is a good place to start as these can then be regularly pruned to maintain a compact and attractive shape before flower buds start to form. Obtaining older, tall and sometimes straggly plants makes the process of height control much more difficult and productivity often suffers with this type of planting stock. Once plants are in place and well established, citrus should be pruned to remove the growing points of any dominant stems and promote the production of several side branches which will allow the plant to carry more fruit and remain compact.

Light, Nutrients, and Pots

Citrus, being fruiting plants, require a moderately high level of light to keep plants compact, prevent elongated growth, and produce sufficient assimilate (sugars) for high-quality fruit. A light level similar to that provided for fruiting tomato and capsicum plants is ideal, provided citrus trees are not overcrowded and kept pruned for maximum light interception. If light levels are low, citrus trees will continue to grow foliage, but often fail to flower or any sparse flowers that do open may not carry fruitlets through to maturity. Temperature optimums are also similar to many other hydroponic fruiting crops, although they vary depending on the type of citrus being grown. For optimal year-round growth, most citrus grows well within a temperature range of 24-30°C, however, will survive much cooler conditions down to 2°C for short periods of time.

Since most citrus fruits are a long-term crop and will continue to be productive for many years, growing containers of at least four gallons are recommended. Substrates such as coconut fibre or perlite are ideal, however, citrus have been grown on a wide range of soilless mediums including gravel, grow rocks, peat, bark, stonewool, rice hull, and even in aeroponics. Good drainage is essential with citrus as oversaturated root zones can be prone to root rot, so the addition of some coarser material in the base of the growing container is always a good idea for long-term plants. Drip irrigation systems are most often utilised for nutrient delivery with standard vegetative and fruiting formulation applied during the different stages of citrus tree growth. A nutrient formation high in potassium with additional magnesium is essential during the fruit formation phase, as citrus fruit quality is related to potassium nutrition as well as environmental growing conditions.

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Left: Manual pollination of citrus flowers is required in an indoor garden; paint brushes can be used to distribute pollen. **Top:** Citrus often set many more fruitlets than can be carried to maturity. **Bottom:** Lemons are well suited to container or hydroponic production.

“A light level similar to that provided for fruiting tomato and capsicum plants is ideal, provided citrus trees are not overcrowded and kept pruned for maximum light interception.”

Tips for Indoor Cultivation

Apart from good light and sufficient warmth, citrus benefit from some gentle air flow through the foliage. This helps remove any stale air and excess humidity and reduces the disease risk to the plants. One of the most vital aspects of growing fruiting citrus indoors is pollination which is essential for fruit set. Outdoors, bees and other insects carry out the pollen transfer role with great efficiency, however, indoors this needs to be done manually. The process is relatively simple as citrus don't need to be cross pollinated. A small paint brush can be used to collect the yellow pollen grains from within a citrus flower; these are then brushed off into the stigma (found at the top of the long column in the middle of the flower). The stigma becomes sticky when receptive to pollen, allowing the brushed-on pollen grains to adhere and stay in place.

This process can be carried out a few times a week when citrus trees are in flower and is usually highly successful. It is normal for many types of citrus to produce masses of highly fragrant flowers, far more than the tree could ever support as fruit. For this reason, it's not usual to see the excess flowers or tiny fruitlets drop from the tree — this is just a natural self-pruning process which thins fruit to only those which the tree can support through to maturity. Young trees may only be able to carry a small handful of fruit in the first season and fruit loading will increase with the age and size of the tree.

Harvesting Hydroponic Citrus

Harvesting citrus fruit is relatively simple — it's best to cut these from the tree rather than pull them off as this often snaps branches or causes fruit damage. Lemons and limes, once mature, can be left on the tree for a considerable length of time, often months, before harvest and this is often used as a way to store excess fruit until it's required. However, retaining a high fruit load can delay flowering and the next crop of young fruit, so prompt removal is often a better option. Excess citrus fruit and even k-lime leaves can be stored in the freezer until required or processed into juice, jellies, marmalade, or syrups.

Whether it's the new and exotic Australian finger lime or a common everyday lemon tree, hydroponic citrus fruits are a valuable addition to any indoor garden. Fragrant flowers, glossy deep green foliage, and bright decorative fruit make these ideal productive specimens well suited to hydroponic systems. 🍊



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Hard or Soft: **KNOW YOUR GARDEN** **WATER**

by Bryan Traficante & Wiley Geren

Not all water is the same and what type of water – whether hard or soft – is flowing through the pipes in your house might be impacting how well or poorly your garden is doing.

Do you know what type of water is flowing through your house and hose spigot? If you don't, it's easy to figure out. Next time you take a shower, pay attention to how your skin feels afterwards. Do you feel slippery, or do you feel squeaky? If you feel slippery, then you have soft water. If you feel squeaky, then you have hard water. Does hard or soft water make a difference to your garden plants? As part of a plant's holy trinity — water, sun, soil — you need to know what kind of water you are using. If you have been having a tough time getting anything to grow in your garden and have checked your soil and sun, then the problem could be your water. But what is the difference between hard water and soft water?

HARD WATER

No, hard water doesn't mean it's mixed with alcohol. Hard water is comprised of dissolved minerals – the majority of which are calcium (Ca), magnesium (Mg), and lime. Unless you have a water softening system, hard water (to varying degrees of hardness) is the standard type that flows through public and private systems. Once again, there is an easy way to tell if you have hard water. If, over time, white/pink scum builds up on your household fixtures (sinks, bathtubs, toilets, etc.), then you have hard water. Those buildups are caused by the minerals slowly collecting. However, that does not mean hard water is bad for you or your garden.

SOFT WATER

Soft water is treated, or softened, with sodium which removes the minerals. That's why your skin feels slippery after showering with soft water and why glassware looks cleaner after washing with it. The minerals that build up on your skin have been removed, so there's nothing to wipe off. To remove the minerals, water is treated with sodium in a system usually set up somewhere within your residence.

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“ Hard water provides your garden with useful mineral content and doesn't have the excess sodium of treated soft water.”


Soft water systems are often installed in areas where there is a high amount of minerals in the water that may affect the plumbing, or simply because some people prefer the taste and feel of soft water over hard water. It may not leave buildup or residue on your fixtures and skin, but that does not mean soft water is good for your garden.

