

TIPS FOR DISINFECTING NUTRIENT SOLUTIONS



REVOLUTIONISING
THE GROW LIGHT
INDUSTRY

Find out more
on page 40

MAXIMUM YIELD

NOV/DEC 2020

A COMPLETE GUIDE FOR THE GROWER

BOOST YOUR LIVING SOIL

WITH ORGANIC AMENDMENTS

DEALING WITH
DOWNY MILDEW

FIGHTING ACIDIFICATION

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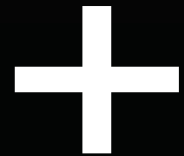


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“
If you really want to champion a high-yield garden, provide them with the right nutrients during the right cycles.”

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Features

28 To the Victor Belong the Soils: How to Boost Living Soil with Organic Amendments

by Eric Hopper

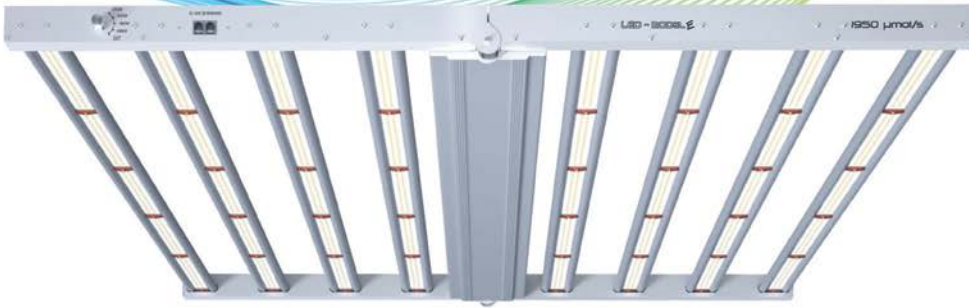
Sure, your plants will do okay if you leave them on their own, but if you really want to champion a high-yield garden, provide them with the right nutrients during the right cycles.

34 7 Ways to Disinfect Nutrient Solution

Dr. Lynette Morgan

With hydroponic nutrient solution acting as a conduit for pathogens, growers need to safely disinfect their systems. Dr. Lynette Morgan examines several ways to disinfect nutrient solution, explaining the pros and cons of each.

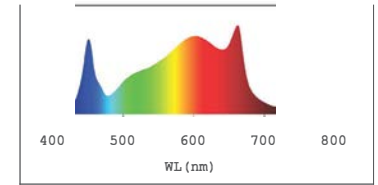
LED - MODEL E 680 W



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SPECIFICATIONS

- Total PPF 1950 $\mu\text{mol/s}$ - 2.85 $\mu\text{mol/J}$
- Samsung & Osram Diodes
- Full Spectrum Array - CRI 91.1
- Inventronics 0-10 V Dimmable Driver
- 1110 mm x 1120 mm - Foldable
- Total Amps: 2.83 A



SMART LIGHT CONTROLLER

- Auto Temp & Humidity Dimming
- Auto Shut Down - Sunrise/Sunset
- Dual Room - 50 Fixtures Per Side

LED - UFO 300 W & 500 W

300 W UFO LED

- Total PPF 620 $\mu\text{mol/s}$
- 2.1 $\mu\text{mol/J}$
- Samsung & Optimum Diodes
- Full Spectrum - CRI 90
- Optimum Driver
- 400 mm \varnothing - 200 mm H
- Total Amps: 1.25 A

500 W UFO LED

- Total PPF 1050 $\mu\text{mol/s}$
- 2.1 $\mu\text{mol/J}$
- Samsung & Optimum Diodes
- Full Spectrum - CRI 90
- Optimum Driver
- 450 mm \varnothing - 230 mm H
- Total Amps: 2.1 A



IP-55 dust and water resistant housings ensure longer operation





MAXIMUM YIELD

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“As World Food Day is recognised on Oct. 16 around the world, it is important for every one of us to stop and take measure of what we eat, how we grow our food, and the impact our food choices have on our environment.”

from the **EDITOR**

TG Toby Gorman

The startlingly widespread and fierce fires in California and Australia we've witnessed over the past year do more damage than just burn structures, which seems to be mainstream media's gauge on how bad they are.

They are also burning a wide swath through both the U.S.'s and Australia's food supply chain.

California, which has seen intense fires for several years now in all regions of the state, produces one-third of the U.S.'s vegetables, two-thirds of its fruit and nuts, and accounts for 13 percent of the nation's total agricultural value.

The fires earlier this year in Australia scorched a land mass the size of Scotland and did vast damage to the country's dairy, meat, wool, and honey supplies.

These fires are not anomalies. They are part of a changing climate that experts say will render many parts of both the southwest United States and northwestern Australia inhabitable over the next 30 years as temperatures sustain 95°F (35°C) and humidity levels spike along coastal areas.

Sustained, these conditions are too inhospitable for humans and many of the crops we rely on to survive and will create mass human migrations out of these areas to more temperate areas.

Even if crops were able to grow it would be too hot for humans to harvest them, says experts who put together a report called "Steambath Earth."

As World Food Day is recognised on Oct. 16 around the world, it is important for every one of us to stop and take measure of what we eat, how we grow our food, and the impact our food choices have on our environment. According to the Food and Agriculture Organization of the United Nations, we can all make a difference by growing our own fruits and vegetables, choosing seasonal produce that takes less energy to grow and transport, supporting local farmers, and encouraging crop diversity. 🍷



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Featured Contributors

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

MM **Monica Mansfield** owned an indoor garden store for 5½ years before selling the business to start 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**
Grubbycup
Rich Hamilton
Philip McIntosh
Dr. Lynette Morgan



A MYCORRHIZAE



Mycorrhizae are a form of fungus which can form a mutually beneficial symbiosis with a plant's root system to increase efficiency of nutrient uptake exponentially.

Mycorrhizae exist as microscopic threads called hyphae. The hyphae create a complex interconnected web called a mycelium. The mycelium network thus created increases the root's ability to absorb water and other macronutrients from the soil by increasing the available surface area for uptake. Mycorrhizae also release powerful enzymes that assist in this uptake. In return, plants will take excess sugar produced in the leaves through photosynthesis and send it to the roots. From here, the mycorrhizae are able to absorb it to sustain themselves.

A mycelium network can grow much smaller and much more complex than a plant's roots. Hyphae can fit between individual, microscopic pieces of soil. They are the roots of a plant's roots.

Mycorrhizae also help protect plants against toxins and to be more resistant to different types of plant diseases, particularly soil-borne illnesses. Mycorrhizal inoculants can be added to the soil to encourage the growth of mycelial networks but it is important to note that there are various plant-specific strains and therefore understanding your specific needs is key.

Check out Eric Hopper's article on page 28 for more information.

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“

...the buds do not have a PGR look to them and they look natural almost organic in their structure... the bud sites are huge and filled with resin!

(USA Commercial consultant)

”

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"Love the website! And all the amazing super helpful info coming from industry professionals."

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

ask a GROWER


by Dr. Lynette Morgan

Q I found Lynette Morgan's article "Open or Closed: What System is Best for You?" (*Maximum Yield*, Aug/Sept 2020) to be a very good article. I found my closed RDWC system far more wasteful than I was expecting. In a 15-gallon capacity system I couldn't really get more than two or three weeks before it would go so acidic I couldn't control it. Not sure if I'm just using too much cal/mag or this is just a result of running out of nitrogen and the plants are creating carbonic acid as a response?
– James G.

A There can be a number of reasons why the nutrient solution in a closed RDWC system might become increasingly acidic. The main ones are often the composition of the nutrient solution itself and differential uptake of elements. When plants remove nutrient ions from the solution, the pH tends to either drift up or down (with upward drifts being more common, but not always). When positive ions such as the cations Ca^{2+} , K^{+} , and Mg^{2+} are taken up by the plant, hydrogen ions (H^{+}) are released from the root system and this lowers the pH of the solution. When anions such as nitrate (NO_3^{-}) are taken up, roots release hydroxyl ions (OH^{-}) into the solution which increases the pH. So, if plants are entering a growth phase which favours the uptake of potassium and calcium in particular, then the solution pH may fall over time. The same would occur if the system is running out of N — the plants can't take up sufficient nitrogen, but will still take up the cations Ca, K, and Mg, making the solution increasingly acidic.

Another reason why the solution may go increasingly acidic is when the nutrients have a certain percentage of nitrogen present in the ammonium form (NH_4^{+}), usually supplied as ammonium nitrate. In some commercial nutrient products, ammonium is used to help counter the high alkalinity and pH which comes from some hard water sources and give a degree of buffering capacity (slowing the rate of pH change). However, ammonium forms of

nitrogen can have a strong acidification affect that is not required in all systems, particularly those that use a soft water or reverse osmosis water for example. Ammonium tends to have an acidification affect in nutrient solutions because unlike nitrate, it is a positive ion and when taken up by plants (which can occur very rapidly), it is replaced by hydrogen ions, thus reducing the pH. If your system continually has problems with the solution becoming acidic with a pH that is difficult to adjust, then avoiding nutrient products that contain the ammonium form of nitrogen would be advisable.

Another reason for the solution becoming increasingly acidic is due to microbial activity in the system, which is more complex. The breakdown of organic material by microbial action under anaerobic conditions can have an acidification affect and often systems which have some form of early outbreaks of Pythium or other root rot pathogens first notice a drop in pH as the disease progresses. Also, the use of some supplements in water culture systems can have the same affect if these are organically based. Supplements that may be used as growth boosters or even hydroponic organic nutrients can contain acids such as phosphoric acid that also lower the pH over time, so it is always advisable to check the pH of these products before adding to a hydroponic system. 

Dr. Lynette Morgan

LM **Dr. Lynette Morgan** holds a B. Hort. Tech. degree and a PhD in hydroponic greenhouse production from Massey University, New Zealand. A partner with SUNTEC International Hydroponic Consultants, Lynette is involved in remote and on-site consultancy services for new and existing commercial greenhouse growers worldwide as well as research trials and product development for manufacturers of hydroponic products. Lynette authors five hydroponic technical books. Visit suntec.co.nz for more information.

