



# Growing Without Soil

The Hydroponics  
Garden

A GUIDE TO  
HYDROPONICS



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# Introduction

## Gardening without soil? Is it possible?

Every child knows successful gardening requires soil, water, plants and sunlight and that if you are missing any of those ingredients; your efforts are doomed to failure.

Every child is wrong.

It may not be possible to replace all of those four options as yet, but along with artificial lighting as a replacement for the sun, soil is one more element of gardening we are learning can be successfully omitted under the right circumstances.

Yes, it is possible to grow plants without soil. It is called hydroponic gardening and although it may seem to border on science fiction, it actually works quite well and can be a great deal of fun.

Hydroponics is not a new development. It has been around since nearly the beginning of recorded history. That wonder of the ancient world known as the Hanging Gardens of Babylon was an exercise in hydroponics and rice has been grown hydroponically for centuries.

Today, hydroponics is used in a variety of settings. Wherever soil is unavailable, hydroponic gardening seems to appear. Wildcatters on offshore oilrigs grow their own tomatoes. Cooks on nuclear submarines hydroponically grow vegetables to use in their crew's meals. Right now, plants are growing on orbiting space stations without a single grain of soil.

Hydroponics may fly in the face of convention, but it does work. In some situations, it is far more practical than traditional gardening, as well, because it requires very little space and other resources and can produce such amazing results.

Hydroponic gardening is not simply something at which to marvel at from afar. It can be something you can do at home, as well. You can grow your own plants, fruits, vegetables and flowers hydroponically. Hydroponics makes for a fun challenging and ultimately very fulfilling hobby.

We have designed this ebook to give you a solid, comprehensive introduction to hydroponic gardening. We hope this information will encourage you to explore the numerous options presented, by gardening without soil.

Not only is it possible, but also Hydroponics Gardening is fun. That's right; I said Hydroponics Gardening is fun! At first, the thought of plants suspended in liquid, growing without soil may seem the subject matter for the latest science fiction novel, but Hydroponics Gardening is a reality and it has been around for a long, long time.

Hydroponics is simple to learn and makes an excellent hobby. So sit back, relax, and enjoy this book. Soon, you too will learn the trend called Hydroponics Gardening.



## Chapter One

# A DIFFERENT KIND OF GARDEN

If you think of gardening, you probably think of soil-intensive preparation, hoeing, tilling, digging, planting, watering, dirt and mud as all necessary parts of the process. Gardening can be hard work and a lot of that work involves “getting one’s hands dirty” in soil.

It doesn’t have to be that way.

The hydroponic approach to gardening makes things a little easier and a whole lot cleaner!

Hydroponics has been an alternative to digging in the dirt for centuries, but it has really come into widespread use only during the past century. During World War II, Allied troops ate fresh veggies from hydroponic gardens located on Pacific naval and air bases. Before that, airline innovator Pan Am supplied travelers with food grown at a hydroponic garden on Wake Island.

The idea of doing away with dirt may sound alien and unnatural, even if it has been practiced for ages in various forms. You will find that today hydroponics is actually quite a sensible way to grow things you want. To make matters even better, in today’s age it can also be very simple rewarding and fun.

In order to embark on a soil-less journey, we have to overcome that mental block that leaves us shaking our head in disbelief. Let’s start by looking at the underpinnings of traditional gardening.

Why do we use dirt in the first place?

Soil is the means by which traditionally planted items get their nourishment. The plants’ roots spread out in mineral-rich soil and draw

nutrients from it. The soil itself, of course, has no nutritional value. It is merely a medium in which those nutrients are hosted.

That's why most serious gardeners spend a great deal of time dealing with soil preparation. They recognize that not all dirt is created equal and understand that successful plant growth in a traditional garden may very well necessitate treating the soil with additional nutrients.

Soil is important in regular gardening. It plays a critical role in nutrient dispersal. However, the wrong soil can actually work against a gardener.

Soil does not merely host helpful nutrients. It is also a home to bacteria, insects and other disease sources. While a plant may be pulling its nutrients from the soil, it may also be absorbing some very destructive unseen elements as well.

Hydroponics provides an alternative. Instead of relying upon the soil as a medium, the gardener instead relies on water. Like soil, water is a neutral medium for the dispersal of nutrients. Unlike soil, water can be better controlled, more easily adjusted and tested and is less likely to play host to common plant-killing diseases and insects.

Lets think about what that means for a moment. Soil was never necessary. It may seem like a logical gardening prerequisite, but upon closer examination, we can understand that we don't need the soil. We just need to give the plants the things they were taking from the soil. Once we fully understand that, and stop perceiving dirt as some sort of magical, mystery ingredient, the idea of hydroponic gardening certainly seems less foreign.

## THE ORGANIC QUESTION

There is a lingering debate over whether hydroponic gardening is organic. That is because most perspectives on the issue of organic gardening begin with a consideration of the soil--a variable that is nonexistent in hydroponics.

Hydroponic gardening, then, really forces a complete re-examination of what it means to be organic.

Organic gardening is usually defined using words like "whole," "natural," and "untreated."

Hydroponic gardeners may not be using foreign substances or strange chemicals to produce results. They may solely rely on natural compounds and elements to grow wonderful plant life and vegetation, but however they are certainly creating a new growth medium by assembling multiple "ingredients," some of which are not the kind of thing you find just "lying around in nature."

At a basic level, however, it would seem as though hydroponic gardening does pass the "organic" test. In practice, things aren't that simple.