PROS AND CONS FOR GARDENING

The simple answer: Treated soft water has little to offer your garden except plant-killing sodium. Although only trace amounts of sodium are present in soft water, it can build up over time in the soil. After enough builds up, the sodium causes your plants to die of thirst. If you are worried this is the case now, you should leach your soil. This is done by watering thoroughly and frequently, which basically washes away the sodium buildup. However, you'll also be washing away some nutrients and minerals that are vital to your garden's nourishment. If you leach your soil, make sure you replace the mineral/nutrient content afterwards with an additive or fertiliser.

Hard water provides your garden with useful mineral content and doesn't have the excess sodium of treated soft water. Calcium and magnesium are vital to a plant's growth but can be harmful in large doses. Too much can cause chlorosis — a yellowing of the leaves which is a symptom of sickness. To prevent sickness like chlorosis, use a raised garden bed that provides better drainage. Excess minerals will leach from the soil naturally, be rebalanced with the minerals in your hard water, and your garden will be much happier.

WHICH SHOULD I USE FOR MY GARDEN?

This is a trick question because the best option for your garden isn't hard water or soft water, but rain water. Rain water, while technically soft water, lacks the sodium of treated water and won't lead to that excess mineral build-up hard water can bring. Rain water is friendly to plants and, conveniently, can be collected in rain barrels for use in your garden. If you don't want to collect and use rain water, the next best option for your garden is hard water. 

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LIGHT LEAKS

AND SEALED GROWROOMS

by Kent Gruetzmacher

Light leaks in your sealed growroom can be disastrous for some kinds of plants. They can also be a sign that more than just light is getting in, including pests and other environmental variables.

When planning and setting up indoor gardens, growers spend time and money in the creation of environments where plant species thrive. For sealed growrooms, this process represents a careful balancing act between temperature, humidity, light, and CO₂. However, once an indoor grow is operational, these synthetic environments create challenges for growers that are non-existent in the natural world. The reaction of indoor plants to light leaks during dark periods (nighttime) presents one of these unusual phenomena.

Certain species of plants are subject to photoperiodism, in which the varying duration of light cycles between day and night cause plants to enter new phases of growth. To illustrate, uninterrupted 12-hour periods of darkness (nighttime) causes some plant species to start flowering. This process occurs when a hormone called photochrome reacts to sunlight intensity and durations, directing plants towards the different phases of growth.

If a sealed growroom is not 100 per cent dark during the nighttime period, photoperiodism cycles can be interrupted, causing photochrome imbalances as related to specific plant processes. These hormonal imbalances can have negative and sometimes detrimental effects on an indoor harvest.

For those looking to avoid issues with light leaks in their sealed growrooms, consider the following points:

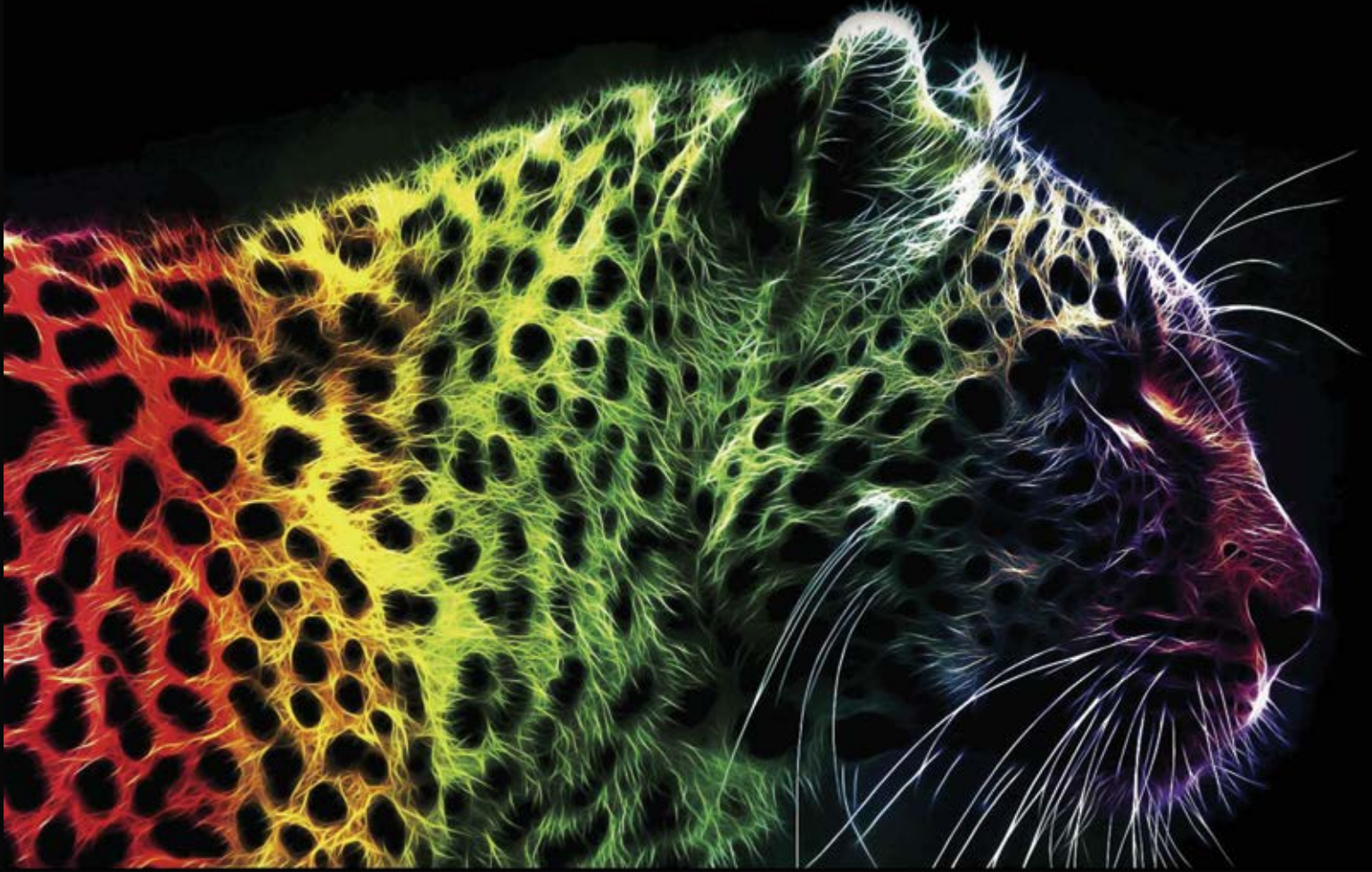
Inconsistencies and Stress

Indoor gardeners should always strive for consistency in their growroom environments. Most crops perform best in stable environments, and bountiful harvests are the result of constant environmental balance — including stable lighting intervals — during both vegetative growth and flowering. A common misconception amongst indoor growers is that light leaks during the vegetative growth phase won't disrupt crop growth. However, any irregularities in lighting patterns can stress plants out. Along this line of thought, all environmental stressors inhibit essential plant functions, such as nutrient uptake, and retard growth.