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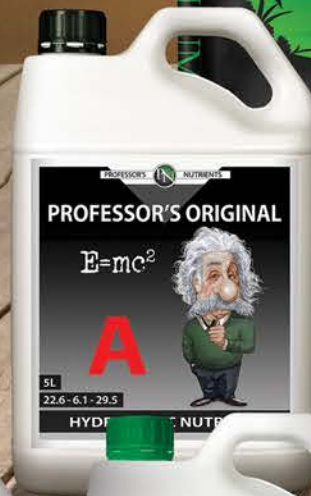
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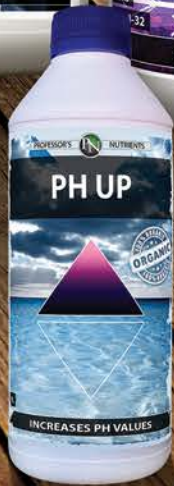
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3 New Apple Varieties Released

Apple lovers can look forward to three new varieties from the oldest apple breeding program in the U.S. The Cornell AgriTech in New York announced the release of three new apples: Cordera, Pink Luster, and Firecracker. As an open-release, orchards across the U.S. will be able to grow the new varieties without licensing exclusivity. Cordera is bred to be scab (a fungal disease) resistant while retaining its flavour and texture. Pink Luster is the culmination of 23 years work with Honeycrisp and Gala apples. It's got a bright, pink-red skin, crisp texture, and juiciness. It matures in mid-September, making it well-suited for on-farm and U-pick sales. Firecracker is being dubbed a "triple threat" as it is great for eating, baking, and hard-cider production. With the addition of Cordera, Pink Luster, and Firecracker, Cornell AgriTech has released more than 70 apple varieties since 1880 including the highly successful SnapDragon and RubyFrost.

– freshplaza.com



Water Runoff Leading to Greater Soil Erosion

Soil loss due to water runoff could increase greatly around the world over the next 50 years due to climate change and intensive land cultivation, according to research by an international team of experts. The finding, which was published in the scientific journal *PNAS*, shows soil erosion has far-reaching consequences and results in a loss of fertile soil, reduces agricultural productivity, and therefore threatens the food supply for the world's population. Based on a global model, the new study now predicts how soil loss from water erosion is likely to change by the year 2070. The researchers based their predictions on three scenarios that outline potential developments in the 21st century based on several different socio-economic postulations. The results indicate climate change is the primary factor driving increased soil erosion. The simulations predict that by 2070, soil erosion will increase by 30-66 percent compared to 2015 figures.

– sciencedaily.com



Scientist Uses LEDs to Show Hops Don't Need Dormant Period

A three-year study of hydroponically grown hops shows the popular crop doesn't need a low-temperature dormancy period. Bill Bauerle, a plant scientist at Colorado State University (CSU), went through 13 hop growth cycles for his research at CSU's horticultural research centre and the results open up new possibilities for indoor, sustainable, local production of hops. "We fooled our hops into thinking it was the middle of summer in British Columbia or somewhere else," Bauerle says, "so we could grow them all year round." It has long been thought that hops require a low-temperature dormancy period, called vernalisation, in which the hop buds reset themselves under winter conditions in order to flower prolifically. "Up until 10 years ago, we didn't have the technology as far as the LED lights and controlling the photoperiods. Because people couldn't get the plants to develop like they would outside, they assumed the lower flowering was because they lacked the vernalisation period," Bauerle says.

– craftbrewingbusiness.com



Researchers Study 'Sound of Plants Dancing'

What do dancing plants sound like? Researchers at Virginia Tech believe the answer could be a future agricultural tool. Using experimental technology in controlled-environment agriculture, scientists are exploring how the sonification of plant movements could be used to assess plant health and aid farmers who need to monitor their greens at an industrial scale. With the idea of increasing plant health, researchers set up cameras on a small number of pepper plants and recorded their movement, noting patterns. The camera captures micro-movements. Then the data they've collected on movement is converted into sound using sonification. In that way, a human could hear patterns present among the plants. The idea is to eventually link certain sounds to indicators a plant needs better light or more nitrogen. Computers, analysing the data at a large scale, could learn "what is a good sound and what is a bad sound," says Bingyu Zhao, lead researcher on the project.

– phys.org

SFU Researcher Exploring Better Organic Pesticide Use

Scientists at Simon Fraser University (SFU) in Vancouver recently received \$300,000 in funding from Innovate B.C. to develop technology allowing farmers to grow more food with less pesticides. The project aims to reduce global synthetic pesticide use by 80 percent by 2030. "The growing world population needs more food and we need to grow food that is environmentally sustainable," says SFU computing science professor Martin Ester, who is the principal investigator for the project. "One approach is to develop organic pesticides that are as effective as chemical pesticides, but less harmful to the environment." The SFU team hopes to use machine learning, image analysis, and robotics to advance using precision agriculture to improve the effectiveness of organic pesticides vis-à-vis chemical pesticides. Researchers will develop data mining methods that learn about the effectiveness of a small number of lab-tested chemical formulations to predict the effectiveness of a much larger number of potential formulations.

– sfu.ca

Spinach Boosts Hair Growth

Spinach is one of the most popular green leafy vegetables. The vegetable contains essential vitamins and antioxidants like vitamins A, B1, K, C, and E. It also contains Omega-3 fatty acids and minerals like zinc, iron, and manganese. Spinach, while being great either raw, cooked, or in a juice form, is also good for hair because of the presence of vitamins A and C, that helps in promoting hair growth. Vitamin A present in spinach helps regulate the production of oils on hair. It also helps in moisturising the hair and skin. Vitamin C is crucial in the production of collagen, which helps in the formation and regrowth of hair. The antioxidants present in spinach help in preventing hair loss. It also helps ensure the scalp is clean and healthy. Vitamins B and C help in accelerating hair growth by increasing the keratin and collagen levels in the scalp.

– freshplaza.com





1 | Fohse A3i 1500 LED Grow Light

As the flagship fixture from upstart lighting company, Fohse, the A3i currently holds the title for the market's most powerful and efficient grow light with a balanced spectrum. Delivering a whopping PPF of 4,529 $\mu\text{mol/s}$ at an efficacy ranging from 3.0-3.3 $\mu\text{mol/J}$ (depending on setting selection), the A3i is a perfect match for licensed cultivators with optimised canopy space seeking an edge to raise their productivity potential. Every A3i is custom-made to order and features three spectrums, an IP67 durability rating, and an LED touchscreen wall controller for system-wide adjustments.

2 | Reiziger Grow Booster

The art of transformation. Reiziger Grow Booster is the first grow booster for hydroponic craftsmen tailored to the needs of all short cultures. Born from nature and made in Holland, this effective natural liquid produces astonishing results with the power to transform plants and quickly increase biomass while amplifying aromatic compounds. Formulated with a high concentration of powerful botanical ingredients, Grow Booster empowers the plant with the energy needed to fortify its natural defence process to help elevate the production of aromatic compounds and terpenes, directly enhancing colour, aroma, and resin production.

3 | FloraMax Resin-XS

Designed to meet the critical demands of growers wanting larger and more potent yields, FloraMax's Resin-XS delivers enhanced resin and oil content, greater potency, and more fruit weight. Growers report more than 30 percent improvement in trichome population and independent labs have verified significantly higher concentrations of essential oils than other leading products. Clean as a whistle, Resin-XS won't induce foul odours or bio films in the reservoir and contains no plant growth regulators for consumer protection.

4 | Bio Diesel Supernatural

Supernatural is a new, premium organic root and shoot stimulant made from a blend of organic sea algae extracts and Bio Diesel's famous bio stimulants. Supernatural (0-1-1) will help your plants create massive lateral feeder roots and increase nutrient uptake with an immediate plant response. Supernatural, which is compatible with all nutrient programs, is ideal for correcting plant stress and trace element deficiency and can be used in soil, hydroponics, coco fibre, clay balls, or any inert hydroponic media.

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★ **NATURAL SILICA** that is instantly plant available and wont effect your pH! Salicylic Acid creates thicker cell walls, with higher weight and water holding capacity for stronger branches, increased photosynthesis and flower yields.

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5



6



7



8

5 | Ed Rosenthal's Zero Tolerance Pesticide

Ed Rosenthal's OMRI-approved pesticide is a potent mix of food-grade plant oils that eliminate and control spider mites, broad mites, aphids, and powdery mildew. Diluted and used as a repellent, it prevents infestations. Ed's blend of herbal oils fully evaporates, leaving no residue. Zero Tolerance is approved for organic production, is Clean Green Certified, and 100 percent vegan. As the commercial market becomes more competitive, it is critical that crops test clean.

6 | PureCrop1 Organic Solution

PureCrop1 is an OMRI-Listed organic insecticide, fungicide, bio-stimulant, and natural surfactant. It interferes with the digestive enzymes of sap-sucking pests without harming beneficial insects including bees. PureCrop1 utilises Colloidal Micelle Nanotechnology that is completely unique to this product and is made entirely from plant-based materials that deliver fatty acids directly to the plant's sap layer where it is used immediately by the plant. It successfully controls mould and mildew by pulling solid particles away from the leaf surface, sterilising the spores, and biodegrades them harmlessly. Find it at Growhard Australia.

7 | FloraMax Flowering Enhancer

Featuring a unique three-in-one performance, FloraMax Flowering Enhancer is an advanced P-K additive containing calcium and iron that promotes vigorous blooms, heavy fruit, and more swell. Flowering Enhancer's heavy dose of calcium and iron serves to fulfill the role that cal-mags are meant to serve in nutrient regimes. Furthermore, this leading-edge formulation offers a unique pH buffering feature that locks pH below 6.5 in the reservoir when in bloom to help prevent common nutrient deficiencies, salt blockages, and lockout.

8 | Reiziger Coco Coir Pith

Coco perfection straight out of the bag. Reiziger Coco Coir Pith is a tribute to the man who in 1984 created a seed-breeding business named The Seed Bank of Holland in The Netherlands. Reiziger's exclusive Nutricoir formula is engineered to deliver a surge of seemingly infinite power, helping plants absorb 50 percent more nutrients than ordinary coco peat to grow plants twice the size and protect against over- and under-fertilising, minimising uneven growth and stunting. Its superior texture maintains an optimum balance of air and water in any hydroponic system.



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TO THE
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How to Boost Living
Soil with Organic
Amendments

by Eric Hopper

Sure, your plants will do okay if you leave them on their own, but if you really want to **champion a high-yield garden**, provide them with the right nutrients during the right cycles.

If a plant is to reach its full potential, it must be provided with specific nutrients at various times throughout its life cycle. Plants grown outdoors and in soil rely on the soil's microorganism to break down organic matter into usable nutrients. Even a high-quality soil with a wide range of ingredients may not be able to supply a plant in its blooming or ripening stage with the optimal ratio of nutrients required for maximised flower and essential oil production. This is why many outdoor growers amend the soil during the blooming stage with either dry ingredients, which contain the elements that enhance blooming, or liquid additives designed to do the same. Although chemical fertilisers and additives can be used in an outdoor garden, many outdoor growers prefer organic or organic-based additives to boost the final stages of growth. Organic additives enable the soil to continue functioning as a living soil and embrace the power of beneficial microorganisms.

Top Dressing

Top dressing is amending a soil by adding various dry fertilisers to the surface around the base of the plants. As the plants are watered, via rain or an irrigation system, the water-soluble nutrients become available to the plants. As time goes by, the organic material on the surface is broken down further by beneficial microorganisms and even more nutrients become available to the plant. In order to ensure a plant receives the appropriate amount of nutrients specific to blooming, a grower may choose to top dress his or her soil at the beginning or in the middle of the blooming stage. It should be noted that the majority of the nutrition provided by top dressing is not instantaneous, so some forethought must be used when top dressing. If a grower wishes to boost the final stages of blooming, it is necessary to top dress a few weeks before that stage begins so the organic material has some time to break down and become available.

