
# HYDROPONICS

*DIVE INTO SOIL FREE GARDENING*

## CONTENTS



## AN IN DEPTH LOOK INTO THE

# WORLD OF HYDROPONICS

*Soil free gardening has become a lucrative and effective growing method that is continually increasing in practice and popularity.*

*FEEDING THE WORLD*

The pressure to feed a rapidly growing global population has inspired many creative and sustainable methods of farming. Scientists and farmers all around the world are constantly finding more efficient ways to get the most out of our valuable natural resources. Hydroponic gardening is quickly becoming one of the most effective and profitable answers to this problem.

According to market research firm Mordor Intelligence, the global population continues to increase by nearly 200,000 every year. With quality agricultural land shrinking on a yearly basis as well, more and more growers are turning to hydroponic solutions that allow them to grow high yield, low risk crops in urban and rural areas no matter the climate. Mordor Intelligence reports that the global hydroponics market value in 2018 was 23.94 billion USD and is going to continue rapidly increasing every year.

The World Resources Institute estimates that the global population will increase to 10 billion by the year 2050 and that we will need to find a way to grow 56% more food to meet demand.

*CLIMATE CONCERNS*

Hydroponic gardening has the greatest potential in climates with short growing seasons and arid conditions. For example, Mordor Intelligence reports that the middle east spends billions of dollars a year importing produce and grains that would otherwise be unattainable in water scarce conditions.

Hydroponic equipment manufacturers are investing heavily in research and development to find more effective methods and more affordable components that will continue the market's rapid expansion to all climate regions for decades to come.

## HISTORY OF HYDROPONICS

*Over thousands of years, discoveries and contributions from scientists and farmers the world over have shaped the field of hydroponics into the productive industry it is today*

**Rome**
Circa 30 AD

The concept of indoor growing appeared during the rule of Emperor Tiberius. Greenhouses were used to shelter sensitive summer produce on cold days. They were constructed from translucent selenite stone or oil soaked cloth frames to let in light.

**China**
Circa 1300 AD

Explorer, Marco Polo, writes of "floating gardens" while describing the Chinese practice of growing crops, like rice, with water as close to the roots as possible.

**Tenochtitlan**
Circa 1325 AD

This great Aztec city was surrounded by large lakes which forced creative growing methods. Small portions of lake were fenced off and filled with lake sediment. The plants grown in these "chinampas" had constantly hydrated root zones.

**Korea**
1437 AD

The first temperature controlled greenhouses are built. Underfloor heating systems called "ondols" provide temperature sensitive plants, like mandarin oranges, with an opportunity to grow during winter months.

**England**
1699 AD

Naturalist John Woodward publishes his experiments with growing spearmint in a water culture environment.

**Germany**
Circa 1929 AD

Julius Von Sachs and Wilhelm Knopp advance the field of hydroponics with extensive research into soil-less gardening in nutrient rich "water cultures."

**United States**
1940s AD

William Gericke coins the term "hydroponics" and grows 25+ feet long tomato plants through solely hydroponic methods. Dennis Hoagland and Daniel Arnon develop the complete hydroponic nutrient solution. Arnon successfully grows hydroponic crops on Wake Island and Ponape Island while serving in the Pacific during World War II.

**United States**
1970s AD

In the 1970s, a "City of the Future" attraction at Walt Disney's EPCOT Center extensively features hydroponic gardening and turns hydroponics from a scientific curiosity to mainstream fascination.

**The Future**

NASA is extensively researching lightweight hydroponic methods due to weight restrictions in space travel. "Aeroponic" or "fogponic" techniques use microscopic drops of nutrient solution, potentially allowing astronauts to grow food during space travel.

## PROS AND CONS OF SOIL FREE GARDENING

*Every growing method has advantages to enjoy and disadvantages to overcome*

## PROS

### *YEAR ROUND GROWTH*

Hydroponic growing provides carefully controlled environmental conditions for light, humidity, and air temperature. Cultivating this ideal environment opens up a world of possibilities for year round growth. Because hydroponic farms do not need to restrict themselves to typical growing seasons, they can operate in full production mode all year long.