Light leaks can also prove troublesome regarding photochrome levels in plants, as unexpected or irregular doses of light can alter stable hormonal conversion processes. During flowering phases, excess light during dark periods can push photochrome activity to the point of converting a plant back into vegetative growth.

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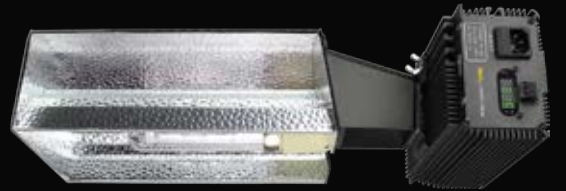
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"It's a good idea for cultivators to regularly check their growrooms to make sure they are

100 PER CENT

DARK DURING THE NIGHTTIME PERIOD."

Hermaphrodites

One of the most widely known negative side effects of growroom light seepage has to do with the transformation of female plants into hermaphrodites. For those looking to grow seed-free flowering plant varieties, hermaphrodites can prove devastating for a crop. This is because male flowers on a single plant can pollinate an entire growroom and greatly devalue a harvest.

Expert horticulturists agree that certain plant species turn hermaphrodite as a result of environmental stressors, and light leaks are notorious for being associated with this phenomenon. However, it should be noted that the occasional beam of light on a garden from a headlamp won't cause plants to "herm." While indoor growers should strive to avoid any disruptions in regular light cycles, it takes rather consistent light exposure to force a plant into hermaphrodite growth. These sorts of leaks come from constant sources, such as under doorways and walls, that occur on a daily basis.

Light Leaks Mean Other Leaks

Indoor growers can be assured that if their sealed growroom is leaking light, it has issues with other leaks. Seasoned cultivators go to great lengths to ensure that their sealed gardens are functioning at their best when it comes to atmosphere, temperature, and sterility. All these contingencies are compromised with an improperly sealed growroom.

If leakage issues arise, growers sacrifice the total environmental control that is so essential in sealed room growing. With this issue comes potential problems with maintaining ideal, static levels of temperature, humidity, and CO₂. Moreover, as sealed rooms are wholly dependent


upon CO₂ injection technology, the regular loss of CO₂ to leaks is financially burdensome and operationally threatening. If light leaks can penetrate the confines of a sealed garden, so can airborne pathogens. As such, it is virtually impossible to fully sterilise an indoor grow if bugs and spores (of powdery mildew and botrytis) can continuously access the grow space via leaks.

Locating Light Leaks

Many indoor growers don't know that their rooms have light leaks until it is too late, and the problem expresses itself by way of hermaphrodites and seeded flowers. As a result, it's a good idea for cultivators to regularly check their growrooms to make sure they are 100 per cent dark during the nighttime period.

To inspect an indoor garden for light leaks, it's best to enter the grow with a green light when the primary lights are off. Once situated in the garden, turn off the green light and sit still for a while to let your eyes adjust to the blackness. At this point, it should be easy to canvass the walls and ceilings of the room and discern any potential points of light leak trouble. Also, this inspection process should be done during various parts of the day, as different angles of sunlight outside can cause light leaks during isolated time frames.

Gardeners should also be advised that control panels on grow equipment, such as atmospheric controllers and AC units, often give off light. This light is usually red or green and is residual from the digital readout. As such, it is recommended that growers cover up these light sources with electrical tape or some sort of removable opaque material.

Compared to any other form of controlled environment agriculture, sealed-room growing provides the most mastery over environmental factors. However, these growrooms present novel challenges of their own, as seen with the issues surrounding light leaks. For the conscientious gardener, regular inspections of one's garden should alleviate any light leak problems. All things considered, this knowledge will provide a better platform for troubleshooting on the macro-level moving forward. 

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UNDERSTANDING
HOW



UPTAKE WATER
AND NUTRIENTS

by Chris Bond

Roots play an integral part in plant survival, whether it's as an anchor or providing life-sustaining water and nutrients. Chris Bond explores just how roots do their job to keep plants alive.

Most folks know what plant roots are and have a vague notion of some of the basic functions they perform. Of course, roots offer an anchorage system to keep plants in place, they store food for the plant in the forms of sugars, starches, and proteins, and roots send water and nutrients up into the plant. Root systems also play a role in vegetative reproduction in some plants. But not everyone knows just how the root system does these amazing things — all without anyone ever really seeing them in action.