"An organic tea, brewed from any of the previously mentioned dry top-dressing ingredients, can be a very effective way to deliver stage-specific nutrition to an outdoor garden."

For example, during an outdoor plant's blooming stage, a grower can top dress the soil with high phosphorus bat or seabird guano. As it rains or the grower waters the plants, the guano will provide a boost of phosphorus and microorganisms to the plants. The added phosphorus will help stimulate the flowering process and the microorganisms will increase nutrient uptake. Plants that are given a boost of phosphorus, potassium, calcium, and microorganisms in the later stages of blooming will produce denser flowers and an increased amount of essential oils.

There are many different organic dry ingredients available to use as a top dressing for outdoor plants. When discussing top dressing or amending a soil for the later blooming stages, the most effective ingredients are those that contain very little or no nitrogen. Supplying blooming plants with too much nitrogen will inhibit large flower production. Organic ingredients with higher ratios of phosphorus, potassium, and calcium are best suited for top dressing a garden in the blooming stage. Due to the relatively fast availability of nutrients, the following are some of the most popular top-dressing ingredients used by outdoor growers:

Top Dressing Ingredients for Adding Phosphorus (P):

- **Bat Guano (High Phosphorus)** — High-phosphorus bat guano is an old favourite of outdoor growers and an excellent source of phosphorus. Bat guano is known to not only increase flower sets, but also their size, aroma, and flavour. Many types of high-phosphorus bat guano contain a good amount of calcium too. Make sure the bat guano you purchase is ethically sourced.
- **Bone Meal** — Bone meal is an excellent source of readily available phosphorus; revered for its ability to promote strong root development. Bone meal is also a great source of calcium.
- **Fish Bone Meal** — Fish bone meal is essentially the same as bone meal, except it is derived from fish. A great source of both phosphorus and calcium.
- **Seabird Guano** — Seabird guano, like bat guano, is known to increase the amount of flower/fruit sets and their size. An excellent source of phosphorus and micronutrients. Seabird guano also contains a wide variety of microbial life.

Top Dressing Ingredients for Adding Potassium (K):

- **Kelp Meal** — Kelp meal is a source of readily available potassium and a variety of micronutrients and plant hormones. This great soil additive can also increase overall plant health and vigour. Kelp meal should be used as an ingredient in the original soil mix. It can also be used sparingly as a top-dressing during blooming. Due to its high plant hormone content, too much kelp in the later stages of blooming could potentially trigger a growth spurt, leading to spindly flower development.
- **Langbeinite** — Langbeinite (sold under many different brand names) is a naturally occurring mineral and is water soluble. A good source of potassium, sulfur, and magnesium.





Top Dressing Ingredients for Adding Calcium (Ca):

- **Oyster Shell** — Oyster shell is an excellent organic source of calcium that will accelerate root development and, in turn, improve nutrient uptake. Oyster shell also works as a pH buffer, keeping the soil from becoming overly acidic.
- **Dolomite Lime (Sweet Lime)** — A rich source of calcium and magnesium. Dolomite lime is also a great pH buffer for any soil composition and, as with oyster shell, ensures the soil's pH doesn't turn too acidic.

It should be mentioned that calcium is imperative for all stages of plant growth and should be incorporated into the vegetative as well as the blooming stage of growth. Calcium is relatively slow to release so it is important to be proactive with dry calcium ingredients in the soil or as a top dress.

"A good organic living soil will provide adequate nutrition throughout the entire life cycle of the plant."

Compost Teas

For outdoor growers who do not want to amend the soil via top dressing, there are alternative methods to provide plants with the specific nutrients to boost flower and essential oil production. An organic tea, brewed from any of the previously mentioned dry top-dressing ingredients, can be a very effective way to deliver stage-specific nutrition to an outdoor garden. Teas are generally brewed in a specific tea brewer or other homemade device that combines water, oxygen, and the organic matter for a period of time. When brewed correctly, these teas will not only contain essential elements, but also an abundance of microbial life. Guano teas, especially teas made from high-phosphorus bat or seabird guano, are great additives for the blooming and early ripening stages. Guano teas supplemented during ripening will help increase bloom density and stimulate essential oil production.

Other Organic-Based Liquid Additives

- **Liquid Kelp Extracts** — Although kelp was once rarely used as a bloom booster, some of the kelp formulations available today are specifically designed to do just that. When harvested at the correct time or in a particular manner, kelp extract can contain a variety of hormones that trigger flowering and ripening. Kelp also contains a high amount of trace elements that are beneficial in the fruiting/flowering stage. Kelp extracts specific to bloom stimulation will encourage rapid cell division during flowering and increase the production of specialised sugars found in fruit or flowers.
- **Liquid Amino Acid Formulas (Protein Hydrolysate and Enzymes)** — Organic products that contain high concentrations of amino acids are great to supplement during the blooming and ripening stage. Protein hydrolysate is essentially organic matter (usually soy protein) broken down into the essential L-amino acids. Amino acids are the building blocks of the proteins and enzymes which directly influence the structure and metabolism of plants. Supplementing a protein hydrolysate during the blooming period will enhance the utilisation of other nutrients, boost the plant's immune system, increase plant respiration, and reduce stress. Protein hydrolysate is a multifaceted additive that increases fruit/flower production in many different ways.



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This means all the natural functions that occur during ripening (bloom density, essential oil production, etc.) will be accentuated. Amino acids also help build the plant's defences against various pathogens. Isolated enzyme formulas are also available and provide specific benefits to plants, such as root, flower, or essential oil stimulation.

- **Liquid Carbohydrate Formulas** — Supplementing a liquid carbohydrate formula during the entire blooming stage is advantageous but is especially so during the late blooming/ripening stage. Carbohydrates provide food for the beneficial microorganisms in the soil, which, in turn, help all plant functions. Increased carbohydrates have also been shown to stimulate essential oil production in many varieties of plants. Adding carbohydrates during the ripening stage will dramatically boost the final production of essential oils, leading to better aromas and flavours.

Outdoor growers are always on the hunt for ways to maximise flower and essential oil production. Although it is the vegetative and early flowering stages that provide the foundation for a successful ripening and harvest, the later stages of blooming is when the majority of the magic happens. A good organic living soil will provide adequate nutrition throughout the entire life cycle of the plant. However, implementing top dressing or liquid additives in the blooming stage can provide the enhanced nutrition needed to maximise flower and essential oil production. By amending a soil by top-dressing organic dry ingredients or by using a liquid tea or extract, an outdoor grower can rest assured that he or she has done everything in his or her power to provide optimal nutrition for the final weeks of blooming. 



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WAYS TO

DISINFECT NUTRIENT SOLUTION

With hydroponic nutrient solutions acting as a conduit for pathogens, growers need to safely disinfect their systems. Dr. Lynette Morgan examines several ways to disinfect nutrient solution while explaining the pros and cons of each.

by Dr. Lynette Morgan

Concern that hydroponic nutrient solution could be a vector for root rot pathogens has been around since the early days of hydroponics. Recirculating systems, as much as they conserve water and nutrients, have come under the spotlight as a means for transmission of the dreaded *Pythium* pathogen and a whole host of others. However, treatments and techniques for preventing and controlling such scourges have flourished within the hydroponic industry and growers both small and large have a range of options when it comes to solution disinfection methods. While slapping on the latest gadget or dosing up the reservoir may seem like a great solution, many of the disinfection methods commonly used in hydroponics are not as straightforward as we would like to think.

The nutrient solution in a recirculating system, and within the crop root zone is a carefully balanced environment or ecosystem made up of live plant roots, organic material, diverse microbial populations, nutrients, moisture, and gasses, such as oxygen, required for root respiration. Within a healthy root zone, a balance usually exists where beneficial microbes outnumber and out-compete any pathogens that may find their way into the nutrient solution or substrate. This balance is the ideal situation in a hydroponic system as many beneficial microbes not only have the potential to suppress disease but may have other growth-promoting effects as well. However, from time to time, root pathogen outbreaks may occur, and prevention of such issues is generally far more effective than any type of control measure.



Nutrient solution disinfection methods include a range of options — while most are effective at killing pathogens contained in the solution itself, they are not a guarantee of keeping a system clear of infection as pathogens contained inside infected root systems are protected from any treatment effects. Commercially, large-scale hydroponic growers who use solution disinfection methods select those that are the least risk to the crop, including UV, ozone, heat, and filtration, as well as biological methods. Use of chemical disinfection agents that are dose responsive are less preferred as there is a risk of toxicity if rates applied are too high or the crop is at a sensitive stage.

UV – Ultra-Violet Radiation Disinfection



UV is a plant-safe and effective water and nutrient solution disinfection method and smaller units are available through the aquarium/fish industry that can be used in hydroponic systems. Anti-microbial activity

largely occurs within the UVC range of 200-280nm with plant pathogens becoming inactivated when UV affects the nucleic acid which strongly absorbs at or close to 260nm.

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A healthy root zone is the ideal situation in all hydroponic systems.



Nutrient solution disinfection can be used in both solution culture and substrate-based hydroponic systems.



Disinfection can assist with preventing the spread of root rot pathogens such as Pythium.



Crops such as spinach that are prone to Pythium in recirculating systems often make use of disinfection methods.

During treatment, the UV equipment passes light from the UV lamp through a thin film of nutrient solution. For the process to work effectively the solution must be clear and often pre filtration is used to remove any organic matter or other material first. The recommended UV dose rates for disinfection of recirculating systems is 100mJ.cm⁻² for control of pathogenic fungi and 250mJ.cm⁻² for control of all pathogens including viruses. When using smaller UV units it is important to obtain the correctly sized unit for the volume of solution to be disinfected and to replace the UV bulbs once the usable life of these has passed (UV bulbs will only be effective for a certain number of hours before they need replacement). The downsides of UV treatment are that these systems do not discriminate between pathogens and non-target or beneficial microorganisms, and UV can effect iron chelates in solution, requiring higher rates of iron application and use of the most stable chelate forms such as Fe-EDDHA.

Ozone



Ozone treatment of nutrient solutions requires an ozone generator onsite that discharges ozone enriched air as small bubbles into the solution flowing through a venturi.

Ozone dissolves from these bubbles into the

solution over a certain contact time and reacts with organic matter including pathogens. One of the major benefits of ozone treatment for water or nutrient disinfection is that any ozone which has not reacted reverts to oxygen, which in turn increases the dissolved oxygen content of the solution. This has the potential to improve crop growth. Ozone generation systems must be installed correctly as off-gassing into the air surrounding the crop can cause crop damage. Ozone destroys pathogenic microorganisms and leaves no residue in the nutrient solution that might be toxic to plants, however, ozone treatment can break down iron chelates and may cause precipitation of manganese, so these trace elements need regular monitoring.