### *ENCOURAGES LOCAL COMMERCE*

Supporting local businesses reduces strain on our environmental resources by reducing the need to transport goods from far away locations. The demand for locally grown produce for restaurants and farmers markets is increasing every year, but some locations do not have the climate or land available to meet demand. So how do you support local farmers when your locale can't offer you what you want, when you want it? Imagine having locally grown strawberries available in the middle of winter. With hydroponic farms, that fantasy can become reality. They can be set up virtually anywhere from dense urban cities to sprawling rural farmland, thus increasing local commercial success.

### *SAVES WATER*

Despite having "hydro" in it's name, hydroponic gardening uses a fraction of the water needed for soil farming. Irrigated farmland continuously loses water to evaporation, runoff, and ground seepage. Hydroponic systems constantly recirculate water as nutrients and oxygen are added to the solution. In 2015, the University of Arizona conducted a study on hydroponic lettuce growth. They concluded that to produce a given amount of lettuce, hydroponic gardening used 10x less water than soil gardening!

### *FASTER GROWTH*

Plants thrive when they are grown in the right environment. In soil gardening,

giving plants the ideal environment consumes time and energy and farmers are still at the whim of mother nature's mood swings. Because hydroponic farms can easily cater to a crop's exact needs, growth rates increase dramatically. The root systems of soil grown plants have to search and share nutrients with the environment around them. Hydroponically grown plants have nutrients and oxygen delivered right to their roots so they can put their energy toward plant growth and not root growth.

*HIGHER YIELDS*

Have you ever looked at the back of a seed packet or at the planting instructions for nursery purchased plants? There are always instructions on how far apart seeds and plants need to be placed. Soil grown plants have to spread their roots far, wide, and deep in search of the nutrients they need and if other plants or weeds are too close, they suffer. Hydroponic plants can be grown right next to each other as everything they need is brought right to their root zone. Hydroponic set ups also can be easily altered for vertical gardening and maximize your crop output.

*LESS CROP LOSS*

Every farmer (soil or hydroponic) has to anticipate some crop loss. Soil farmers worry about crop loss due to pest invasions, storms, and dramatic changes in temperature. Hydroponic farms are not prone to the same environmental catastrophes. The most common crop loss for hydroponic farms occurs at the very beginning when growers are working out the kinks in setting up their system.

*FEWER PESTS*

Soil is the perfect breeding ground for crop damaging insects at all life stages. With hydroponic growing, this threat is greatly reduced, thus decreasing the need for drastic and sometimes toxic pest control methods.

## CONS

*GREATER UPFRONT COSTS*

Launching a hydroponic or soil farm both require upfront costs as equipment and supplies are acquired. For hydroponic gardening, the upfront costs can be greater than for a soil garden. Maintaining the ideal growing environment involves purchasing equipment to measure and stabilize air temperature, humidity, and water temperature. Growing trays, growing medium, water pumps, and nutrient solution reservoirs also need to be purchased. If you are starting a hydroponic garden completely indoors, growing lights will also be added to the list.

*HIGHER ELECTRICITY USE*

Even if you are growing in a greenhouse that has access to natural light, hydroponics has additional continuous energy costs from pumps, fans, and temperature control equipment. Fortunately the field of hydroponics is advancing rapidly and more energy efficient models are becoming available. Using a hydroponic energy usage calculator will help you anticipate how much electricity is needed to run certain pieces of equipment and help you make the best purchases for your operation.

*PLANT RESTRICTIONS*

Unfortunately not every crop can be grown effectively in a hydroponic garden for various reasons. Some crops, like root vegetables, just grow better in soil. Some plants, like fruit trees and vines can overwhelm the growing space. And there are some crops where the yields are not high enough to make economic sense. This is important to note, because the high yield crops are going to help offset the upfront equipment costs necessary for hydroponic gardening.