Gardeners use pesticides regularly; although a hobbyist in hydroponics may be able to grow a wonderful crop in the home without using any pesticides, larger-scale hydroponic operations do rely on some pesticide use.

Is hydroponic gardening organic? At face value, it most certainly can be. However, it isn't intrinsically organic. Defiantly the use of pesticides or fungicides (which are not commonly necessary, but may be used in some instances) would take a hydroponic garden outside of the organic realm, by most definitions.



## Chapter Two

# CRYSTAL CLEAR ADVANTAGES TO HYDROPONIC GARDENING

### SIZE

Nothing can ruin plans for a bountiful garden quicker than a lack of space. There are millions of frustrated apartment dwellers that would love to have a garden, but don't even bother thumbing through seed catalogs because they cannot manage to make a garden fit with their living environments.

Hydroponic gardening is great because it allows us to avoid those concerns. Even those of us living in relatively small spaces can grow fresh fruits, vegetables and herbs without worrying about the size of our lawn.

Plants can be grown in containers in even the smallest of spaces. One can even successfully convert a linen closet into a garden with the right hydroponic know-how and a specialty light.

### CLIMATE

In addition to saving space, hydroponics also allows gardeners to escape one of the most frequent causes of garden failure--weather. You can grow the plants of your choice indoors due to the space saving, this allows you to skirt problems like early freezes, torrential downpours and other weather-related aggravations.

### CONTROL

Hydroponics also provides a degree of control that is lacking from traditional gardening strategies.

Although soil preparation does allow one to control the nature of the garden somewhat, pinpoint control with soil is not possible. The medium is

not adequately responsive due to drainage or lack there of, and so soil adjustments are usually rather uncontrolled, to a large extent.

That is not the case with the hydroponic garden. When soil is out of the picture, one can directly and easily control the nutrient intake of plants, allowing for maximum efficiency and incredible results.

Why arduously tinker with the pH balance of soil, finally getting it just right only to throw it completely out of whack by adding a bag of fertilizer? When instead, you could make sure your growing conditions are optimal with hydroponics.

## **GROWTH**

The efficiency of the hydroponic approach is not limited to the ways it makes life easier for the grower. The plants themselves catch a break.

The roots of hydroponically grown plants do not have to engage in an endless struggle through soil in pursuit of sufficient nutrition. That saves a great deal of energy for the plant, allowing it to focus on its actual growth instead of survival.

Those pampered plants produce larger blooms and more produce than their soil-bound brethren!

## **CONSERVATION**

There's another advantage to hydroponics that does not even seem possible. You can actually conserve water by switching to a liquid garden.

How?

Most Hydroponic gardens are designed to re-circulate only the water the plant needs. The small containers usually used in these systems often hold less water than a traditional gardener may use on a single plant on a single day. In addition, when you consider the amount of water waste due to

over saturation, evaporation and other issues endemic to traditional gardening, you can begin to see why going with a hydroponic methodology defiantly encourages water conservations.

Many hydroponic systems use what is known as an “Ebb and Flow” system. This system uses the same water in a cycling manner, limiting the amount of water being used to an even greater extent.

This is not only great for gardeners, but it is also beneficial to the environment. Conserving water should be a priority of all people, and saving water while growing organic and nutritious foods is an advantage all growers should seek.

Along with water conservation, there are additional environmental benefits. Hydroponics prevents the depletion of valuable nutrients and minerals in soil. The efficiency of the hydroponic approach allows us to get more food with less expenditure of natural resources.

Many scientists consider hydroponics huge part of the potential solutions needed for meeting the growing demands for food in our hungry world. Hydroponics provides a realistic and tangible option in areas where poor soil, limited resources and climate difficulties make traditional gardening and planting difficult.

## **NUTRITION**

Oh, and the food grown hydroponically do not just come out bigger and tastier. It is more nutritious, as well. When hydroponic gardeners grow their vegetables with just the right mix of nutrients, it translates not only into bigger fruits and vegetables, but also into ones that pack more vitamins and minerals into every bite.

When one begins to consider the long list of advantages associated with hydroponic gardening, it becomes clear that thinking past soil makes perfect sense.

**A short list of Hydroponic benefits includes:**

- Gardening in any location
- Growing your own healthy fruits, vegetables and medicinal herbs
- Limiting pests and diseases from invading your plants
- Fine tune control of nutrients in your crops
- Conserving water
- Producing larger crops
- Providing food to meet community needs
- Practicing a viable solution to world hunger
  
- Growing food locally eliminating the need for transporting food long distances
- Creating Vitamin and Mineral rich foods which fortify the body against sickness and disease.
- Control or elimination of pesticides used in food for your consumption



## Chapter Three

# ESSENTIAL HYDROPONIC SYSTEM COMPONENTS

### Water Culture

#### PLANTS

Gardening is all about the plant knowledge or “green thumb-ness” and hydroponic gardening is no different. Thankfully you have many opportunities to choose, find and follow the directions of more experienced gardeners. On the web you will find a plethora of Forums and Blogs filled with the rightful bragging rights of friendly and successful hydroponic gardeners willing to share what they have learned about various ways to adapt hydroponics for a variety of specific plants.

In no time at all you will become more acclimated with the processes and embolden to strike out on your own adapting new plants to hydroponics and I hope sharing your success with the rest of the world.