Filtration



Membrane filtration can be used to remove pathogens once courser-grade filters have first cleared the solution of larger organic particles. Hydroponic water and solution filtration methods include micro filtration (pore size 100-1000nm),

ultra filtration (10-100nm), nanofiltration (1-10nm), and reverse osmosis (<1nm). The most efficient membrane filtration systems use combinations of different filters to progressively remove smaller and smaller particles as the solution flows past. Membrane filtration has been shown to be effective for several different pathogens, however, such systems require regular maintenance to keep the system working effectively.

A man with a grey beard and glasses, wearing a straw hat and a checkered shirt, is wrapped in a thick green hose. He is holding a spray nozzle that is spraying water. The background is a bright, sunny outdoor setting with trees.

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Slow-Sand Filtration or Biological Disinfection



Slow-sand filtration or biofiltration is a method of water/nutrient disinfection that works by passing solution slowly through different layers of aggregate where large numbers of beneficial microbial populations reside.

The sand/substrate screens have organic material in the upper layers, while the microbial species in the lower layers provide biological filtration that assists with pathogen removal. This system has the advantage that the nutrient solution discharged from the filter is enriched with beneficial microbial species that can further assist with the reduction of pathogens in the hydroponic system. To be effective the flow rates of solution through the biofiltration system need to be correct and slow enough for disinfection to occur.

Heat



Heat disinfection (pasteurisation) of nutrient solutions is one of the most reliable methods of eliminating all types of plant pathogens and is used commercially by greenhouse growers. Most heat treatment systems first pre-filter

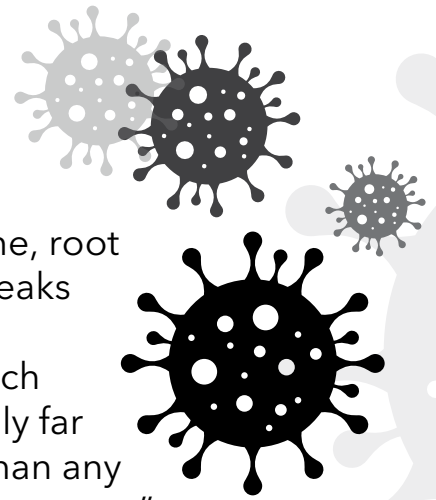
the solution to remove organic material, then heat to a temperature of 95°C for a holding time of 30 seconds which has been found effective in the control of root rot pathogens such as *Phytophthora* and *Pythium*. While heat treatment is effective and crop safe, the drawbacks are the high energy requirement to heat solutions up to temperature and the time required to cool the solution back to ambient before reintroduction to the hydroponic system.

Chemical Disinfection



The two main chemical disinfection agents that may be used to treat water supplies and hydroponic nutrient solutions are hydrogen peroxide and chlorine. While both are effective in killing pathogens if the correct rate is applied,

both have the drawback of potentially damaging crops if overused. The effectiveness of chlorine as a disinfection agent is dependent on dose, temperature, organic loading, and microbial content of the solution being treated. Also, pathogen species and the life stage of the pathogen being controlled are also factors in the effectiveness of chlorine treatment. Studies have reported that zoospores of *Pythium* were controlled by exposure to 2-2.5mg/l, however, a higher



“From time to time, root pathogen outbreaks may occur, and prevention of such issues is generally far more effective than any type of control measure.”

level of free chlorine of 14mg/l was required to control other pathogen species — this level was also phytotoxic to many common nursery species. Chlorination toxicity symptoms include necrotic mottling, stunting, and premature leaf drop. Hydrogen peroxide (H_2O_2) is an unstable oxidizing agent that reacts to form H_2O and an O-radical that reacts with any type of organic material including pathogens. The byproduct of using hydrogen peroxide is the release of oxygen into the nutrient solution. The overuse of H_2O_2 in recirculating nutrient solution carries the risk of damaging root systems. Young sensitive plants are particularly prone to damage from H_2O_2 dosing with rates as low as 8-12ppm found to reduce the growth of hydroponic lettuce, while concentrations of 50ppm were required to kill *Pythium* and 100ppm to control *Fusarium*. Both chlorine and hydrogen peroxide react with organic matter in the nutrient solution, thus rates need to be carefully considered and based on the organic loading of the system to prevent the risk of plant damage from occurring.

Surfactants



Application of surfactants to the recirculating nutrient solution is another method used for the control of pathogens. Non-ionic surfactants have the ability to rapidly lyse mobile zoospores of pathogens such as *Pythium*

and *Phytophthora* within one minute of exposure. While surfactants can destroy large numbers of mobile zoospores in the nutrient solution, the application has no residual effect on plants already infected when the disease is already contained inside plant tissue. Thus, the use of non-ionic surfactants as a nutrient solution additive is more of a preventative action than a curative one.

The use of any nutrient solution disinfection method should be made carefully as many methods not only destroy plant pathogenic microbes, but also those species that are beneficial in hydroponic systems. Disinfection treatments can have potential downsides and incorrect use of some can even be phytotoxic to plants, particularly young sensitive crops, so knowing the pros and cons of each method is an important step before implementation. ¹⁰



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-- Steve Cantwell, owner, Green Life Productions

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-- Kevin Kuethe, Chief Cannabis Officer, Lume Cannabis Co.

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Revolutionising THE GROW LIGHT INDUSTRY

When the innovative team at Fohse saw a gap in the grow light market, they seized the opportunity and ran with it, producing high-quality grow lights without cutting costs and developing a loyal following within the cultivation industry.

by **Chris Bond**

The Fohse company manufactures innovative grow lighting. "Fohse," an acronym for the Future of Horticultural Science and Engineering, is also a play on the Greek word for light, "fos." The future of grow lighting is exactly what American-engineered Fohse products are. For too long, inefficient HPS and underperforming LED lights have dominated the market. The creative team at Fohse saw the problem, committed to create the solution, and has outshone their competitors ever since.

Chief Technology Officer, Alex Gerard, spent almost two decades in the medical and military electronics fields working on the lighting components of defibrillators, welding components, and laser markers. Raised by avid garden enthusiasts, he was compelled to take those skills and devote them to the voids and deficiencies he and his partners, Ben Arnet (President) and Brett Stevens (CEO) saw in the market. They could see the downfalls of relying on HPS, and that LED lighting fixtures were largely overpriced and not as effective as they claimed to be.

They spent more than two years on the research and development of a suite of lighting fixtures and technology that would improve the horticultural industry. The result was high-quality products that would convince long-time growers to abandon the lighting types and strategies they had employed for years.

Unlike their competitors, the Fohse team wasn't interested in a race to the bottom. The trend in commercial grow lights was to try and make each fixture more affordable by cutting costs wherever possible in the production process. Ben, Alex, and Brett eschewed this legacy of HPS and LED lighting manufacturers and took a different approach; they wanted to increase yield per square foot of growing space, thereby making their product not just another grow-light in the sea of thousands of indoor growing aids, but a vital part of a successful indoor growing operation. "When everyone else was trying to figure out how to make their lights more efficient to lower the electric bill, we were trying to get higher yields," the leadership team at Fohse recounted. Competitors continually cheapened their parts, while Fohse designed and continues to design fixtures with higher power and increasing yields, all while lowering the fixture count and boosting each product's photon footprint.

Like any other novel approach, there were skeptics and detractors. Those who doubted them, however, were left in the dust during the Fohse team's debut at a 2019 industry trade show in Toronto. They sold out on everything they had made and took orders for thousands more.



Lab testing example with an integrated sphere that closes and measures the entire photon output of the fixture.

What made them stand out? "Our display was like a spaceship in the middle of the convention floor," they recalled. What made them sell out that day was the proof in the pudding. There was the only display featuring fixtures that could replicate natural light. They had created "indoor sunshine" and developed a loyal following as a result. Not only does their product beam, so do their customers when describing the unbelievable results they got after switching over to Fohse lighting products.

“ FEW THINGS MAKE THIS TEAM PROUDER or more energised than getting a chance to show how their products outperform their peers under actual, real-world conditions on actively growing crops.”

Fohse can engineer a lighting system that will fit into the footprint of any growing operation or crop. Few things make this team prouder or more energised than getting a chance to show how their products outperform their peers under actual, real-world conditions on actively growing crops. They do this by taking the time and effort to make sure their products are crafted to the highest standards. When Fohse products are hung in place and have been calibrated to the precise PPFD (the measure of photons on a given surface area) levels specific to each crop's needs, the stage has been set for plants to fulfill their biological destinies. Each of Fohse's 30 team members relishes being a part of that challenge and it drives them every day to keep excelling.

Just how well-made are Fohse's lights? The team at Fohse can proudly say they have never had to buy back a single fixture. None of the tens of thousands of grow lights that have been produced over the past five years by the hard-working team at Fohse has yet to disappoint. That is a claim many of their peers cannot make.





Fohse CTO Alex Gerard overseeing an install of their A3i Model at Green Life Productions in Nevada.

These guys are not just risk takers and innovators in the world of grow lighting; they are risk takers with the hobbies they pursue in their “off-duty” lives. Alex Gerard, Fohse’s Chief Technology Officer, flies planes for fun; James Bradley, Fohse’s Chief Marketing Officer spends some of his free time skydiving. These guys embody the motto: “work hard, play hard.” They credit their shared drive both in and out of the office to being adrenaline junkies; a trait that is common throughout many of their employees.

Their creativity and hard work have not only allowed the gang at Fohse to attract some of the largest commercial greenhouse growers in the industry, it has attracted the attention of respected light manufacturers from around the world, as well as the attention of a research department at a major Ivy League university. Light harvesting, as it is known, has become the subject of a collaboration between the talent at Fohse and some of the most highly regarded horticultural researchers in the country.

“**WITH LIGHT HARVESTING**, all the plants receive the same amount of light with all the benefit of the full spectrum that natural light provides.”

Utilizing Fohse’s new Pleiades fixture, the research team and engineers at Fohse are able to adapt any zone in a greenhouse or indoor growing area to the specific needs of a crop and adjust to the amount of natural light it is receiving in real time. If any light is obscured, such as by the passing of a cloud, more light is emitted by the fixtures thanks to sensors that are continually monitoring the light levels. This is particularly useful for large greenhouses that may cover acres of space which do not receive a uniform amount of light from the sun even on clear days. The structure of buildings themselves block some of the rays as well depending on which side of the greenhouse the plants are on.

With light harvesting, all the plants receive the same amount of light with all the benefit of the full spectrum that natural light provides. In addition to a happier plant and larger harvests, light harvesting can save on electricity costs as it provides precise lighting quantities to only those areas that need it rather than bathing the whole facility in the same amount of light across the board.

Though they would not dwell on it and would likely push your kudos aside, the team at Fohse knows they are part of a community. When the tragic shooting took place in Las Vegas in October of 2017, the leadership team at Fohse shut down production and helped their hometown out anyway they could.




Fohse President Ben Arnet checking light levels with Mike Howard, Director of Cultivation at The Grove Nevada.