Root Anatomy

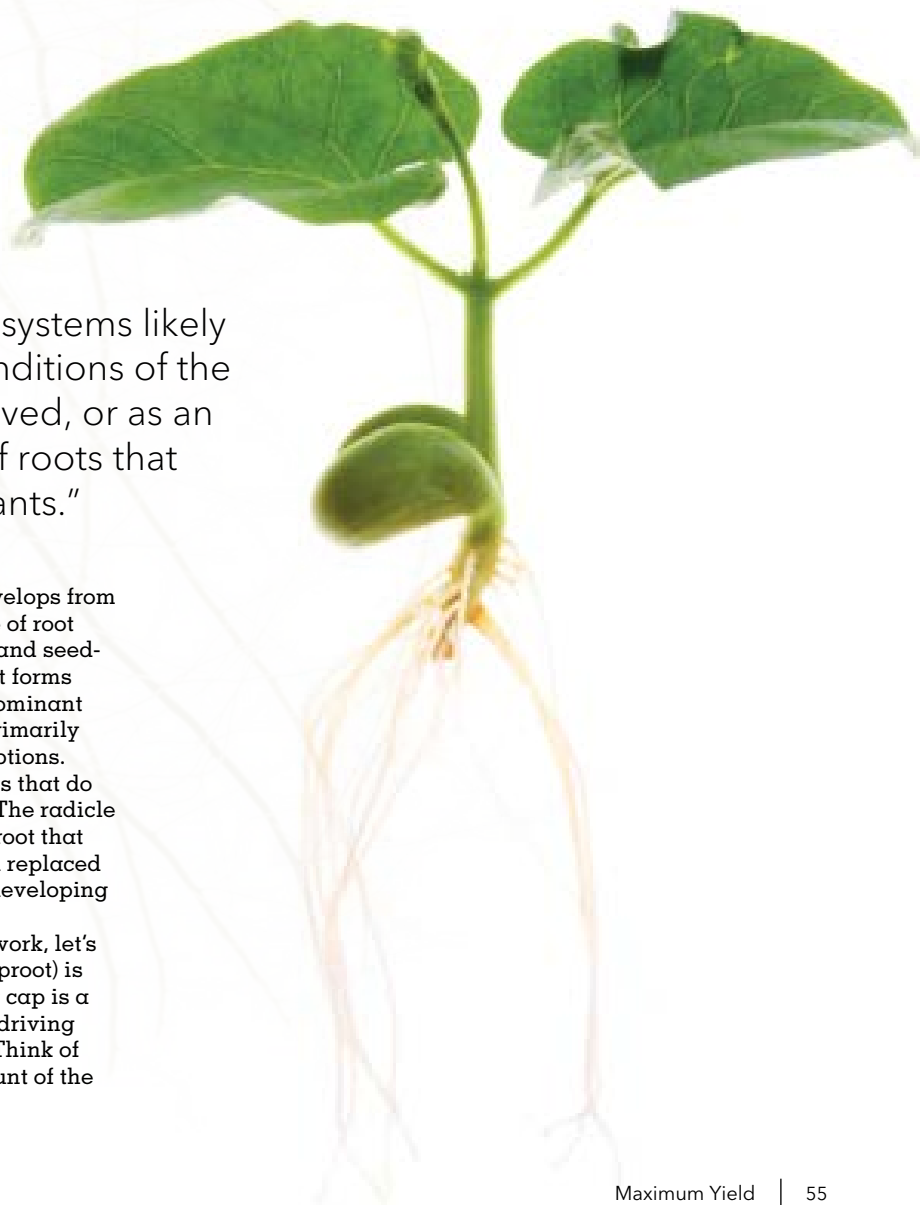
There are two primary types of root systems — taproot systems and fibrous root systems. Both serve nearly identical purposes but in different ways. Plants with their respective root systems likely evolved based on the conditions of the native soil where they thrived, or as an adaptation to the types of roots that supported competing plants. Through site-specific evolution and human intervention, it is quite probable that in any typical landscape you will find plants with both kinds of roots growing in proximity to each other.

plants

with their respective root systems likely evolved based on the conditions of the native soil where they thrived, or as an adaptation to the types of roots that supported competing plants.”

In taproot plants, the first root or proto-root that develops from the germinating seed is called the radicle. This type of root system is commonly found on most conifers, dicots, and seed-bearing plants. It consists of a predominant root that forms from the radicle and grows downward. Other less dominant root branches will form off this tap root. Monocots primarily develop fibrous root systems, though there are exceptions. Fibrous roots are a dense mat of similarly-sized roots that do not venture as far away from the shoot of the plant. The radicle in monocots does not stick around for long; the first root that develops and holds the seed in place is aborted and replaced by others shortly thereafter, starting the process of developing the robust stitchwork of the fibrous root system.

To peel back a further layer of roots and how they work, let's start at the bottom. The end or tip of the root (on a taproot) is protected by a structure called the root cap. The root cap is a mass of hardened cells that are the tip of the spear, driving the root downward, protecting the layers behind it. Think of it as the nose of a space shuttle that can take the brunt of the resistance upon re-entry into the atmosphere.





inside the roots or root cells, water and dissolved nutrients travel through different root pathways in one of two ways – either symplastic movement or apoplastic movement.”

The Secret World of Roots

Root systems are a network of connected botanical appendages whose entire mass can sometimes dwarf the above-ground portion of the plant it is supporting. It takes a lot of work behind the scenes to feed and care for all the flowers, fruits, and leaves getting most of the accolades. They don't, however, work alone. The root (mostly below ground) and shoot (mostly above ground) systems work in unison in a positive feedback loop. Though an oversimplification of the process, it's safe to say the photosynthesis work the leaves and greens do sends nutrients below to the root system, which is then able to expand and grow, sending more food and water upward so more leaves can be produced. Then more photosynthesis can occur, and more roots can develop and so on.

Roots are constantly attracting and transporting water and dissolved nutrients from the medium they are in. Deep down in the root cells, a pressure builds. This root pressure creates a siphon-like action which forces water and nutrients up into the above-ground portions of the plant while water and nutrients from the surrounding soil are drawn into the root. This is due to the higher concentration of nutrients and minerals inside the root cells than in the soil environment around the root system. In addition to this force, moisture from the soil is continually being absorbed into the roots by the negative water potential within the root cells.

Symplastic vs Apoplastic Movement of Water and Nutrients in Roots

Once inside the roots or root cells, water and dissolved nutrients travel through different root pathways in one of two ways — either symplastic movement or apoplastic movement. Most water and nutrients move through the roots via apoplastic movement. When this happens, water does not actually enter the cells, but travels through the passages between cells. Think of this as a hallway connecting bedrooms. This is easier than travelling by symplasticity.

Behind the root cap is the cortex, which makes up the bulk of the rest of the root. The cortex is loosely packed with cells and empty space, both of which store water and allow it to flow into the xylem vessels, sending water and dissolved nutrients to the above-ground shoot systems. Roots lack openings such as the stomata found in leaves. Rather, roots are covered in thin-walled cells, known as parenchyma cells, which act as a water-absorbing membrane. These are primarily found in the cortex of the root. This entire outer wall of the cortex is known as the epiblema and the main conduit for this transport at the centre of the cortex is known as the endodermis. Unlike the rest of the cortex, the cells in the endodermis are more tightly arranged so water does not escape back into the cortex but can be sent on its merry way upwards through passage cells. However, this does not happen until the water and nutrients have passed the root system's smell test. To that end, the endodermis is a plant guardian. If the plant has inadvertently absorbed any toxic material, the endodermis filters it out and rejects it. A waxy barrier known as the Casparian strip is the gatekeeper at play here. Proteins within the cells allow for the good compounds and molecules to pass, while toxins are weeded out and removed.

Root hairs are an extension of the endodermis. These fine, long, and narrow projections grow out from mature roots, helping increase a root system's ability to absorb moisture and nutrients by increasing the root system's surface area, which increases contact between roots and soil.