### Advice and information on acquiring plants for hydroponic gardens:

#### Seeds vs. Plants

Most systems are best suited for use with small plants and not seeds. Seeds are small and often float away or clog drainages in some hydroponic systems. Although you may be able to adapt a system to successfully start from seeds, you are virtually guaranteed success if you begin with small plants. Although if you have ever started seedlings by placing seeds on a damp paper towel in baggy arguably you have already started seed hydroponically.

## **Cuttings**

Any plant that will successfully take root from a cutting can be placed in your new hydroponic garden. To work with a cutting, simply clean the leaves and apply a root hormone to the stem.

## **Transplanting**

You can transfer plants into your hydroponic garden. Transplants that come from soil should have their roots washed gently to remove the dirt.

It is best to use cold running water to free the roots of dirt. It should be noted that you might have less success transplanting vegetables than you will from hardier houseplants or herbs.

## **LIGHTING**

Plants need light for photosynthesis and the hydroponic Garden is no exception. When growing hydroponic plants, you will need to choose your lighting carefully to ensure that your plants will thrive. You should avoid the misconception that artificial light will produce the same wavelengths as the sun.

That simply isn't true. The sun constantly distributes energy that differs from artificial lights and different artificial light differs from each other. However, artificial lighting is perfect for growing your hydroponic plants both indoors and outdoors. Later in this ebook we will go over lighting in greater detail.

## **STERILE MEDIUM**

Along with lighting, you will also need to select a growing medium for your garden. Even though your garden will be without soil, you will still need something in place to support the weight of the plant.

However, keep in mind that the growing medium will not be a necessary part of the plants food source. All nutrients will come to the plant through the formulas that you provide. The growing medium may consist of a number of different materials, but a typical hydroponic growing medium may include sand, gravel, vermiculite, plastic or Styrofoam.

## **Nutrient solutions**

The solution that you feed your plants will consist of fertilizers, water, and micronutrients. Micronutrients are needed by every plant to maintain healthy growth. Plants can suffer serious sickness and disease with out these micronutrients.

Today, many crops, fields, and soil are devoid of micronutrients. This produces foods that are low or void of significant nutritional value.

By adding the right amounts of micronutrients to your hydroponic garden and by ensuring that your plant consistently receives these amounts of micronutrients, you will be rewarded with healthier crops of more delicious and nutritious herbs, fruits, and vegetables.

## **The most common micronutrients and some of their most obvious benefits to plants include:**

- Iron: Iron is vital to chlorophyll production.
- Magnesium: Magnesium is one of the components of chlorophyll. Magnesium is also involved in distributing phosphorus throughout the plant.
- Boron: Boron is needed in very small amounts. No one has yet to discover how plants use Boron.
- Calcium: Calcium encourages root growth in plants. It also helps plants absorb potassium.
- Zinc: Zinc is essential in the transference of energy in plants.
- Manganese: Manganese aids a plant in the absorption of nitrogen. It is also an important component in the energy transference process.
- Sulfur: Sulfur heightens the effectiveness of phosphorus and assists in the production of plant energy.
- Molybdenum: Molybdenum assists in the chemical reactions that take place in plants.

## **PH BALANCE**

Along with micronutrients, it is important that you test the PH balance of your growing solution. You can purchase paper test strips or liquid PH testing kits that will enable you to test the PH balance for your growing solution.

You will find that if you need to adjust the PH balance of your growing solution it is much easier to accomplish this with a Hydroponics Garden

than it would be in regular garden soil, because mixing measuring and testing can be done for the entire processes completely in one bucket.

Phosphoric Acid is recommended for lowering PH and Potassium Hydroxide is recommended for raising PH levels.

If you find that your tests reveal a need to adjust the PH balance levels, either to make them more alkaline or more acidic, you can easily purchase adjusters to complete the process from places online like <http://www.ecogrow.com>

### **Water Quality "Hardness"**

U.S. Consumers have reported that water 'hardness' or an over abundance of minerals in water is found in 85% of homes. An excessive amount of calcium and magnesium in water results from ground water flowing over rocks under the ground.

You may want to do a test to check the hardness of your water. A water hardness test will tell you the alkaline mineral ion count of your water. You can easily purchase a total alkalinity test kit online and they are pretty cheap.

Water that has a high count is called "hard water." If your water test over 150 parts per million, you have hard water. Do not be upset. You can still have a hydroponic garden; you will just have to make some adjustments.

The easiest way to work around hard water is to use a special nutrient formulated specifically for hard water. This nutrient will have been produced using the correct balance of nutrients, which will help to balance out the excessive alkaline mineral ions that are in your water.

Using a hard water nutrient benefits you because you will not have to add a great quantity of chemicals to get your hydroponic garden to have the correct pH.

## Oxygen in the mix

Oxygen in the mix for healthy roots: Oxygen is essential to root health in all hydroponic gardens as in any soil-based gardens; air or oxygen must be available for roots. In soil based gardens this is accomplished by the many spaces left between soil particles, rocks and gravels. If water floods these small spaces or "pockets" for long periods of time a gardener could expect to see root rot due to the lack of oxygen available to the roots. This premise embodies the major obstacle with suspending roots in liquid or in other words the trouble in hydroponic gardening but this problem is easily solved through systems which either adds oxygen to the liquid via pumps or by exposing roots to air occasionally via a flooding and withdraw method.