Team members drove around, donated and delivered food and water to their fellow Nevadans and emergency service workers in need. These guys realise when you have been lucky enough to hit on a winning product, and have seen some success, you are in a position to give back and help those that may not be doing quite so well.

Find the Pleiades fixture, the A3i, or any other of their groundbreaking products at your local hydroponic or growing supply store. They will help floral and food growers alike of any sized operation significantly improve their production. Their products can be found in locations around the globe. You can also get in touch with them through their website at fhose.com to customise a system that is right for your space and your crops (their website is uber-cool, by the way, and is chock full of data for the grow-light nerd in all of us). They would be glad to arrange for a demonstration to show you how their

product can make your operation more productive and profitable by using their innovative product line. Keep an eye on this team and the groundbreaking research they are a part of. This is a name you will hear in the industry for many years to come.

Fohse: it truly is the future of horticultural science and engineering. 

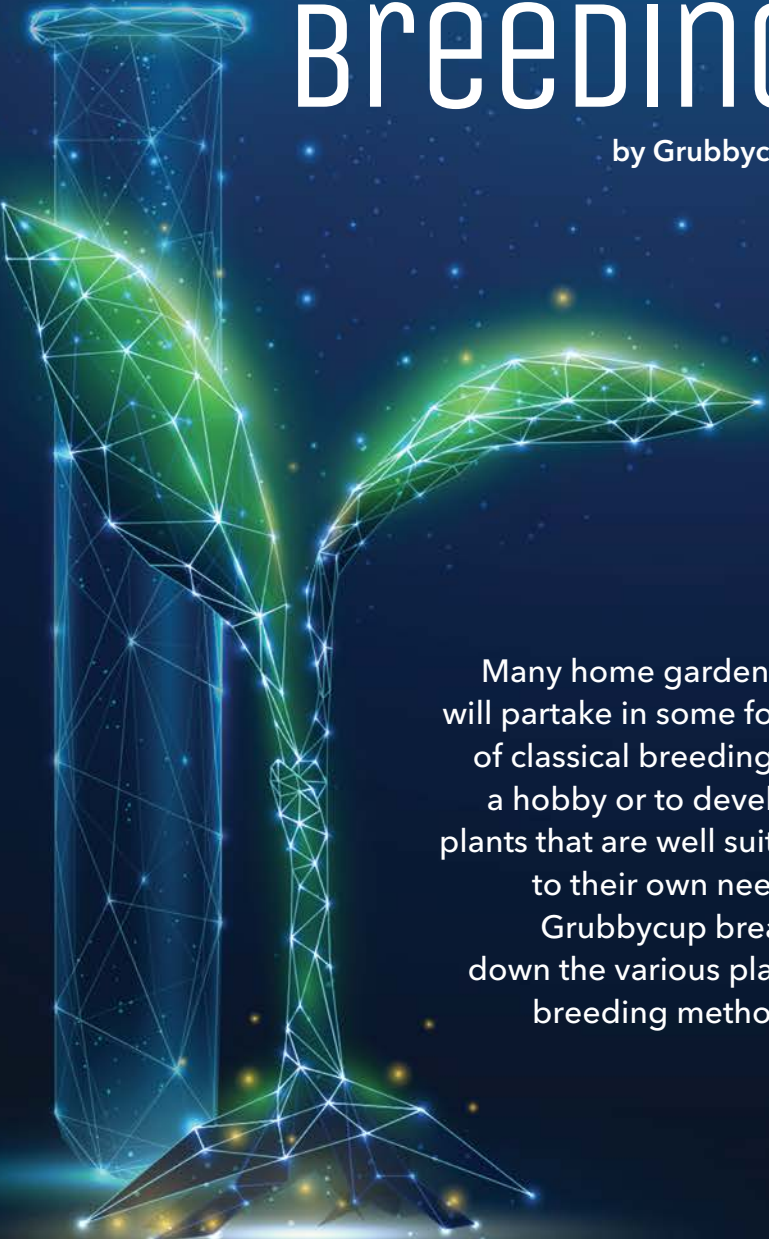
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UNDERSTANDING GENETIC
COMBINATIONS IN

PLANT BREEDING

by Grubbycup




Many home gardeners will partake in some form of classical breeding as a hobby or to develop plants that are well suited to their own needs. Grubbycup breaks down the various plant-breeding methods.

Natural Selection

Imagine a hypothetical stand of plants growing naturally. The environment will put genetic pressure on the plants. If a plant doesn't survive the growing conditions long enough to reproduce, then it is selected against. The plants that do survive long enough to reproduce are selected for. Plants that do better and have more successful offspring will out-propagate the others. Over generations, as the successful plants outcompete the less successful plants, the colony will adapt to the environment or naturalise.

Early Plant Breeding

What is most successful in an area is not necessarily the most desirable to humans. For example, if our hypothetical plant has flowers, then it may be that a plant with red flowers is more desirable to humans than a plant that has white flowers, even if the plant with white flowers is better suited for reproductive success (maybe the pollinators like the white flowers better). Simple forms of plant breeding would involve human intervention, and could involve either removing plants with white flowers, or saving seed from the plants with red flowers. This creates a situation where the plants with red flowers are selected for, and those with white flowers are selected against. Eventually, with enough generations, all (or at least most) of the plants will start producing offspring with red flowers. One benefit to this type of breeding is it's relatively simple to just keep saving seed from the plants closest to a particular ideal, and the plant line will tend to approach that ideal.



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“GREGOR MENDEL

is often referred to as the father of modern genetics – he developed the laws of Mendelian inheritance in the 1800s and advanced our understanding of how inheritance works.”

Brassica oleracea is a well-known example of this type of selective breeding. In its original form it is known as wild cabbage, but human intervention through breeding has led to a variety of domesticated forms. There are different varieties of *Brassica oleracea* in much the same way as there are different breeds of dogs, although it is generally better known by its various common names:

- *Brassica oleracea* bred for loose leaves is better known as kale.
- *Brassica oleracea* bred for large tight-headed leaves is better known as cabbage.
- *Brassica oleracea* bred for small tight-headed leaves is better known as Brussels sprouts.
- *Brassica oleracea* bred for large stems is better known as kohlrabi.
- *Brassica oleracea* bred for their edible immature flowers has resulted in cauliflower, broccoli, romanesco, and so on.

All of these were bred just by selecting for certain traits over many generations.

A problem with this level of basic plant breeding is unexpected results can occur. If at least some of the underlying mechanisms involved are understood, then a breeding program can be much more efficient and predictable.

Mendelian Genetics

Gregor Mendel is often referred to as the father of modern genetics — he developed the laws of Mendelian inheritance in the 1800s and advanced our understanding of how inheritance works. This type of classical breeding is commonly used to improve the existing population of plants into new varieties.

In our hypothetical red and white flowered plant example, flower colour is a trait dictated by the gene for flower colour.

The value of the gene is dictated by two alleles. Each parent will have two alleles, which may or may not be the same. They will pass on one or the other (random chance) to each of their offspring. When a seed is formed, for every gene, one allele is inherited from the pollen (on the father's side) and the other from the egg (on the mother's side). For the flower colour gene, let's call the red allele 'R' and the white allele 'r'.

True Breeding Traits

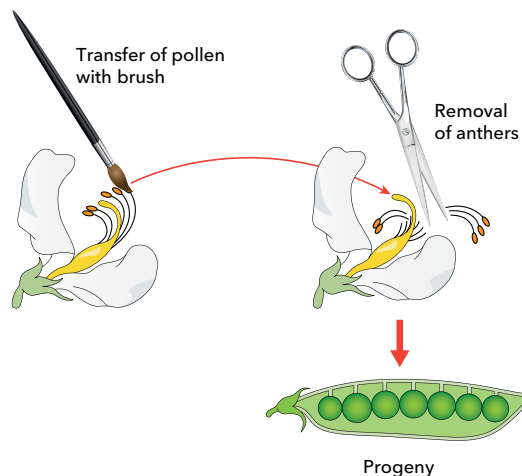
If a red-flowering father is true breeding (homozygous) for red flower colour, then both of his alleles are the same (in this case coded for red). For simplicity, this can be expressed as RR, one R for each of his two alleles. Since both of his alleles are for red flowers, he will have red flowers, and no matter which allele he passes on to his children, it will be an allele for red flowers (because it will either be an R or the other R). The same is true for homozygous mothers.

If a white-flowering mother is true breeding for white flower colour, then both of her alleles are the same, but this time coded for white. For simplicity, this can be expressed as rr. When she produces seeds, she will donate either her first r or her second r, but an r in either case. Again, the same would be true for homozygous fathers.

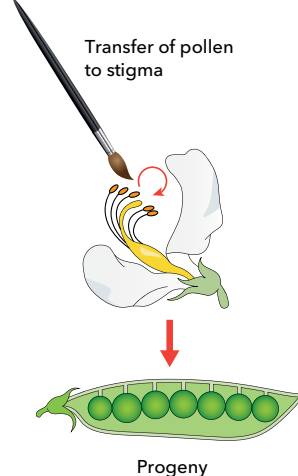
The parent generation is called the P generation. When two members of the P generation are crossed, the resulting children are members of the F1 generation. The children of the F1 generation are called the F2 generation, their children are the F3 generation, and so on.

If both members of the P generation are true breeding for red flowers, then the offspring will all have red flowers.

Cross-pollination



Selfing



Any of the possible combinations of alleles will result in every member of the F1 generation getting an R from each of the two parents. The father will give one or the other of his two Rs and the mother will give one or the other of her two Rs, forming offspring that will have two Rs. The same would be true with white flowers. Two parents homozygous for white flowers will make offspring with white flowers.

Where things start to get complicated is when a red-flowered pollen-bearing hypothetical plant and a white-flowered egg-bearing hypothetical plant are crossed together. The father will donate one of his two Rs, and the mother will donate one of her two rs, resulting in children that will all have one of each (Rr). This is the F1 generation (in this case also the hybrid generation). Since the offspring will have one R and one r, they are heterozygous for flower colour.

Hybrid F1s

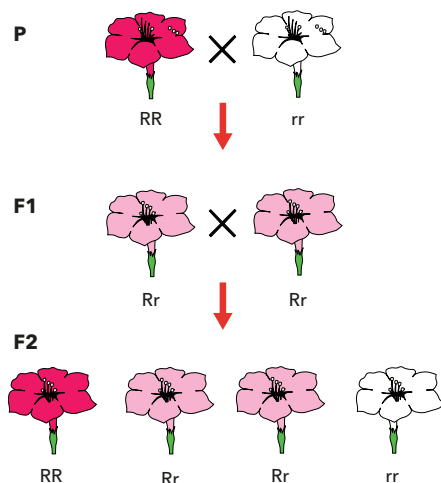
Two Rs form red flowers, and two rs form white flowers. What flower colour the plants will have when they have one allele of both will depend on which is dominant. Alleles that win ties (when there is one of each) are called dominant, and those that lose ties are called recessive. So, if red is dominant, then the Rr children will all have red flowers. If white-coloured flowers were dominant, then the F1 generation would all have white flowers (there are also some cases where heterozygous alleles have what is called incomplete dominance that can result in things like pink flowers, but that is a more advanced topic). F1 hybrids tend to be similar to each other and can exhibit a robustness that is called hybrid vigour. For this example, assume red flower colour is dominant.