# EXPLORING THE ROOT ZONE

Hydroponic plants don't have to focus as much growth energy toward root production. Oxygen and nutrients are delivered right to the root systems so there is no need to search far, wide, and deep to survive. Consequentially, root health is the most important factor in hydroponic farming. There are many root health factors to monitor:

*SOLUTION TEMPERATURE*

Keeping your water solution reservoir at 65° F/18° C will ensure your root zones thrive. This temperature goal is ideal for nutrient absorption, dissolved oxygen levels and algae prevention. Because hydroponic water solution needs to be kept cooler than the ambient air temperature, a reservoir chiller is often required.

*NUTRIENT LEVELS*

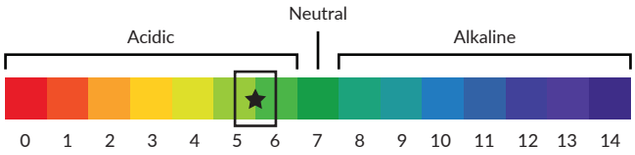
The nutrient solution formula developed by Hoagland in the 1940s has been altered throughout the years. This formula also differs depending upon the crop being grown. Make sure to research your preferred crop and find out what parts per million (ppm) your plants will need. Your formula may also change depending upon light levels, air temperature, and growth cycle stages. The basic hydroponic nutrient solution contains the following:

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 N Nitrogen | 15 P Phosphorus | 19 K Potassium | 12 Mg Magnesium | 16 S Sulfur | 20 Ca Calcium | 5 B Boron |
| 17 Cl Chlorine | 25 Mn Manganese | 26 Fe Iron | 28 Ni Nickel | 29 Cu Copper | 30 Zn Zinc | 42 Mo Molybdenum |

*ALGAE GROWTH*

Many plants thrive in hydroponic environments, including an unwelcome plant...algae. Almost every hydroponic operation encounters algae at some point. If left unchecked, algae can grow quickly, clog your system, and even become toxic to your crop. Algae spores need light, nutrients, water, and warm temperatures, so the easiest way to keep algae levels low, is to remove 1 or more of these elements. Since you can't exclude nutrients or water, light and temperature control are the best options. Using closed growing trays (to protect your water solution from light) and reservoir chillers is usually enough to control algae growth.

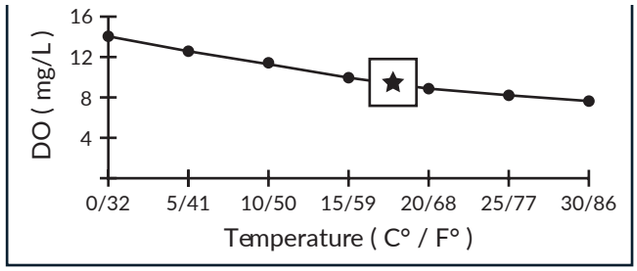
*pH BALANCE*




For most hydroponic crops, ideal pH levels are between 5.5 and 6.5. Sometimes when plants display a nutrient deficiency, growers immediately assume their nutrient solution needs to be altered. However pH imbalance can also cause your roots to not absorb certain nutrients correctly.

*OXYGEN LEVELS*

Dissolved oxygen (DO) is essential for a healthy root system. Aerobic respiration keeps your roots permeable and more able to absorb nutrients. DO also cultivates healthy bacteria around the root zones, which protect your plants from fungal infections.




Using an air pump and air stone oxygenates your water solution to keep DO levels up. Anything below 5 mg/L is very detrimental to plants.

*MICROBES (The Good And The Bad)*

Due to high nutrient concentrations and closed loop water circulation, many types of microbes can grow quickly in hydroponic systems. Avoid using harsh chemicals, like hydrogen peroxide, to sterilize your system because they kill both bad and good microbes. Good microbes can help balance out harmful pathogens and fungi, so biological counter measures will work more efficiently. Beneficial colonies can be purchased and mixed into your water solution at scheduled intervals to inoculate your system and continue to protect it in the future. Microbial needs will vary depending upon the crop and the growth stage, so it is important to find out what your chosen crop will need before your microbial balance becomes compromised.