### Advanced Hydroponic tips concerning air pumps:

Care should be taken when placing the air pump so that the intake draws "normal air", advanced gardeners utilizing enriched CO<sub>2</sub> environments should note that drawing "air" from within "enriched CO<sub>2</sub> environments" would serve only to kill the roots. The idea of the pump is to dissolve oxygen into the nutrient solution, and not to dissolve CO<sub>2</sub>. Caution: CO<sub>2</sub> although great for leaves during photosynthesis, it can kill root systems and in high quantities kill humans as well. A simplified explanation would be Humans breath in oxygen and exhale CO<sub>2</sub> while plants Inhale oxygen and CO<sub>2</sub> through there leaves and give off extra oxygen through there leaves in the process of photosynthesis but, in the roots where no light is, photosynthesis does not occur, therefore roots cells require more oxygen than is present in a water solution



## Chapter Four

# 5 BASIC HYDROPONIC SYSTEMS

Now that we have discussed the importance of soil, light, micronutrients, and air let us take a look at the various hydroponic systems that are available. There are six basic systems to choose from: Water Culture System, Ebb and Flow System, The Nutrient Film Technique, The Drip System, The Wick System and The Aeroponic System.

### **WATER CULTURE**

With the Water Culture system, the plants are sustained on a Styrofoam base that literally floats over the micronutrient liquid solution. An air pump is included that provides oxygen and helps circulate air.

The Water Culture system is praised for its ability to grow lettuce in a fast environment. For this reason, it is the system of choice for many teachers who are instructing a class on the basics of hydroponics.

The Water Culture system offers advantages, due to the fact that it is a fast growing system for plants. However, it is important to prevent light from reaching the nutrient solution to prevent the growth of algae.

## **EBB AND FLOW**

The next system is the Ebb and Flow system. Sometimes, this system is also referred to as the Flood and Drain system.

This system works on the premise of periodically flooding the roots and some sort of medium to support roots such as rock wool in a tray with a nutrient liquid solution, allowing the liquid to flow out after flooding into a reservoir chamber to store for the next cycle. The system works with the assistance of a pump that repeats each cycle.

One of the major advantages with the Ebb and Flow system is that it requires a minimal amount of water. However, it is dependent upon electricity to keep the cycle functioning.

Therefore, it can be a difficult system to maintain in the event of power shortages or outages.

## **NFT**

NFT System, or Nutrient Film Technique, is the standard or most typical hydroponic system. In these systems roots of plants are suspended in channels while small amounts of an aerated nutrient rich solution flow continually over parts of the roots keeping them moist but not water logged. This system can be tricky to set up due to over or under flooding, but once set precisely can prove to be very cost effective because if you are planning to grow many different plants over a period of time unlike other forms of hydroponics which involve roots entangled in rock wool or gravel for support this form usually involves a simple plastic basket or colander to support plants letting the plants roots dangle in the running solution over a smooth surface. This means that when you are done growing a specific plant you can easily clean out your system and prepare it for another entirely new plant.

Like the Ebb and Flow systems, the NF T. systems rely heavily upon the flow of the liquid nutrient solution through the use of an electric pump. If there are any power outages or shortages, the result upon the plant is devastating.

## **DRIP SYSTEM**

Another common type of hydroponic system is known as the Drip System. This system may be either Recovery or Non-Recovery. As the name implies, the Recovery system uses the excess liquid nutrient solution in a recycling method.

The overflow nutrient solution that runs off the grow tray is collected in the reservoir chamber, where it is circulated and brought back to the grow tray. This is both economical and highly effective.

The Drip system works with a timer and a pump that is submersed into the solution.

One of the major advantages for using the Recovery Drip method is that the liquid solution is used repetitively. This proves to be cost effective. However, it does require a certain degree of diligence on your part, to ensure that the plant is receiving the liquid solution and that the PH balance is maintained.

With the Non Recovery Drip system, you will not need to maintain the PH balance of the nutrient solution because you will continually add new formula.

However, since you will not be using the runoff so you will need to regularly manually add more solution as needed. Or make new formula to add.

## **WICK SYSTEM**

The Wick System is the simplest of all the hydroponic systems. A wick is placed in the growing tray and extends below into the reservoir chamber.

As the plant needs the nutrients from the liquid solution, it draws from the wick.

This system is also beneficial for growing a wide variety of plants and is a great system to choose when introducing children to Hydroponics.

Large plants may tend to drink more of the solution than smaller plants. Unfortunately, that can make it a task for the wick to keep up with the plants needs.

## **AEROPONICS**

The most advanced of all the systems is the Aeroponic System. The Aeroponic System uses a high-powered pump that mixes Oxygen with the liquid nutrient solution.

A feature that stands out with the Aeroponic system is that the roots of the plant are exposed and are sprayed with the liquid nutrient solution in a mist form.

It is important that the Aeroponic system utilizes a timer to ensure that the roots receive adequate amounts of the nutrient solution. The continual misting allows the plant to grow at rapid speeds.

Because the plant can suffer serious damage if the roots are allowed to become dry, it is important to check the misting nozzle heads regularly to make sure that they are not blocked.

## Considering the options

Along with the various systems, growing mediums, nutrient solutions, adequate lighting, and proper PH balance for your solution, it is important to realize that every Hydroponics System needs air.

Pumps are critical to ensuring that your system will have the proper circulation and aeration needed to sustain maximum growth and a healthy plant.

Oxygen is vital to the success of your Hydroponics system. Air that circulates will prevent mold and algae from growing on your plant. Some systems may even include a small fan to ensure that proper circulation is being maintained around the plant.

Now that we have discussed the various systems, your first step in beginning your own hydroponic garden is to choose the system that works best for your needs, as well as for the plant type that you would like to grow.