F2s

If two members of the F1 generation (Rr) are crossed (say that three times fast) then each parent will pass one of their two alleles. The four combinations possible in the F2 generation are RR, Rr, rR, and rr. These are commonly expressed as a punnett square.

- In the case of RR, the child plant will have red flowers.
- In the case of rR or Rr, the child plant will have red flowers (because of dominance).
- In the case of rr, the child plant will have white flowers.

In other words, about 75 percent of the offspring will have red flowers, and about 25 percent will have white flowers.




Breeding for recessive traits is easier than breeding for dominant traits. In the example, while there are fewer white flowers, they will all be rr (because they didn't have an R to lose to). For the dominant trait however, RR, Rr, and rR will all have red flowers, and no way to tell them apart. With recessive traits, if they show, they are true breeding. With dominant traits, one has to run trials and use statistics to be able to determine when it is statistically likely to be homogeneous.

GMOs

While traditional forms of breeding have involved probability and record keeping to determine and change the alleles in an existing plant population, there are also more direct methods that can create genetically modified organisms (GMOs). By using genetic engineering techniques, the alleles are changed or replaced in the laboratory. Early methods included introducing a mutagen and observing the survivors for promising candidates. Later methods include using a gene gun and carrier viruses to alter (or replace) alleles. One concern with GMOs is they allow the resulting lifeforms to be patented/owned by the generating company that can have legal and social repercussions if they are allowed to become a major source in the public food chain (or health).

Gardeners

Many gardeners perform some form of classical breeding if for no other reason than to develop plants that are well suited to their own needs. It can be a fun and engaging hobby, if not one suited for instant gratification. With time and patience (and a little know how) progress can be made in home gardens, which can help with both diversity and disease defence. 

“**F1 HYBRIDS** tend to be similar to each other and can exhibit a robustness that is called hybrid vigour.”





DEALING WITH DOWNY MILDEW

While it doesn't get the same scrutiny as powdery mildew, downy mildew can become just as devastating on your plants. Chris Bond explains how to deal with this damp-weather plant disease.

by Chris Bond

Downy mildew is the name collectively given to a number of different, but symptomatically similar plant diseases. Often confused with gray mold (*Botrytis*) or powdery mildew, downy mildew often shows as a fuzzy, bluish (sometimes purplish) cast and occurs during cool (40-72°F; 5-23°C,) and humid (above 80 percent) or foggy weather, as opposed to powdery mildew which occurs during warmer and humid weather.

Wet foliage can also be a sufficient microclimate to produce spores and infect plants. It is unsightly and can become a systemic pathogen killing the entire plant, but fortunately is not necessarily fatal with proper prevention and treatment.

Symptoms and Causes of Downy Mildew

Downy mildew can be festering on your plants for some time before being noticed. That is because it usually first appears on the undersides of leaves. The leaf bottoms can appear to have white or bluish-white fuzzy or fluffy looking growths. After some time, the tops of the leaves may develop small green or yellow translucent spots. If these spots remain untreated, they leave a gray coloured lesion in their wake. Eventually whole leaves, then branches, even flowers and fruit will die. These deceased brown or bronze coloured portions will continue up the plant, if not controlled and the climatic conditions do not change or are otherwise unaddressed.

Downy mildew is caused by several related, but host-specific fungal species of pathogenic water molds (oomycetes). This means the type that infects one kind of plant may not be the same species of fungus affecting another plant, though the symptoms may appear the same. Downy mildew spores are produced only on living plants and spread primarily through wind displacement and air movement, though they can be spread by insect pests moving from plant to plant. As spores land on a host plant, they can germinate and infect within as few as eight to 12 hours if the plant or foliage is wet. Some of the more commonly occurring pathogens for downy mildew are *Peronospora* spp., *Plasmopara* spp., and *Pseudoperonospora* spp. It should be noted, however, that finding downy mildew on one type of plant typically means that the conditions are favourable for the development of other downy mildews on other types of plants as well.

If unsure what kind of disease you have, take a large sample to your local cooperative extension service or larger garden center for identification where it can be viewed by a trained professional with a keen eye or viewed under a microscope. Downy mildew appears under the lens in a branched pattern whereas powdery mildew appears in a chain-like formation when view under extreme magnification.



“EVENTUALLY WHOLE LEAVES, THEN BRANCHES, EVEN FLOWERS AND FRUIT WILL DIE.”

Plants Commonly Affected by Downy Mildew

Downy mildew affects a wide range of plants. Host plants can be vegetables, fruits, herbs, annual flowers, perennials, and woody shrubs. Anywhere that cool, damp conditions exist, downy mildew can appear. The following list is by no means complete, but shows the range of hosts:

- Herbs – basil, rosemary, verbena
- Fruit (botanically speaking any plant that produces a seed-bearing vessel) – cucurbits (squashes, cucumbers, pumpkins, gourds, etc.), peas, tomatoes, grapes
- Vegetables – potatoes, kale and other cole crops, spinach, lettuce, onions, garlic, asparagus, rhubarb
- Annuals – alyssum, poppies, sunflowers, impatiens, pansies, coleus, snapdragons
- Perennials – coreopsis, aster, perennial geraniums, daisies, Veronica
- Woody shrubs – roses, viburnum
- Other – hops

Treating Downy Mildew

The good news is downy mildew can usually be effectively controlled with a wide range of commercially available fungicides. Many products are formulated to control a range of plant diseases and downy mildew can often be treated with the same formulations available to combat other common plant diseases such as Pythium and Phytophthora. Fungicides formulated to combat or control true fungi, however, will not often be effective to use on downy mildew as the biology of each respective disease is quite different.

“Traditional” fungicides for downy mildew include many of the most commonly occurring chemicals on the market. These include (this list is not exhaustive, but representative) fungicides containing: chlorothalonil, copper sulfate and lime (commonly sold as “Bordeaux mix” and sometimes used in organic food production), fosetyl-Al, mancozeb, metalaxyl, mefenoxam, or trifloxystrobin. For those seeking less harsh alternatives, there are indeed some formulations approved for organic food production that can be used to treat downy mildew.



“SOME DOWNY MILDEWS CAN SURVIVE COLD WEATHER; OTHERS CAN BE CARRIED BY WIND AND INSECTS FROM WARMER CLIMATES.”



Neem oil is a naturally occurring substance derived from the *Azadirachta indica* tree from India. Neem oil can also be used to control a wide range of insect pests organically, too. Additionally, biological control can be found by using a naturally occurring bacteria, *Bacillus subtilis*, which will prevent downy mildew from attaching to plant surfaces. Other fungicides available for the environmentally conscious include those containing baking soda and rhamnolipid (a type of fat) biosurfactants that burst the cellular walls of mildew and other diseases naturally upon contact.

As with any pesticide, remember “the label is the law.” Use each fungicide in accordance with personal protective equipment (PPE), rates, and only on plants listed on the document included with each pesticide at the time of purchase. If you have lost the original label or it has become difficult to read, copies of product labels are required to be found on each manufacturer’s website.

Prevention

As with many diseases, botanical or otherwise, preventative measures are preferable to treatment. Whether plant selection or cultural practices, there are several strategies for avoiding downy

mildews. While the weather cannot be controlled, the conditions favouring the formation of any mildew can be. Any planting area, new or existing, should be cleaned out to remove plant debris. Many types of spores can overwinter in field and garden debris and emerge from seemingly nowhere the following season. Some downy mildews can survive cold weather; others can be carried by wind and insects from warmer climates. This means removing frost-killed vegetables from the previous year’s garden before planting new and clearing out fallen branches and leaves from around the landscape.

New plants should be selected based on their resistance to downy mildew when such options exist. This information should be available on nursery tags at the garden or box store where they are being selected. Lists of downy mildew-resistant plants can be found from many reputable sources with a quick online search if there is no information on the tags. Certified root stock that is guaranteed to be free of downy mildew spores for onions, garlic, asparagus, and rhubarb should be selected if planning to grow these types of crops. Practising crop rotation in the garden will help manage the spread of downy mildew as well.

Observe a three-year minimum rotation cycle for root crops to help avoid contracting any types of downy mildew that may be lingering in the soil. Delaying planting until after the threat of cooler, moist weather is another strategy. Existing plantings can be managed to avoid downy mildew formation as well.

No matter how established your plants are, making sure there is enough airflow around them is critical to help avoid mildews and fungal problems of all kinds. For mature plants, make sure the lower branches and leaves are not laying on the ground. Keep all dead or damaged branches pruned out regardless of their location on the plant. Keep your plants trimmed back away from the house and other structures as well. For overly dense, but otherwise healthy plants, make some periodic thinning cuts to make sure there is good air circulation around them. This will help to reduce humidity around your plants and allow for better drying out of the foliage. Consider removing (or transplanting) mature landscape plants if they have grown too much into, or too close to their neighbouring botanical friend. When planting new, consider spacing your selections based on the maximum spread listed on the tag so they do not grow into one another. Again, if this information is not readily available on the plant or nursery tag, there are hundreds to thousands of reputable plant databases online.

Once the spacing and thinning issues have been addressed, consider watering practises. Too much moisture is one of the key causes of fungal issues including mildews. Since downy mildew develops in cool and moist environments, care should be taken when irrigating plants that may be susceptible to it. Watering should be done during the warmest part of the day or prior to it so that excess moisture has a chance to evaporate. When irrigating plants, try to keep all off the leaf surfaces, instead favouring the root zone and soil around the plants.

With such a range of practical and easily performed preventative strategies, downy mildew does not have to be a garden scourge. If you do, however, lose the battle on any of your plants, make sure to fully remove the plant and any fallen leaves or branches, and don’t allow them to decompose near your garden. Where possible, burn or otherwise dispose of plants that have been affected by downy mildew to help prevent its further spread or return. 🍷

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THE IMPORTANCE OF AIR PURIFICATION IN THE GROWROOM

by Rich Hamilton

Supplying fresh, clean air through the use of a proper ventilation system is of utmost importance to your growing environment. Get it right and you have one of the keys to producing bigger and better yields.

Why do your plants need fresh air and how do they use it? Ideally in your growroom you want conditions exceeding those a plant would experience naturally. One of these conditions is the provision of fresh air that is rich in CO₂ so the plant can perform the maximum amount of photosynthesis possible.

Plants are used to natural environmental exposure, wind, and an endless supply of fresh air. It is obvious that in comparison, the environment of a growroom can be still and stagnant, with a low concentration of CO₂. An ongoing stream of fresh air brought from the outside and passing through the growing environment is a must to keep CO₂ levels optimised, allowing the plant to perform photosynthesis and boost growth and yield.