The stele, pericycle, conjunctive tissue, and vascular bundles round out some of the lineup that make up the typical root. If you really, really want to know more about the intricate functions of roots, or have a severe case of insomnia, look up "histogen theory" and/or "Quiescent Center." For our purposes here, these go way beyond the realm of useful knowledge for the layman horticulturist, this author included.

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With symplastic movement, water and nutrients must cross over a cell membrane to enter into the cytoplasm, a gelatinous material inside the cell. Water and nutrients must then travel upwards by moving through the cell walls. Think of this as gaining access to bedrooms through the adjoining walls instead of taking the hallway.

To recap the process of water and nutrient uptake, we can reduce it to four basic steps:

- **Step 1:** Water and dissolved nutrients enter the roots through the root hairs by the process of osmosis or root force.
- **Step 2:** Water and dissolved nutrients then cross over the root cortex either through symplastic or apoplastic movements.
- **Step 3:** Water and dissolved nutrients enter the xylem.
- **Step 4:** Water and dissolved nutrients are sent up into the plant stem in the transpiration stream to deliver needed nutrition to all the shoots of the plant.

These processes will go on so long as the plant is alive, and water and nutrients can be found in the soil. Periods of drought will slow down these actions and, in some cases, encourage root growth as plants seek deeper sources of water and nutrition.

Mycorrhizae: Roots' Fungal Friend

Worthy of inclusion, though not a component of root anatomy or function proper, is mycorrhizae. This lauded beneficial fungus attaches itself to plant roots in a symbiotic embrace that can exponentially increase the reach of any particular root system. As many as 85 per cent of plants may owe all or some of their nutrient uptake capacity to mycorrhizae. The fungus not only gets fed while attaching itself to root systems, but acts as a force multiplier by increasing the reach of plant roots and the surface area of the root system. The hyphae, or tentacles of the fungus, are much smaller than even the root hairs and can therefore mine into much smaller crevices in search of nutrients.

In addition to the basic and more complex functions described earlier, roots also serve to aerate the soil they are anchored in and can pull the plant closer to the dirt for protection from the elements. All of these and more are functions of roots in the care and feeding of the shoots. 🌱



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for outdoor soil gardens





While automation is a huge part of indoor growing, outdoor soil cultivators can also take advantage of technologies like controllers and fertigation injectors to cut down on labour and overall costs.

by Kent Gruetzmacher

N O P T I O N S

Indoor and outdoor horticulturists enjoy certain perks of their respective practices, and these perks are generally interrelated with gardening labour and work environment. For indoor growers, access to conveniences such as electricity allows for the use of technology related to environmental controls, lighting systems, and irrigation setups. These workplace bonuses generally make the day-to-day routine of the indoor grower more enjoyable, as they lighten the workload and allow for the precise monitoring of the indoor garden atmosphere. Conversely, outdoor gardeners grow their crops under the expanses of blue summer skies, breathing fresh air with their hands in the dirt. For outdoor growers practicing organic cultivation, these natural environments blend seamlessly with a deep appreciation for the living biologics of soil growing.

Looking at the perks of both indoor and outdoor growing, one must ask: Can't I enjoy the benefits of both? While it goes without saying that indoor cultivators can't enjoy the freshness of the outdoors, who says outdoor growers can't make their lives easier with some technological advancements? With that, *Maximum Yield* decided to look into automation options for outdoor soil gardens to ensure that, over the long summer, outdoor gardeners have ample time to bask in the rays of the summer sun. For those outdoor enthusiasts looking for a technological boost in their operations, here are a few options.



“CONTROLLERS ARE THE ESSENTIAL ELEMENT

in transitioning an outdoor soil garden from a hand watering or drip system to a smart irrigation program.”

can be programmed to mix up to 20 different fertiliser feeding regiments, simultaneously, for a single garden.

The ease-of-use for smart irrigation controllers is tied to both their technological perks and practical applications. Generally, controls are the most beneficial for outdoor cultivators as relating to timing and consistency, they can be set on digital timers or light sensors for automated irrigation on a daily basis. As many plant species thrive on consistent watering and environments, the precision

of controllers makes them a serious value-add for outdoor commercial operations. Also, many controllers feature “cloud-based capabilities,” in which a grower can monitor and change irrigation and nutrient levels from their smart phones or computers. As such — and if implemented correctly, outdoor soil growers can alter irrigation practices from afar — this perk is particularly notable concerning changing weather and temperature patterns. All things considered, controllers can add efficiency and stability in outdoor gardening practices that are notorious for getting off schedule due to human error.

It’s worth noting outdoor growers must be diligent in taking care of controllers, as sun, dirt, and dust can easily damage these somewhat fragile pieces of technology. Controllers should be well-mounted in a protected, low-traffic area, ideally within a metal or wooden box.

Fertigation Injectors

For both indoor and outdoor growers, fertigation injection systems have become a staple of ease and efficiency. Traditionally, water-based fertilisation processes have been hinged on the labour-intensive practice of manually mixing nutrients in reservoirs or holding tanks. For commercial sized operations, this demanding and tedious chore often involves the mixing of thousands of gallons of water at a time, multiple times a day. However, with some ingenuity and careful planning, the engineers behind fertigation injectors have developed a product which nearly eliminates the painstaking chore of hand mixing water-soluble fertilisers.

Controllers

Advancements in digital control technology for controlled environment agriculture have made controllers, or “brains,” an essential tool in modern gardening, both indoors and outdoors. For indoor growing, controllers have taken the thinking process out of mundane, yet easy to forget, chores like setting lighting timers and regulating temperatures. Similarly, for tech savvy outdoor growers, the fluidity and ease-of-use of these smart-products is too tough to resist. While most smart indoor garden technology sets forth to regulate ambient environments, automated systems for outdoor growing focus solely on irrigation.