Your system can be as small or as large as you need it. There are many plans available that will allow you to build your own hydroponic systems, or you can purchase a system that is assembled and contains all of the basic tools that you will need, or choose to build one of the examples we supply later on in this ebook.



## Chapter Five

# MORE ON NUTRIENTS SOLUTIONS

### BASICS

Your liquid nutrient solution will play a vital role in the overall success of your hydroponic system. Because your system will need to supply all of the essential nutrients, it is recommended that you do not purchase standard commercially prepared garden fertilizers for your system.

The solution that you use should be designated as a hydroponic fertilizer or hydroponic plant food. It is also important to note again that you will need to regularly test the PH balance of your nutrient solution to make sure that it is within the recommended levels.

The solutions PH levels should remain between 5 and 6. Keeping these levels in check and providing the most nutritious liquid nutrient solution will ensure that your plant will be healthy and thrive.

If you want to make your own "special" growth solution you can try this home brew recipe.

This recipe has been tested numerous times by organic gardeners  
But you may want to try your own optional ingredients (you will see what I mean once you read this recipe)

These are base recipes and you can experiment to get the best growth from your plants by adding or subtracting the elements.

**HYDROPONIC VEGGIE BREW SOLUTION, per gallon:**

Miracle Grow Patio (contains trace elements) 1 teaspoon

Epsom salts 1/2 teaspoon

Urine (OPTIONAL - may create odors indoors.) 1/4 cup

Oxygen Plus Plant Food (OPTIONAL) 1 teaspoon

This mixture will insure your many kinds of plants are getting all major and minor nutrients in solution, and will also be treating your plants with oxygen for good root growth, and potassium nitrate. Another good growing phase mix is 1/4 tsp a brand of 20/20/20 fertilizer per gallon of water, with trace elements and oxygen added, or fish emulsion. Fish emulsion is great in the greenhouse or outdoors, where smells are not an issue, but is not recommended for indoor, due to its strong odor.

Trace elements are necessary too; try to find foods that include these, so you don't have to use a separate trace element food too. Home improvement centers sell trace element solutions rich in iron for lawn deficiencies, and these can be adapted for use in hydroponically growing plants. Prices for these mass-produced fertilizers are significantly cheaper than the specialized hydroponic fertilizers sold in indoor gardening shops, and seem to work just fine.

**HYDROPONIC HOME BREW FOR FLOWERING PLANTS,  
Per gallon:**

1-teaspoon high P plant food, such as 15-30-15, or 5-50-17, etc.

1/2-teaspoon Epsom salts

1 -teaspoon Oxygen Plus Plant Food (Optional)

1 -teaspoon Trace Element food (like standard houseplant food)



## **DIAGNOSING PROBLEMS WITH SOLUTIONS**

Since you are in full control of the nutrients that your plant receives, it is very easy to diagnose and treat any problems due to lack of nutrients in your plants.

Here are some common symptoms of nutrient deficiencies and the associated nutrient that will help restore your plant to optimum health.

- If you notice a decrease in the growth of your plant, yellow leaves, or that the plant appears light green in color instead of a vivid lush green, then you will need to increase Nitrogen.
- If plant growth appears to be stunted, and you notice that the plant has a blue/green color or a reddish tone then you will need to increase Phosphorous.
- A Potassium deficiency can cause the leaves of your plant to have a thin papery look. The growth will be stunted and the leaves will have dead and decaying spots.
- A lack of Magnesium will result in the lower leaves yellowing and wilting.
- If your solution is lacking the correct amount of Calcium, you will notice that new leaves will die and decay, as well as newly sprouted stems.
- Zinc is important to maintain the proper color of your plant. If you notice that the area between the veins on leaves is light, thin and papery, or yellowing then you will need to adjust the amount of Zinc in your solution.
- An Iron deficiency will cause the opposite effect as a Zinc deficiency. If your solution is lacking the appropriate amount of Iron, you will notice that the veins of the leaf will remain a vivid green, while the remaining leaf area will be yellow.
- If the leaf edges are curled, have turned blue or dark green, and you discover that all new leaves are wilted then you will need to adjust the amount of Copper in your liquid nutrient solution.

- A stunted plant with new leaves turning light green, while the older leaves remain a vivid green is lacking Sulfur.
- A Manganese deficiency will result in a checkered pattern on lower leaves, consisting of both yellow and green. The overall growth of the plant will also be affected.
- If there is a deficiency of the mineral Boron, you will see a scorched appearance at the edges of newly sprouted leaves.

#### OTHER CONSIDERATIONS WHEN ADDING MICRONUTRIANTS:

Some hydroponic systems may deliver the liquid solution to the plant in a manner too fast for the plants to thoroughly absorb. If this is the case, you may discover that there is a nutrient deficiency in the plant despite proper levels of nutrients in your solution.

One way to battle this problem is to apply solution more often.

This brings us to our next chapter and another important element to making certain that Hydroponics systems are working in perfect order-- lighting.



## Chapter Six

# LIGHT OVERVIEW

Your Hydroponics system has basic needs to ensure the longevity, success, and quality of your plants. We have discussed the importance of proper circulation, oxygen, nutrients, and choosing the proper system and recommended growing medium for your plants.

Let's address the importance of choosing the best light source.

When gardening outside in soil, the sun provides the lighting required for ultimate growth. However, even outside there are certain plants that favor direct and bright sunlight, while others tend to thrive better in the shade.