# TYPES OF HYDROPONIC SYSTEMS

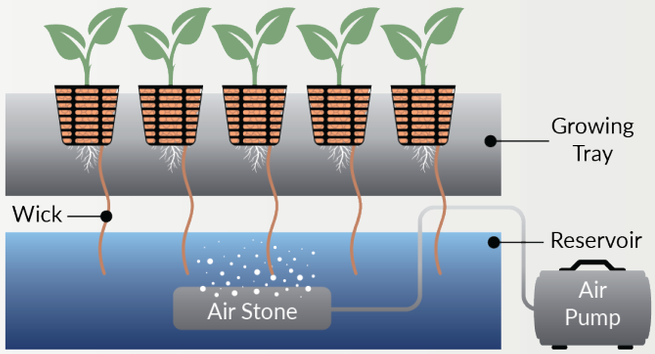
*There are 2 main categories of hydroponic systems: passive and active. Within those categories, there are 6 basic types of hydroponic systems: wick, deep water culture, aeroponics, drip feeding, ebb and flow, and nutrient film.*

## PASSIVE SYSTEMS

Passive hydroponic systems have fewer mechanical parts and are less expensive to set up. Because they require less maintenance, they are also well suited for hydroponic beginners. These systems passively deliver the water solution to the root zones instead of using a water pump. However, passive systems can be less efficient at producing higher yield crops than active systems.

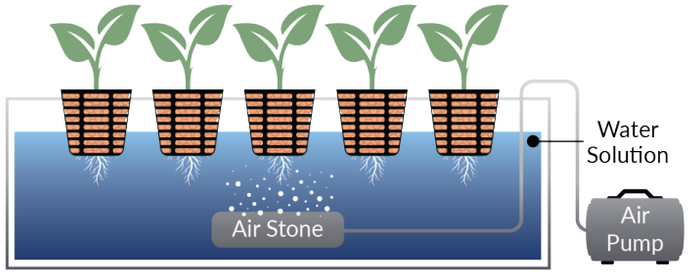
### *WICK*

The wick system is the simplest set-up for hydroponic beginners. Rope wicks made from an absorbent material, such as cotton, extend from the growing medium down to the water solution. Capillary action continuously draws the water solution up to the root zone. To speed up plant growth, additional wicks may need to be added to your system. Wicks also need to be checked frequently for mold growth to maintain plant health.



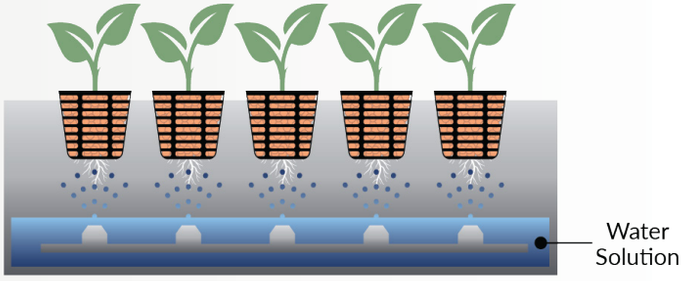

### *DEEP WATER CULTURE*

In a deep water culture system, root zones are constantly submerged in a reservoir of nutrient solution. This method can be a very low maintenance option with the exception of monitoring oxygen levels. DO levels must be monitored regularly to make sure your plants do not drown.




### *AEROPONICS (Fogponics)*

In an aeroponic system, root zones are misted with water solution while suspended in the air. One of the advantages of aeroponics is that the water solution becomes oxygenated as it is sprayed. Misting nozzles need to be clean or replaced regularly due to mineral build up from the nutrient solution. The growing chamber also needs to be well sealed to prevent moisture loss.