Controllers are the essential element in transitioning an outdoor soil garden from a hand watering or drip system to a smart irrigation program. Utilising cutting-edge computer technology in conjunction with touch screen displays, controllers send precisely dictated electronic signals to components in the physical figurations of irrigation infrastructures (see next section). With electronic integration, these smart controls regulate valves relating to both nutrient and water dispersal in the macro-irrigation system. The more sophisticated of these controllers

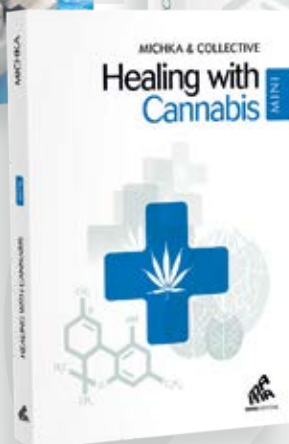
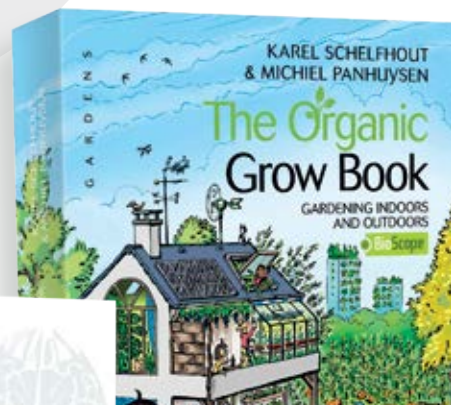
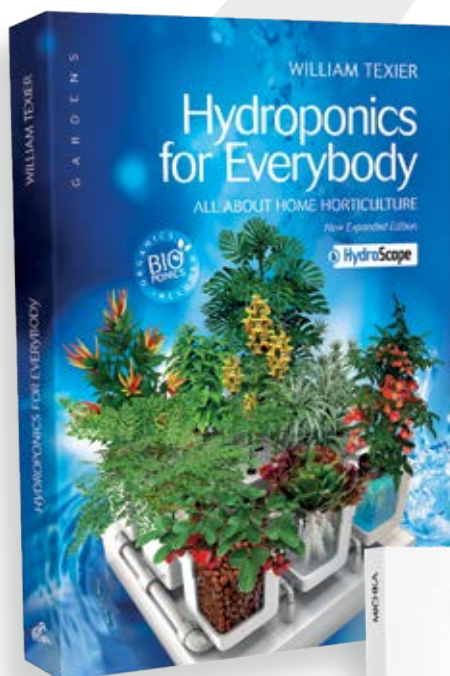


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As discussed in the previous section, smart controllers can be implemented in conjunction with fertigation injectors, creating a highly efficient and precise system for outdoor soil irrigation. In layman's terms, the controller dictates the operations of several pressurised valve systems that are fed from separate containers of nutrients. The controller also regulates water pressure from the primary water source. When the irrigation process begins, water flows through a pipe that is integrated with the nutrient valve system, then the fertigation injector releases nutrients into the water flow in conjunction with specific levels of water pressure. When operating and balanced correctly, the fertigation and controller combination delivers precisely measured, nutrient-rich water into soil containers — with little human effort.

For good reason, outdoor commercial cultivators have come to cherish the ease-of-use of fertigation injectors. For outdoor growers committed to a six- to seven-month growing season, automation options like fertigation literally eliminate hundreds of hours of unnecessary labour in manual nutrient mixing. The precision of fertigation is entirely unmatched by human effort; top-of-the-line injectors disperse carefully controlled amounts of nutrients down to five millilitres per injection.

For economically and environmentally conscious cultivators, the precision afforded by fertigation injectors brings significant savings on both water and fertiliser use compared to traditional hand-mixing methods. Because hand mixing nutrients in large reservoirs always leads to an excess of leftover water that generally cannot be reused — this problem is non-existent with the strict controls of fertigation.

“FOR ECONOMICALLY
AND ENVIRONMENTALLY
CONSCIOUS CULTIVATORS,

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fertigation injectors brings
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and fertiliser use compared to
traditional hand-mixing methods.”*

Drip Systems

While drip watering components don't necessarily fall into the automation category, they are an essential element in any smart irrigation plan for the outdoors, especially concerning organic growing. With that, the controller and fertigation injector combination feed nutrient-rich water through hoses or pipes, and finally into soft-plastic tubes that should be embedded deep in the soil of each garden container.

Since outdoor growing containers are generally far larger in size than their indoor counterparts (Smart Pots can range up to 1,000 gallons in size), top drip systems work inefficiently for outdoor growing. Concentrated drips of water in such large containers leave a clear majority the soil unirrigated, leading to several serious problems. Therefore, to effectively deliver water and nutrients, automated outdoor irrigation systems must utilise long lengths of perforated irrigation tubing that is coiled around inside the soil-filled container. With this method, fertilisation will be accomplished in a uniform fashion, and organic soils will retain the requisite moisture content to maintain the integrity of their biological communities.

In utilising some of the automation perks from indoor gardening, and adding some necessary tweaks, outdoor cultivators can enjoy the benefits of cutting-edge irrigation technology. For commercial-sized operations, the benefits of smart equipment like controllers and fertigation injectors far outweigh financial costs. Looking forward, one can only assume outdoor growers will continue to combine their passions for soil growing with the modern gardening technologies, making for a practice that utilises the best of both worlds. 🌱





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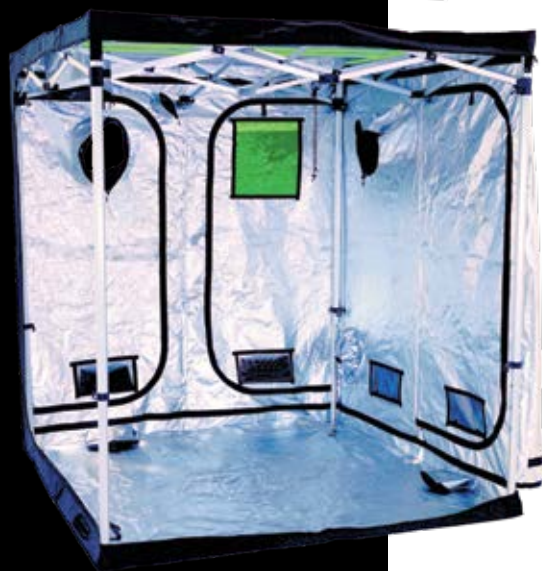
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Direct feedback from industry professionals and consumers drives innovation at Green-Qube, which now features 30 models in its grow tent product line, including the industry-first pop-up grow tent. *Maximum Yield* sat down with Green-Qube's director and founder Dan Van Keogh to see what the company will come up with next.

Green
Qube

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Thanks for taking the time to share your story with us, Dan. Could you please give us a brief description of your business?