Since your Hydroponics System may be established either indoors or outdoors, you will need to address the question of lighting and make sure that you provide the proper lighting needed for your plant to ensure its health and vitality.

The best place to begin choosing the type of lighting that you will need for your Hydroponics system is by determining what type of light the plant you are growing requires in its natural environment.

If a plant requires full sun in a soil garden then you will need to recreate the same type of environment with your hydroponic system. It is also important to understand that all plants require periods where they are subjected to darkness.

In fact, recent studies have shown that the amount of darkness a plant receives is just as important as the amount of sunlight it requires.

## TYPES OF LIGHTS

Lights used in hydroponic systems are known as grow lights. There are three types of grow lights, these are:

### Incandescent

Incandescent lights are the least expensive, yet many feel that they are inadequate in meeting the needs of most plants. However, they are readily available at any home and garden store and cost roughly \$5.00 and provide about 150 watts.

### Fluorescent

Fluorescent lighting is also relatively inexpensive and has been used by gardeners with success for many years. This type of lighting is recommended for starting seedlings. Fluorescent lighting emits less heat than High Intensity Discharge lights and is a great way to grow and clone plants. One of the main disadvantages seen with fluorescent lighting is in the fact that fluorescent lighting is only targeted towards one area. Manual rotation of the lamp will be required to ensure that all areas of the garden will receive adequate lighting. However, when growing seedlings, rotating the light source isn't necessary. This makes fluorescent lighting the perfect choice for sprouting seeds. It is also recommended to purchase the "cool white" fluorescent lighting. You can find fluorescent lights at home and garden supply stores for roughly ten dollars.

### High Intensity Discharge

High Intensity Discharge lamps are often marketed for outdoor use. However, these lamps are perfect for the indoor gardener and can enhance your Hydroponics system. When selecting High Intensity Discharge lamps, you have two choices. The first is called Metal Halides and the other is known as High Pressure Sodium lamps. Metal Halides (MH) lamps create a natural looking light and the rays have a bluish tint. These lamps frequent convention centers, stadiums, and gymnasiums. Many gardeners believe that Metal Halide lights promote vegetative growth - such as leafy

vegetables. High Pressure Sodium lamps emit a yellow/orange ray and are known for promoting flower growth.

Depending upon the needs of your plant, you may even choose to use both Metal Halide and High Pressure Sodium lamps (or interchange the bulbs), to promote both vegetation and flowering. Many people will try a number of different lights until they find one that best meets their plant's needs, as well as fits in their budget.

### **Understanding how different lights are rated:**

**Color Temperature.** The next important aspect of lighting is Color Temperature. The first point to understand when discussing Color Temperature is that the measurement pertains to the color of the light and not the temperature that the light emits. Color Temperature is measured in degrees Kelvin or (K), and can be identified by the color of the light. Natural light from the sun contains a spectrum of colors. These colors are evident by putting a beam of light through a prism. When it comes to measuring Color Temperature, light that is blue/white or very bright are said to have a high Color Temperature and are "cool". Cool light measures at roughly 3600K and higher. Natural sunlight is measured at 5500 K. Warm light measures at about 3400 K and lower. These lights are yellow/white or reddish white. As a general rule, light that has a high color temperature is typically more expensive than other lights.

**Color Rendering Index.** Color Rendering Index is a scale that measures the quality of light. The scale consists of measurements between 0-100 with sunlight and incandescent light both measuring 100. Plants show the most growth with a Color Rendering Index of 100 however; it has been shown that lamps with a high CRI often have low efficiency.

**Lumens:** Lumens are the measurement used to describe the intensity of the light. All lamps diminish in brightness over a period of time and it is important to replace them to ensure the health and vitality of your plants. A garden requires between 1000-3000 lumens per square foot for optimum

growth. Choosing a grow lamp should be based upon the amount of lumens the light provides and how much square footage you will need to cover.

When choosing grow lights, be sure to replace the bulb when it becomes dim. Never wait for the bulb to completely burn out. As soon as the bulb dims, your plant is not receiving adequate lighting and is in jeopardy.

## **ELEMENTS OF EFFECTIVE LIGHTING**

Be sure to purchase bulbs that work with the lighting system that you have purchased.

Many companies also provide replacement bulbs and you may find it in your best interest to purchase some replacement bulbs when you make your initial lamp purchase.

Choosing your lamp is a vital part of maintaining and sustaining your hydroponic system. Many gardeners find the most success by changing their light sources during the vegetation and flowering periods.

Manipulating the light source, ensuring that the correct amount of lumens are present for the area you are covering, and maintaining strong and visible bulbs that aren't dim will ensure that your plant will grow, thrive, and produce the bountiful crop that you hoped for and are expecting.



## Chapter Seven

# BUILDING YOUR OWN HYDROPONIC GARDEN

This is a guide to building a relatively simple hydroponic garden. Although this is not a complicated garden, it is well designed. The basic foundations you can learn by implementing this system will leave you well prepared to produce bigger and more complicated rigs.

This system can be used for indoors gardening with the addition of appropriate lighting.

It is best not to start with seeds for either system we show here. Purchasing small plants at your local nursery is a better option.

**If you want to start your own seeds try using this method:**

Germinate seeds in a medium of rock wool or vermiculite.

Fill a pan with vermiculite or rock wool; fill the pan area with 1/2 strength hydroponic nutrient fluid mixer.