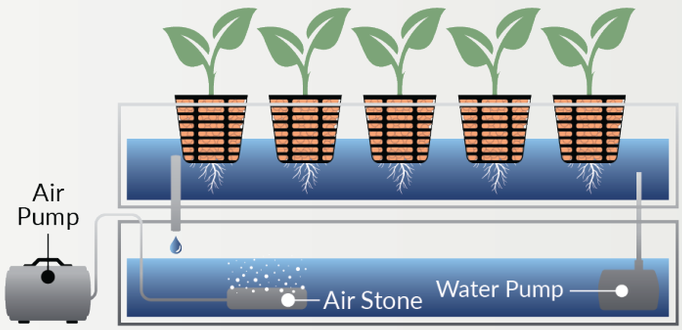


## ACTIVE SYSTEMS

Active hydroponic systems use mechanically driven pumps to move the water solution from the reservoir to the root zones. Because these methods require additional start up purchases and continual maintenance, they are ideally situated for growers with a little more hydroponic experience. The benefit of active systems is they more efficiently provide nutrients to the root zone and produce higher crop yields.

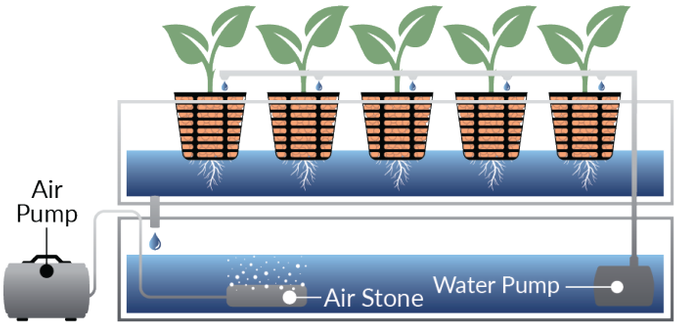
*EBB AND FLOW (Flood and Drain)*

Ebb and flow systems work by flooding the growing tray with water solution at specific time intervals and then draining the solution back into the reservoir. This method provides the grower with a lot of control over their system by customizing watering time and durations. The drain period of time also gives you "dry" time so you can visually monitor root zone health.



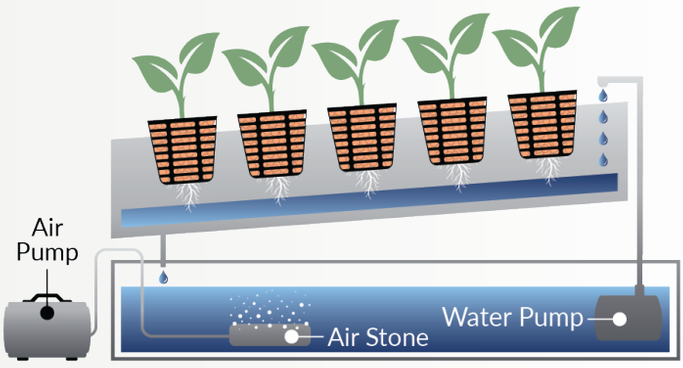

*DRIP FEEDING*

Drip feeding provides a slow feed of water solution from the reservoir up to your preferred growing medium. This method of watering is not unique to hydroponics. It is a popular practice in soil gardening as well because it results in less water loss due to evaporation. Drip feeding is frequently used in large hydroponic operations because it is highly efficient and reduces water usage.




*NUTRIENT FILM (NFT)*

The nutrient film technique (NFT) involves a growing tray that is slightly elevated on 1 side. A continuous flow of water solution is passed over the root zones and drained back to the reservoir via gravity. The most ideal flow of water solution is a thin layer or "film" of fluid running across the bottom of the growing tray. Extra care needs to be devoted to finding the right angle of drainage, the best channel of flow and the right growing tray length. If these conditions are met, NFT can be one of the most productive hydroponic growing methods available.



## STARTING A HYDROPONIC BUSINESS

Getting started with hydroponics, for operations large or small, can feel daunting at first. Purchasing equipment, choosing a location, crop selection, and setting up a routine takes time and effort. Luckily you live in a time when you can benefit from the experience of others and take some of the guesswork and trial and error out of setting up your hydroponic system.