Green-Qube designs and manufactures high-quality, technology-led hydroponic grow tents for home growers, predominately in the UK and Europe. We lead the way in terms of product development and aim to be the first to introduce new ideas and grower-beneficial features into the grow tent industry.

We work closely with growers, hydroponic shops, and industry leaders, and have established an open dialogue for feedback and product development, ensuring that we have continual fresh tent updates and creative improvements. We strive to provide innovative high-quality grow tents at low price points.

We have a range of over 30 grow tents, including the Roof-Qube and the Quick-Qube, the brand new, first-of-its-kind pop-up grow tent. Based on an adapted industrial gazebo frame, the patented design literally allows you to simply drag the frame out to put it up.

What did you do before starting Green-Qube?

Very randomly, I branded high-end parasols, umbrellas, and gazebos from corporations, breweries, hotel chains, big events, and all sorts of companies. I worked closely with contacts in China to source and manufacture such products, along with having more than 10 years of experience importing. I also had a passion for design and spent time educating myself in design software so I could get involved with the design element of the role too. I absolutely loved this side of the job, especially as I have always had a geeky curiosity about design, architecture, and engineering.

When and where did the company begin?

I started designing grow tents in 2009 and the first Green-Qube hit the market in 2011. Being Welsh, it was important for me to stick to my roots and run the business from Wales. I chose Cardiff as it was such an expanding and diverse city, and it is just down the road from my hometown of Caerphilly, so I could still pop home for my mum's home-cooked dinners. And yes, Caerphilly is where the famous cheese comes from.

Has your company moved or expanded since the beginning?

We have moved locations but not far. We are now just outside Cardiff in the buzzing and creative seaside town of Penarth. With age, kids are now in the equation, so a quieter pace of life and the beach was a real draw. It is important for us to have a work-life balance and Penarth offers amazing cafes, bars, and restaurants as well as countryside and sea — what more could you want?

What is your current product line?

Our product line diversifies and grows year on year. We have become known within the industry as innovators and are proud to be the first to bring countless new concepts and features to the market. Being design-led, this came naturally to us and we loved the chance to create innovative solutions to problems that growers had. Based on feedback and ideas that growers themselves had, we took to the design board and got creative. As a result, we not only offer brand new features and time- and money-saving nifty ideas such as the Uplift Bar for gravity-fed water systems, we also thrive on bringing new tents to the market.

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After the success of the Green-Qube, the Roof-Qube followed. This was the grow tent that really got us noticed as it was the first grow tent designed specifically for attics. It allowed people, for the first time, to grow in loft spaces. There was a huge need for people to maximise the space to grow and this opened up a whole new level to growers, especially in the UK where houses are limited on space.

Our latest addition is the revolutionary Quick-Qube. Again, this a brand new concept to growing indoors, but this time we have learnt from our mistakes and invested in a patent to protect the idea and concept. The Quick-Qube is a completely new and different way to create an easy growing space quickly. Adapted from an industrial gazebo frame, the pop-up framework combines Green-Qube's class-leading outer shell with a super sturdy yet light-weight aluminium frame. The frame comes as one piece, so it simply pulls out and clicks up so you can put your grow tent up — and down — in minutes. It also means that you won't lose any poles and it is much easier to store. As it is aluminium, it doesn't rust or corrode and it is even stronger than steel. It can easily hang more than 100 kilograms off it. We believe in this frame so much we are offering a one-year frame guarantee too.

Where do you distribute Green-Qube products?

As a UK company, we predominantly sell to the UK as well as all across Europe. We also distribute to more far-flung countries such as Chile. Our big project for 2018 is moving into the US and the Canadian markets. We are excited to be backed by Wales Trade, which is run by the Welsh Government. They believe in us and our products and are going to be helping us establish our brand in the US and supporting the work we do out there.

What are your company's strengths?

We're innovative, quick to move with new ideas and designs, we solve growers' problems with time- and money-solving solutions, we produce high-quality products at low costs, and are quick to design and manufacture.

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

Innovating is the best way to make your way in the industry. Innovating and keeping low overhead, if that's possible.

What makes your employees so awesome? How does the team at Green-Qube bond?

We all have the passion and drive to build and develop our products and the company. We work together closely and make sure we communicate and share whatever is going on, however big or small. To develop a brand that has grown so quickly and seen in such high regard within the industry really spurs us on. What's better than working for a successful and expanding company? And, of course, we love to celebrate that too. Go-karting seems to bring out everyone's competitive side, and we tend to finish off the day by eating a lot of meat and consuming beer in Cardiff. Socialising and celebrating our successes is definitely vital to keep that team spirit alive. 🍷

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(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

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

Indoor Sun Shop
745 Victoria Rd.
Top Ryde NSW 2112
(02) 9808 6873

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.
Toornina 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.
Greeneater NSW 2190
(04) 1460 9241

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



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

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

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

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

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

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

VN Hydro
8 Robert St.
Belmore NSW 2192

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

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

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

NORTHERN TERRITORY

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

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

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

QUEENSLAND

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

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

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



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



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

Aquatic Oasis

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

Billabong Hydroponics
1/43 Billabong Cr.
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 Cr.
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 Cr.
Varsity Lakes QLD 4227
(07) 5593 7385

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

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

Hydroponic Roots & Shoots
Lot 3 Herberston 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 28/20-22 Fleming St.
Townsville QLD 4810
(07) 4728 3957

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

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

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

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

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

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



Sunstate Hydroponics
10/13 Kerry 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

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Adelaide Hydro
Shop 3.267 Greenwood 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

Martins Rd. Hydro
5- 353 Martins Rd.
Parrafield 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

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& Building Supplies**
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Windsor Gardens SA 5087
(08) 8369 2498

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

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

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Homebrew Supplies**
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Exeter SA 5019
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Burton SA 5110
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Peachey Rd.
Elizabeth West SA 5113
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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
117 West Tamar Hwy.
Legana TAS 7277
(03) 6330 1177



Green Acres Hydroponics
46-48 Bingleong 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
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(03) 6424 7815

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Derwent Park TAS 7009
(03) 6272 2202

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

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

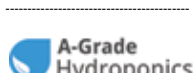
VICTORIA

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

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

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

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



A-Grade Hydroponics
60/148 Chesterville Rd.
Cheltenham VIC 3192
(03) 9555 6667

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.
Intervale VIC 3196
(03) 5674 2584

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

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

Crown Garden Supplies
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Echua VIC 3564
(03) 5480 2036