5-55-17 mixture of store bought plant food should stimulate root growth of the germinating seeds and the new seedlings. Use a much diluted solution, in distilled water, about one-third normal strength, and keep temperatures between 72-80 degrees for most seed type (check seed package or nursery directions). Warm temperatures are very important. Many growers experience low germination rate if the temperatures are out of the correct range for the seed type you are germinating. A heating pad set to low or medium may be necessary. No light is necessary and may slow germination this is why a heating pad would be a better choice over using a lamp for warmth. Cover germinating seeds with black paper to keep out light. Place seedlings in the light only once they have sprouted.

## Water Culture Directions

These are directions for making a simple yet beautiful *water culture* style hydroponic garden, cheaply and quickly so you can get to garden hydroponically right away!

Please read *all* of the directions through once and make sure you understand them before beginning and then refer back to them often while you are building your own hydroponic garden, for best results.

### Parts list:

1. One rectangular fish tank
2. Enough cardboard to cover the out side surface of the fish tank (perhaps the box it came in)
3. Contact Paper enough to cover fish tank sides twice.
4. One inch thick Styrofoam sheet ( The kind used in construction of houses works great)
5. Two or three plastic pots or colander type baskets, which if placed upside down, inside the fish tank would not cover over half of the fish tank bottom. Three inch plastic pots should work.
6. Gravel sized to large so as not to fall through holes in pots - - enough to fill the pot 3/4<sup>th</sup> the way full.
7. Fish tank air pump and hose with rock air bubbler attached.
8. Clear Silicone caulk
9. Hydroponic plant food
10. Water
11. Small plants -- like Greek Oregano plants.
12. Bag of sea shells

**Tools list:**

1. Duct Tape
2. Saws and Hole saws
3. Scissors
4. Magic marker
5. Yard stick
6. Spray bottle of glass cleaner
7. Gorilla ® glue or any other glue that glues Styrofoam and seashells together

**Instructions:**

1. Measure the fish tank glass side dimensions from plastic lip at top to plastic lip at the bottom. This is the area we will be filling in with cardboard to block out light.
2. Carefully cut out cardboard panels to fit the outside of fish tank and tape in place getting a good fit to block out light.
3. Take down cardboard and cover one side with contact paper this will be the side facing the glass later and will be seen when looking thru the glass from the inside of the fish tank.
4. Replace cardboard panels tape in place admire the view of a decorated fish tank from the inside. If you are not pleased this is the time to redo it.
5. Time to cover outside of fish tank and cardboard panels with contact paper on all four sides the goal here is to completely seal out light. Hold cardboard panels in place and decorate sides to meet room décor. (Note bottom of tank need not be covered unless you have plans to set garden on glass tables where light could get in)
6. Chose a side that you are the least satisfied with esthetically and designate that as the back of your garden we will use that side to hide air pump.
7. Set air stone in bottom of tank then run hose across bottom of tank to one of the back corners tape hose down in place; then up the corner

and out of the fish tank. Tack hose at top of tank with bits of tape. (The goal is to have air hose of the pump fit snugly into corner.)

8. Silicone hose in place.

**Tips for great silicone:**

**(Silicone forms a skin quickly and become hard to work with. The more you mess with it the worse it gets. So have all of your tools ready and then do it quickly, once the best you can and the leave it completely alone until it is dry)**

- i. Place tape along the sides of hose about a quarter of an inch away from original caulk line in fish tank.
- ii. Cut a piece of cardboard in a 3inch square and then lop off one corner of the cardboard so that when placed in corner of the fish tank you can run it up the sides of tape with out hitting the hose. This cardboard trowel you made you will use later to strike off extra caulk.
- iii. Apply silicone generously over hose in essence gluing and encasing the hose in Silicone.
- iv. Use more silicone than is needed excess can easily be removed. When caulking it is best not to lift applicator away from the bead of caulk you are applying to avoid air bubbles in caulk.
- v. When you are sure that you have enough caulk in the corner quickly mist caulk and surrounding area with glass cleaner and immediately start from bottom of tank with your cardboard trowel and move up to the top in one motion. Striking off excess caulk leaving hose encapsulated in a triangular shaped caulk prism running inside the fish tanks corner.
- vi. Pull tape off along sides when silicone is dry.

9. Making the floating platform which the pots will sit in, out of the 1 inch Styrofoam sheet. For this you will need to cut the Styrofoam sheet in a rectangle just slightly smaller than the inside dimensions of

the fish tank and also with the clearance allotted for the caulked corner which is holding your air hose.

**Tips for cutting Styrofoam:**

1. Cutting straight lines with a table saw works really well.
2. Cutting holes for pots: Using a hole saws from the back side and cutting repeatedly at angles make nice conical holes to snugly hold pots.

10. Arrange flowerpots on fitted foam rectangle, evenly no closer than two inches from edges.
11. Trace bottoms of flower pots to use as lines for cutting there placement holes
12. Cut out holes so pots fit snugly in up to there lip.
13. Decorate top with light seashells glued down with Gorilla ® glue and let dry.
14. Fill tank half full with clear room temperature water and nutrient solution.
15. Place Floating Styrofoam pot platform in tank ensure tight fit but with the ability to float up and down with water levels.
16. Gently wash away soil from Plants in bowl of cool water swishing gently.
17. Gently transplant plants into new pots carefully arranging gravel around bare roots without damaging them.
18. Place pots in holes of Styrofoam Platform.

19. Gently pour room temperature water thru gravel around plants until platform is floating near the top.
20. Turn on bubbler and enjoy watching your plants Grow.
21. Add water or nutrients as necessary.