ACCOUNTING FOR LOSS

It is recommended to give yourself at least 6 months to get equipment set up and get started. Crop loss in those beginning months is to be anticipated as you work out the kinks in your system and educate yourself on how to effectively monitor your plants.

Keeping detailed journals will help you improve as a grower and avoid repeating mistakes. Just like a traditional soil farmer, walking your land (greenhouse) at regular intervals and carefully documenting plant health will drastically reduce crop loss. Some hydroponic equipment manufacturers provide their customers with checklist templates to help with these environment health checks.

*USING CONSULTATION SERVICES*

One of the best ways to tap into this wealth of experience is to use a hydroponic consultant. There are many companies out there who are highly motivated to elevate the hydroponic industry as a whole and will share their tried and true knowledge. One such company is AmHydro, an experienced US based hydroponics company with decades of experience. They have helped clients set up successful businesses in 66 different countries and offer many different types of services.

Their seminars, blogs, and webinars (for those unable to attend classes at their farm in California) can help you avoid some of the trial, error, and frustrations that come with getting started. AmHydro also offers in person consultation services to help new growers find the best equipment and set-up for their exact location.

*EQUIPMENT BUNDLING*

At first glance, the amount of equipment needed to start a hydroponic garden can be overwhelming. Most hydroponic equipment suppliers offer bundles or kits of equipment to reduce research and purchasing headaches.

The best bundles also include a support program for continuing questions and needs that arise as you are setting up and beginning to grow. AmHydro offers continuing technical support with their equipment bundles that give growers peace of mind throughout their hydroponic journey.

## MONITORING CROP HEALTH

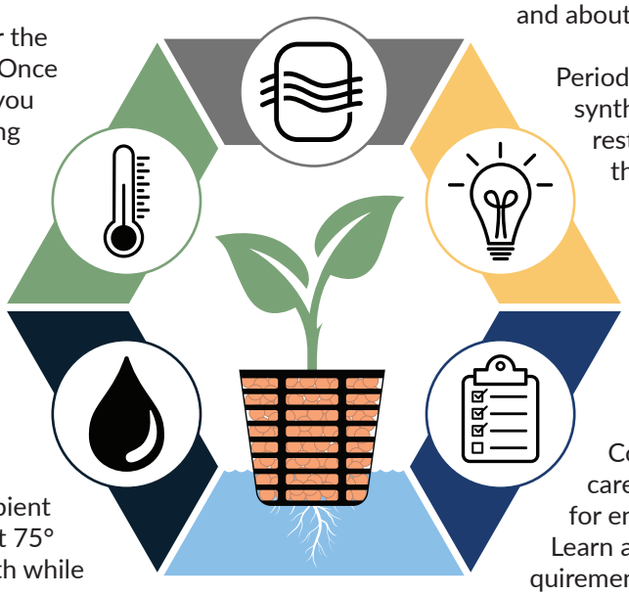
Regularly monitoring your greenhouse and crop health will save you money, reduce crop loss, increase your yields, and make you a better hydroponic farmer.

*WATER SOLUTION HEALTH*

Carefully follow the dosing instructions and schedules on your preferred nutrient mixes and microbe colonies to keep water solution healthy. Avoid using harsh chemicals to try and correct water solution health.

Use a pH tester daily to monitor the balance of your water solution. Once a routine has been established you may be able to reduce the testing frequency.

Use a DO meter to measure oxygen levels in your water solution to keep your roots permeable and protect them from drowning.



*TEMPERATURE (Air and Water)*

Keeping your ambient air temperature at 75° F/24° C encourages even growth while preventing plant wilting and stress.

Chilling your water solution reservoir to 65° F/18° C increases nutrient absorption in your roots and reduces algae growth. Inspect your growing trays for algae growth daily. Checking your air and water solution temperature daily will protect your carefully cultivated greenhouse environment.