Echua Pump Shop
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Echua VIC 3564
(03) 5480 7080



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

Excel Distributors Pty Ltd
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Preston VIC 3072
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**F.L.O.W. Plants
& Environments**
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Windsor VIC 3181
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Fastway Hydroponics
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West Footscray VIC 3021
(03) 9314 1119

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T/A Westside Hydroponics**
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Ballarat, VIC 3350
(03) 5338 7555

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AutoPot Systems**
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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

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

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



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

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

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



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

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

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

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

Hyalite Westend
128 Oglivie 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

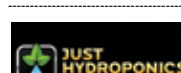
Inner City Hydroponics
155 Darebin Rd.
Thornbury VIC 3071
(03) 9480 1078

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

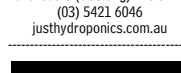
JB Lighting
492 - 500 Neerim Rd.
Murrumbidgee VIC 3163
(03) 9569 4399



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



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



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



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



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Mornington VIC 3029
(03) 5973 6281
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Morwell VIC 3804
(03) 5133 9140

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Footscray West VIC 3012
(03) 9314 0055

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

M.H.C.
Unit 4, 9 Rutherford Rd.
Seaford, VIC 3198
(03) 9775 0495

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

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

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

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



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

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



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

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

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

Prestige Hydroponics Pty. Ltd.
S 210 Level 2, 343 Little Collins St.
Melbourne VIC 3000
(61) 4187 81083

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

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

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



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

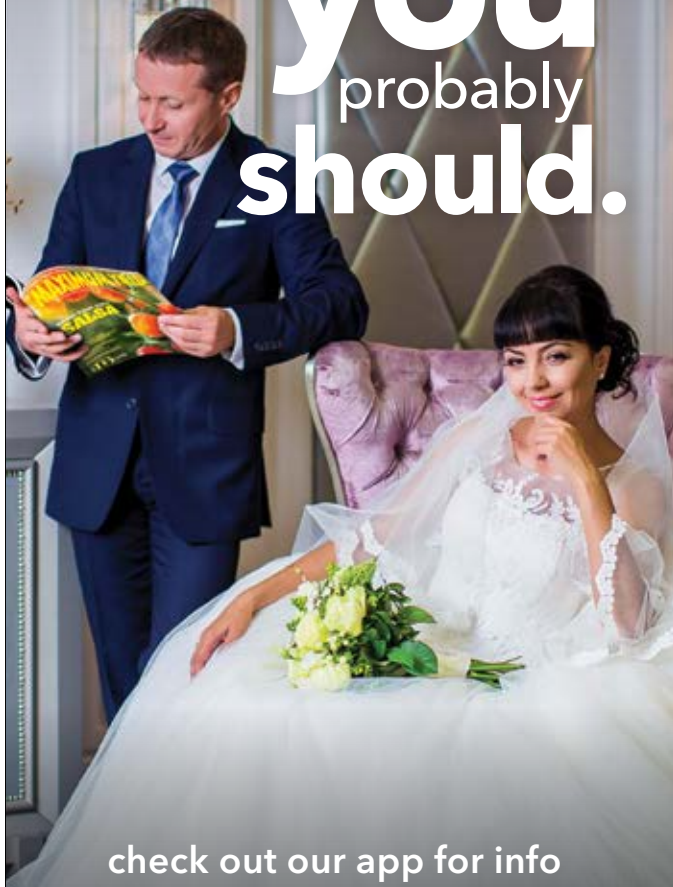
Smart Hydro Garden
3/4 Lacy St.
Braybrook VIC 3019
(03) 9318 8110

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

Sun-lite Hydroponics
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South Geelong VIC 3220
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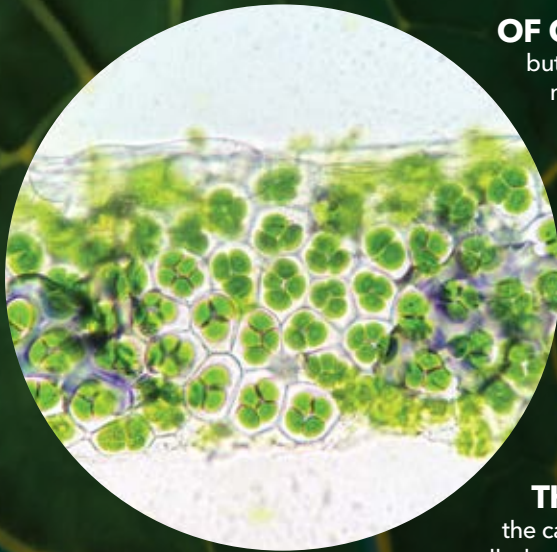
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FACTS ON

CHLOROPLASTS

by Philip McIntosh

No organelle is as closely identified with what it means to be a plant than the chloroplast.



FROM GREEK, *CHLOROS* means green and *plastos* means formed. Indeed, chloroplasts are well-formed small green entities that in some ways look and act like miniature cells within the cell.

IT IS PROBABLY one of the most universally known biological facts that plants are green because they contain chlorophyll, and chlorophyll is critical for photosynthesis.

OF COURSE, CHLOROPLASTS contain chlorophyll, but there is so much more to them than that. Estimates put the number of proteins to be found at work in a chloroplast to be between 3,000 to 5,000.

WHERE DO ALL those proteins come from? Some come from the relatively small genome (120,000 to 150,000 base pairs) of the chloroplast itself, which means the rest are coded for by the nuclear genome and must be transported into the chloroplast.

AS IS TRUE for mitochondria, chloroplasts possess their own DNA which is much like that of bacteria.

THAT AND OTHER evidence suggests that, as is also the case for mitochondria, chloroplasts originated as prokaryotic cells that were engulfed by early eukaryotes, eventually co-evolving into a symbiotic relationship.

CHLOROPLASTS, UNLIKE MOST other organelles, possess two membranes instead of the usual one. As you might guess, there is one other organelle enclosed by a double membrane (hint: it starts with an m).

INSIDE THE CHLOROPLAST double membrane is an aqueous liquid called the stroma. The stroma is where the Calvin cycle takes place.

THE CALVIN CYCLE is a series of light-independent reactions that produce carbon compounds using carbon dioxide as a carbon source.

THE LIGHT-DEPENDENT REACTIONS take place in stacks of flattened membranes called grana, where electromagnetic energy is absorbed by chlorophyll and converted into chemical energy which is then used to drive the Calvin cycle.

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