Air Flow in a Closed System

There are some closed-system environments that can be very effective for the right crops. A closed system is an environment that is completely closed to any outside factors including air coming in or out. The air in the grow environment is simply re-circulated using a conditioning unit. While these systems do work very well, even a closed-system expert will tell you that a breath of fresh air in that closed room every now and again does the plants a world of good.

Plants are very susceptible to temperature fluctuations and generally perform best under stable conditions. When growing indoors we are substituting the sun for grow lights so there is a risk of over- or under-heating a growroom.

A ventilation system ensures continuous air flow between the outside world and the indoor grow area. Ventilation systems use a combination of exhaust and intake fans, ducts, and pipes to maintain airflow. This airflow helps to stabilise the temperatures of the indoor growing environment as well as cleaning any dirty, stagnant air in the process.

Importance of Ventilation

Ventilation systems are also essential for humidity control within your growing environment. Plants work as efficient dehumidifiers naturally by themselves but when growing inside, if your environment is not properly ventilated, you will soon see problems occurring.

With no air movement and exposure to high temperatures, a plant expires water vapour rapidly and there will be nothing to move it away from the plant or out of the air. If left in this state, your growroom will become very humid and damp. This in turn creates the perfect environment for mold to thrive, which can be the kiss of death for your crops and equipment. A ventilation system will work to move the humid air away from the plants and out of the environment. The plants can then breathe and take in more water (and nutrients) through the roots.

A steady flow of fresh air keeps your medium dry, minimising the risk of insect infestations. The use of fans is also beneficial in managing the presence of any flying pests like gnats. By maintaining a breeze, it prevents them from having free access to all your plants as they find it much easier to move around in still air.

Your ventilation system needs to be customised to suit your specific setup, taking everything into consideration such as the species of plant you are growing, the heat and humidity requirements, and the size of the space you are growing in, as well as the changing volume of space as your plants grow.

Ventilation Setups

There are two types of basic ventilation setups: passive and active. A passive system features one extractor fan blowing warm air out of the tent while allowing fresh air to enter through an intake hole or vent. An oscillating fan keeps air circulating and regulates the temperature within the tent. A passive system is a good choice for a small growing environment.

An active intake system is a better option if you have a larger grow tent to ventilate. In an active intake system, an additional fan is used — an intake fan. An intake fan pulls fresh air into the growroom. Most types of growroom ventilation fans can be used for either intake or outtake purposes. A simple in-line duct fan is usually the most effective and popular choice and can be mounted inside or connected to ducting.

To find the perfect-sized fan you need to consider the diameter and size of the fan. You want a fan that will completely replace the air inside your environment in around one minute and to do this you need to calculate the volume of your growroom. It's a simple calculation: multiply your growroom's length, width, and height. This gives you your cubic feet per minute (CFM) number and is the ratio that tells you how much air that fan can move in the space of one minute.



"An ongoing stream of fresh air brought from

the outside and passing through the growing environment is a must to keep CO₂ levels optimised, allowing the plant to perform photosynthesis and boost growth and yield."

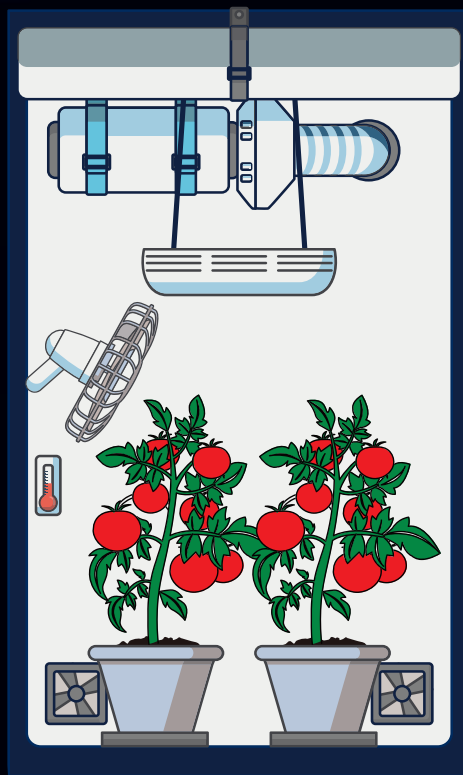
Ideally, you want a fan that has a higher CFM number than the volume of your growroom. This ensures the fan will extract all the inside air in less than a minute.

Fan size is important, too, and needs to be correct to the size of the portals and vents on your growing area. Fan size also determines the size of the ducting you will need.

Ducting in a Growroom

Ducting has a simple yet crucial role. It is a collapsible tube running from your extraction fan, taking the warm, humid air away from the fan quickly and quietly. There are many ducting types available designed to reduce any whistling or noise created by your fans or extraction system.

Wherever possible you want to have the shortest length of ducting running from your extraction fan. This is because the air will cool rapidly once it hits the ducting, and condensation may form, hindering your air extraction efficiency. Likewise, for the same reason it is important that your ducting is hung as straight as possible to avoid any small puddles of water forming in any dips or bends. You will also need to buy clamps to secure the ducting. You are looking to make an airtight, secure seal that will stand up in all conditions for the duration of your grow.



There are additional items that you can add to further enhance conditions and performance like carbon filters, which are great for scrubbing odours. However, starting off with the foundations of ventilation and getting them right is fundamental to your understanding and your future success.

Your indoor ventilation system is just as important as the lighting system or feeding regime. When you take time and pick the right equipment to maintain temperature, humidity, and CO₂ levels at a perfect range, your plant's ability to photosynthesise will not be compromised and your plants will thrive in the optimal conditions needed for fast, strong growth and monster yields. 🍅

GreenBroz manufactures machines that allow clients to process their harvests gently and more efficiently. It is the company's attention to detail through engineering and listening to their customers that has defined GreenBroz since its inception. *Maximum Yield* sat down with CEO Cullen Raichart to learn more about GreenBroz's backstory, what lies ahead, navigating a pandemic, and working together with his kids.



MEET **GREENBROZ** AUSTRALIA

HOW DID YOU COME UP WITH YOUR COMPANY'S NAME?

Well, that's a great question. Back in the inception phase of the company, we were sitting around talking about what to call this idea that we had. We wanted 'Green' in there somehow, both since it's the industry and because we wanted to manufacture using Earth-friendly practices (our machines are almost entirely recyclable by the way). "Well, why not call it GreenBroz, because we're bros (good buddies)." We decided to add the 'OZ' instead of 'OS' at the end, as a further nod to the industry because we used to always call it an OZ or a Zip, so that's how it came to be. We've experienced some kickback for the name being a little immature to some, but it means something to us and we've stuck behind it. Now it's internationally known and synonymous with industry-leading harvesting equipment.

HOW IMPORTANT IS SAFETY WHEN YOU'RE ENGINEERING NEW PRODUCTS?

Safety is paramount, both for our production staff while they are manufacturing our equipment, as well as the end users who are trusting our machines in their harvest process.

We just went through this iteration of converting the Alchemist to a personal protective equipment (PPE) cleaning machine for hospitals, first-responders, or anywhere else PPE is needed in this time of short supply. We're working with a number of contributors, including IGTCAN, on this project and hoping to secure government contracts for the technology. When it comes to government contracting, and you start to go through the FDA certification process, you really see what it means to look at safety and regulations in a comprehensive and very serious way.

So, it's really, really important. After all, you can't make things too safe, right? There's no such thing. Except for if that requires a machine not to function. I think of a table saw. One of the most brutal machines for fingers ever created is the table saw. It's a great machine, but you do need to be taught how to use it. Well, there's a company called Saw Stop that manufactures table saws, and if you touch the blade, it instantly stops. You could stick your finger into it, and I don't recommend ever doing that, but you can, and it will stop. It just literally throws a piece of aluminum into the blade at light speed because it's all piezoelectric. Bam, like that, and it just locks the blade.

I've actually seen it work and I've seen it on a guy's finger, and he just nicked his finger. Point being, safety is a huge concern. You don't want rough edges on your equipment. You don't want sharp spots. You don't want to create the opportunity for people to get injured because if they can, they will. Even with all that said, there's a limit to what you can do. You do everything you can and then hopefully training and common sense will prevail and keep people safe while operating your equipment.

WHAT ARE SOME NEW INNOVATIONS YOU'RE USING IN YOUR PRODUCTS?

This seems like a two-part answer. There are the innovations we're creating and releasing, then the innovations we're implementing in our manufacturing process. In terms of our manufacturing process, one cool shift has been our move to laser welding. Not 100 percent because there's still a need for TIG welding on the stainless steel in larger parts, but we've moved over to mostly laser welding, which is radically changing the welds and the speed with which we can weld. It's just unbelievable.

Additionally, we've moved over to 100 percent 316 stainless steel (from 304). Initially we thought we would only implement it where the machine touched the plant, but we decided we wanted to do better than that. So, we got creative and worked out a really good deal with the mill who supplies the steel, and now we utilize it throughout the machine, further enhancing our product quality.

Switching to all 316 stainless steel also prevents confusion or mismatching in our production facility, so it won't get mixed up with 304. 316 is more corrosive resistant and higher quality. It's used in labs, kitchens, and other facilities like that.

In terms of our products, we're constantly bringing innovation to the industry. Our latest release is the PPE Remediator, which will sterilise PPE equipment for hospitals, first-responders, and even cultivation facilities that find themselves needing to reuse protective equipment in these times of short supply.

The PPE Remediator implements technology we also plan to bring to the plant remediation process, which is sorely in need of a machine that works as advertised. We have experience with other companies that have attempted to bring this solution to market, and failed, so we've collaborated with a handful of companies (each leading their own industry), to figure out a solution that works. We're excited to bring this product to market later in 2020.

The Deserest drying machine will be another release in 2020, which will bring a drying technology to the industry unlike anything that it has seen before. We're incredibly geeked out on this machine and it's going to be another game-changer for GreenBroz.

WHAT ARE SOME STEPS GREENBROZ HAS TAKEN TO IMPROVE ENVIRONMENTAL RESPONSIBILITY?

Well, that's a great question, because I think from the beginning, we have been a leader in that respect. Everything that we have used in our products has been recyclable. We use high-density polyethylene that's untreated for that very reason. So that can go into reuse easily; same with the aluminum and the stainless steel. Even the electronic parts are mostly recyclable as well because they can be broken down and reclaimed, but we're over 96 percent recyclable. And for a reason, we not only want to build the best machines possible, but we want to do it the right way and be stewards of our environment whenever we can make it happen.

"We're incredibly geeked out on this machine and it's going to be another game-changer."



"Our Precision Sorter has gone gangbusters over the past year, and cultivators are realising the dramatic labour savings associated with quickly size-sorting your harvest."

WHAT ARE YOUR TOP THREE SELLING PRODUCTS RIGHT NOW?

People continue to recognise GreenBroz as producers of the finest dry trimmer in the market, so we continue to see our Model M Dry Trimmer and 215 Dry Trimmer lead the pack.