*AIR QUALITY*

Keeping fans and air filters clean and operational will reduce the chance for mold and mildew to infiltrate your greenhouse. In general, humidity levels can start out between 60-70% and gradually reduce to around 40% as your crop matures. Closing greenhouse entrances and exits quickly as your pass through them helps you preserve your ideal air quality levels.

*LIGHTING*

Greenhouse lighting should resemble natural sunlight schedules as closely as possible. It is important to maintain a consistent day and night schedule. Ideally greenhouse plants should receive about 14 hours of artificial light and about 10 hours of darkness.

Periods of darkness suspend photosynthesis and allow your plants to rest and metabolize. Avoid turning the lights on during dark periods so you don't trigger growth stage stress in your plants. This lighting schedule can be adjusted depending on growth stages or if you are growing perennial or annual crops.

Consider your light bulb choices carefully to make sure you account for energy usage and heat output. Learn about the lighting distance requirements for your crops to make sure you place your lighting fixtures correctly.

*CLEANLINESS*

Greenhouses need to be kept clean in order to preserve the ideal growing environment. Dead plant matter should be quickly removed to prevent pests. Water spills should be dried and cleaned before mold, mildew, or algae can grow. Walking your greenhouse daily will help you keep things clean and thriving. Conduct cleanliness checks during periods of light so you do not disrupt plant rest.

## SETTING UP YOUR HYDROPONIC SYSTEM

*LOCATION, LOCATION, LOCATION*

Your location, whether indoors or outdoors, will set the parameters for the future of your garden. Size and dimensions will determine lighting needs, environmental control needs, number of growing trays, and layout.

*CROP*

Once you scout your location, you will know how much room you have to work with. Consider starting with simpler crops at first, then learn how to maximize your yields. If you plan on starting from seeds, start germinating as soon as possible. If you plan on growing a taller crop like tomatoes, invest in trellises early to be prepared. Research your crop's pollination needs and plan ahead if you need to assist with pollination.

*LIGHTING*

Decide what kind of bulb you want to use. Read lighting equipment ranges carefully so you purchase the correct number of fixtures. Place them according to your plants' lighting needs during the different growth stages.

*ENVIRONMENTAL CONTROL*

Once your crop has been selected, purchase and set up environmental control equipment as your seeds germinate. Getting your thermostats, humidifiers, and fans up and running sooner will allow you to work out kinks while your crop is small and reduce plant loss.

*GROWING MEDIUM*

Hydroponic seeds are not ready for coarse growing medium right away, so you have a little more time for this decision. There are advantages and disadvantages to all growing media so you can start with a couple different types to help you find your preferences.

*SYSTEM*

Determine which of the 6 types of hydroponic set up matches your skill level, location, and crops. Consider bundling your equipment purchases to make sure each component works well together.

*NUTRIENT SOLUTION (Reservoir and Distribution)*

Some equipment bundles contain nutrient solution needs such as a reservoir, pipes, pumps, etc. Your crop selection will determine what microbe colonies, nutrient mixes and pH levels you need. Make sure you always have plenty of nutrient solution supplies on hand as well as the meters necessary to monitor levels.

Remember that a reservoir chiller will protect your carefully cultivated root zones. Keeping your water solution chilled increase the DO levels, reduces algae growth, and increases nutrient absorption.

## HYDROPONIC SOLUTIONS FROM NORTH SLOPE CHILLERS

### FLUX WRAP JACKETS

Our fully insulated, multichannel jackets easily wrap around a wide variety of reservoir sizes and shapes. Conforming to your reservoir, Fluxwrap's channels of cooling fluid efficiently keeps your reservoir cool thus protecting the health of your entire hydroponic system.


### INDUSTRIAL CHILLERS

Our portable industrial chillers keep your hydroponic environment healthy without disrupting your system. With a wide range of sizes and cooling ranges, you can find the right custom chilling solution for your needs.

PHONE: 866.826.2993 EMAIL: INFO@NORTHSLOPECHILLERS.COM 3130 SOUTH 1030 WEST, SUITE 1 SALT LAKE CITY, UT 84119
WWW.NORTHSLOPECHILLERS.COM