However, our Precision Sorter has gone gangbusters over the past year, and cultivators are realising the dramatic labour savings associated with quickly size-sorting your

harvest. It really opens up the variation in processing material into a number of end-products.

Finally, the Precision Batcher, by our premier partners at Green Vault Systems, is the leading weighing and batching system in the industry. Before this machine hit the market, people either weighed/batched by hand, or used the crossover multi-head weigher, which is very inaccurate and boasts a high overpack and/or rejection rate compared to the batcher. The Precision Batcher was specifically designed for the plant by engineers who had previously worked on multi-head weighers and knew that technology would fall short with the plant. Once this machine hit the market and people saw the dramatic difference in operation, labour savings, and accuracy, it has become a must-have for anyone who wants to be a serious player in their arena.

WHAT ARE YOU DOING TO RETAIN STAFF?

Retaining staff is very important to us as a company. We take various steps to encourage our employees to buy into our company culture. We do 401k matching and offer medical benefits. We're competitive in the marketplace for our wages and we foster a good team environment where everybody has room to thrive. One of the biggest things for me is allowing people to have their creative freedom. To be able to really shine in whatever area they're really good in. Obviously, you don't find it for everybody, but when you do, you get these people that are just rock stars and you're like, "Wow." And all I did was give them an opportunity.

DO YOU HAVE ANY EXPANSION PLANS?

We're always growing and evolving as a company. Our latest push into the PPE remediation market could really change the way this company functions. Instead of being a company that's branched into the industry, we could be one of the first companies to branch out of it, using the plant as the foundation. And, of course, we will always stay true to our first love, but if we can get into the medical market with our equipment, that would be exciting too.

HOW ARE YOU KEEPING PACE IN SUCH A FAST-MOVING INDUSTRY?

From the beginning, we've worked tirelessly to not only keep pace with this industry, but at times leap ahead of it in terms of the equipment we offer. It has been fast paced since we joined over seven years ago, so we're more than accustomed to the hard work it takes to keep pace.

I was just thinking about this the other day. Here we are in the midst of a pandemic, and we're developing three or four new machines. I got my engineers on overdrive. They're absolutely getting run over by work. The manufacturing floor is constantly improving as we're tweaking our process to streamline operations even further. Our small media team is on fire, promoting our large variety of machines while creating new collateral for our new releases. We've hired a heavy hitter to absorb some of my workload, which is great but at the same time hasn't made any of us less busy. It's more like, now we have time for these 10 other tasks we wanted to get going on.

I never had anybody tell me what my limitations were when I started this. I had my limitations told to me when I was in athletics, when I was in corporate America, I was well aware of what my limitations were.

But since I founded GreenBroz, I've never had anybody tell me there was any limit, and I've just treated it that way. I don't care what anyone else thinks, we're going to do this. We're going to have fun. And we operate it that way.

DESCRIBE YOUR COMPANY CULTURE.

I think the culture is interesting. It's shifted a little bit. It was a little tighter and more familial when we were a smaller company with less people. More intimate if you will. I think what we have now is more of a team, like a competitive organisation, a competitive crew. You've got people throughout the whole thing who are interested in performing, seeing what they can add and contribute to this organisation, but it's loose enough in the structure that no one is being throttled and held down. Everyone is given the room to go and get it, and people are going and getting it. It's like an all-star team of people who are really jiving. I think, culturally, we're a well-oiled machine. We're a nice cohesive unit right now. And that's like a team instead of a family.

YOU'VE BEEN ABLE TO BRING YOUR KIDS INTO THE BUSINESS AS WELL. WHAT DOES IT MEAN FOR YOU TO BE ABLE TO PROVIDE THEM WITH GAINFUL EMPLOYMENT AND SEE THEM AT THE OFFICE JUST ABOUT EVERY DAY?

Well, it's interesting to see them as adults. I couldn't be happier. It's funny, my dad taught me my work ethic growing up. He was a workaholic. He worked at a brutal pace. And that was always my vision of success, that experience. And while, ultimately, he was not successful in the grand scheme of his business, I'm fortunate that I have been. I've always felt like that experience, learning that work ethic to be extremely valuable to me as a person.




I wanted to have the ability to provide that for my children. When I started this company, they were younger, and there was more underground culture surrounding the company. There wasn't really any need or desire for them to be engaged.

It's interesting, though, my kids have more awareness than I do. It was solely black market when I was growing up. If you smoked, it's because one of your buddies knew somebody, but you didn't know anything about it. So for me, there was this moment where the kids were young and I obviously can't take them to trade shows or expose them in certain areas, because I'm not taking them to some of these clandestine farms and locations just out of respect for my family, because some places you go to and you realise it's serious.

They take their operation very seriously, with tight security. But now that it's changed and the culture has changed, and I've being able to bring them in. Plus, they're all adults now. My oldest son is 22 and he's running operations. He got a degree in business finance. My youngest son has another year, but he's getting his computer science degree, which has been a great help. He gets to practise his craft here. We don't have to have a full IT staff and he can handle everything remotely. My daughter is planning on becoming a doctor and in the meantime she can earn a decent living, learning life skills she might not get in that profession. She's training on the press brake, working with her hands and getting this whole other side to her development. I think it's very valuable. I like it for her and she appreciates it. So, I enjoy it. I'm glad. I wouldn't have it any other way, but I mean, they'll all probably grow up and go off and go do other things. But at least for the moment, we can share a relationship that's really unique. It's an adult relationship that many parents don't get to experience.

WHAT ARE YOUR THOUGHTS ON THE FUTURE OF THE INDUSTRY?

I think the industry's going the way that every other industry is, and that's bigger, better, faster, more. We're working on ways to increase production throughput and value, and that's everybody's goal. You want to start knocking down the things that get in your way while increasing your margins and value to your customers, and then of course, to your company and to your employees. And then if you have shareholders, to those guys too.

I see it becoming more automated. I see the growth accelerating. I see the acceptance of a global industry. I see consolidation happening, of course. But even with consolidation, you're seeing rapid changes from our perspective. A consolidated company has a different mindset. They're doing much more work. They have a different mindset about equipment and everything else, which helps us to help them streamline and move forward. 



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a brief HISTORY OF COCOA BEANS

by Philip McIntosh

Mmmm, chocolate. While no longer used as currency, cocoa beans are still a prized commodity for equatorial nations. Processed into chocolate, they retain their value globally as gifts, key ingredients in baked goods, and one of the most popular treats on the planet.



Don't you wish chocolate grew on trees? Wait it minute, it does! The chocolate tree, *Theobroma cacao* (*L.*) is native to the equatorial zone of the Americas where it was cultivated possibly as long as 5,000 years ago. Now, the tree carrying the much-loved cocoa bean is found in a geographic band encircling the Earth near the equator. The original cocoa trees are thought to have come from Mexico, Venezuela, Ecuador, and Brazil. Cocoa beans were so valued at one time that they were used as a form of barter currency in the Aztec civilisation. Since then, production has shifted to the Ivory Coast, Indonesia, Ghana, and Nigeria.

Cocoa trees flower year-round and the fruit do not all ripen at the same time, so they require constant attention and significant labour to successfully produce profitable crops. Cocoa beans are, of course, the seeds of the cacao tree. They form in groups of 20 to 60 inside the fruit known as a cocoa pod. The seeds are a source of food for mammals. Once the seed containing pods form, and before the mammals get them, they are cut from the trees to have their seeds taken out to be dried in the sun. The white pulp surrounding the seeds in the pod must remain attached to the beans as they dry, otherwise the required microbial action won't take place. After a short fermentation period, the seeds become darker in colour, often a brownish red inside, and have now been transformed into cocoa beans.

Then the beans are converted into either cocoa butter or chocolate solids. Beans are dried, roasted, and ground to become cocoa mass which is then either melted to make cocoa liquor or squeezed really hard to make cocoa butter. The cocoa bean

can be up to 50 percent fat which makes it an excellent candidate for extraction to make butter. The cocoa liquor can be molded into chocolate blocks ready for many uses and the butter is used to mix with chocolate powder and other ingredients to obtain the delicious range of textures that are such an important part of the chocolate-eating experience.

And just what does this chocolate-eating "experience" consist of? Is chocolate some kind of drug that people come to crave? Well, chocolate does contain small amounts of the heart stimulant theobromine, a mild shot of caffeine to wake you up, and in many cases a dose of sugar and fat that humans tend to like because they contain lots of energy, taste good, and have a pleasant effect on the palate.

The cocoa bean's versatility can't be overstated and the continued introduction of new creations by innovative chefs is impressive. In making chocolate, the fundamental material is cocoa liquor, which contains no alcohol. By blending cocoa butter back onto chocolate powder or melted block chocolate, a myriad of flavours and textures can be created as evidenced by the many chocolate dishes that exist.

One way of classifying chocolate is by colour. White chocolate contains cocoa butter along with milk and sugar — no chocolate solids. Milk chocolate is light brown in colour due to the combination of chocolate liquor, milk, and sugar to make a very popular smooth and sweet confection. The darkest chocolate is made from straight chocolate liquor and sugar — no milk. Even with sugar, dark chocolate is known for its less sweet, bolder, perhaps a bit bitter, chocolate flavour. 🍫

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10 facts on **SUGARCANE**

by Philip McIntosh

Also known as $C_{12}H_{22}O_{11}$, refined sugar comes from sugarcane and a few other places.



- 1 **Sugarcane** has been around for about as long as any domesticated plant, arising in New Guinea sometime between 4,000 and 8,000 BCE and separately in China from around 5,500 BCE.
- 2 **Like many** domesticated plants, the species we now know as *Saccharum officinarum* (L.) is really a hybrid selected by humans over the centuries.
- 3 **The genus** *Saccharum* is in the grass family Poaceae. Sugarcane and its relatives are found worldwide in tropical and subtropical areas.
- 4 **The sweet sap** of sugarcane stalks contains significant concentrations of sucrose, a disaccharide consisting of one glucose molecule and one fructose molecule linked together.
- 5 **Brazil** is a perennial top producer of sugarcane. About 95 percent of the sugar produced in Australia is grown in Queensland.
- 6 **Many fruits** and vegetables contain sucrose, but besides sugarcane, the only other economical source of sucrose is the sugar beet.
- 7 **Breeding of** new and improved varieties is an active area of research. Many cultivars are available, often with names such as Ho 07-613 or L 11-183.
- 8 **Being composed** of the simple sugars glucose and fructose, sugar is pure carbohydrate. One 2.3-gram sugar cube contains zero percent of any of the recommended daily requirements. A larger sugar cube might contain one percent of the daily requirement of carbohydrates.
- 9 **Honey**, white sugar, brown sugar, and maple syrup all contain sucrose in varying amounts and have similar nutritional values.
- 10 **Sugarcane is also** used in the manufacture of molasses and rum, as an animal feed, for fibre, and a fuel called bagasse.

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