Note:

From time to time you may want to check the condition of water you can do this easily by removing one of the pots or occasionally you may need to remove entire platform to address problems with algae.

A fun thing to do is to buy extra plants and grow them traditionally in pots next to your hydroponic garden for a bit of friendly competition.



This is what it will look like when you are done.

## **Building a NFT System**

This is a basic beginner's set-up. Although if you master the smaller hydroponic garden you will easily be able to modify these plans to be used for a much larger system, by just using larger pieces of PVC, or more than one pair of arms, and a larger bucket to hold the nutrients. This system can be used to grow plants indoors with appropriate lighting.

Purchase plants or grows your own from seeds and when your plants are about 4-6 inches tall or long, they are ready to be moved to this system. Remove them gently from the vermiculite, using clean water to get every last chunk off of the roots. Then wrap the stems in polyester fluff and garden hose (see instructions for this below)

### Building instructions and materials list:

In order to build this basic hydroponic garden, you will need:

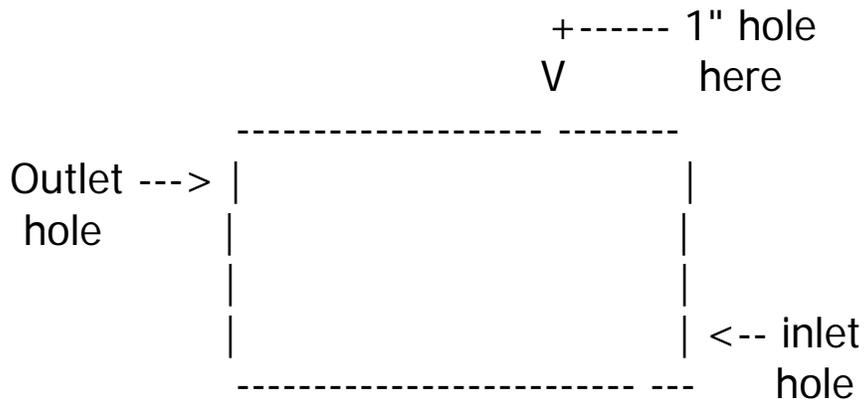
- 1 5-10 gallon bucket
- 2 Pieces of PVC or ABS pipe, 8-10" long, 5" or greater diameter. 4 Caps for PVC/APS pipe ends.
- 1 water pump capable of about 50 Gallons per Hour (you will need
- A bigger pump if you choose to make this a larger system) 4' of hose that will fit the water pump (often 3/8").
- 1 TEE joint (or Y-splitter) that fits the water hose.
- 4 clamps for the water hose (one for pump to hose, and 3 for hoses to TEE fitting.)
- 1 Air pump, air stone, and some airline from a fish tank.
- 1 Can White epoxy based spray paint
- 1 Can Black Epoxy based spray paint

### INSTRUCTIONS

1. Everything must be made "light tight." Paint all hoses, the bucket, the PVC/ABS (which will be called PVC from now on) and the lid of the bucket with a layer of black paint. Let it dry overnight, and then cover it with a layer of white paint (to make it reflective, and reduce the temperature of the nutrient solution).

2. Take each of PVC pieces and drill a 1" hole in the side, about one inch from the end. Then epoxy the caps onto the ends of the PVC.

3. Drill the inlet/outlet holes (these should be located on the caps of the PVC), See diagram



The inlet hole should be as low as possible (as close to the wall of the PVC), and the outlet hole should be as high as possible)

4. Now cut two 5" holes in the sides of the bucket (close to the top), and epoxy the PVC in place, so about 2" of pipe (and the outlet hole) are inside the bucket, and the 1" hole is facing straight up.

5. Place the air stone in the bottom of the bucket, and find a place for the air pump.

6. Place the water pump in the bottom of the bucket (assuming it is a submersible one) and attach a hose to it, long enough to reach the top of the bucket. Cut a hole in the lid of the bucket for this hose to go through.

Then attach the TEE fitting to the hose. Now attach hoses to the free ends of the TEE, and run them to the inlet holes on the end of the PVC pipes.

Use clamps on the TEE fitting and on the pump itself, but use epoxy to attach the hoses to the PVC. This seal must be completely watertight. Let them dry for 24 hours.

7. Put some water in the bucket and turn on the pump. What should happen is the PVC pieces will fill with water, and then when they are full, they should begin to continuously drain out the outlet holes, and back into the bucket.

If you are getting leaks anywhere, fix them immediately. If water is coming out of the 1" hole on the top of the pipe, then either your pump is too strong, or your outlet hole is too small. Fix one or the other.

8. Empty the system (hint, remove the hose from the pump to drain the arms), and replace the water with some form of hydroponic nutrient solution (look in a hydroponics book for details on what exactly to use, or visit a gardening store, and ask).

9. Place your plants into the system. The best way I have found to do this is to take a 1 1/8" garden hose and cut a 1" tube off one end. Then slit the tube down one side. Wrap the stem of your plant (just above the roots) with polyester fluff (available at aquarium stores, for stuffing into external water filters) and then wrap the garden hose around the fluff.

Then force the hose into the hole at the top of the PVC arm. People also have used rubber stoppers.

10. Turn on the air/water pumps, and let your garden grow.



## Chapter Eight

# TROUBLESHOOTING YOUR GARDEN

It is sometimes difficult to give specific growing tips and instructions for hydroponics. It depends greatly upon your water quality, type of system you are using, nutrient ingredients and the environmental factors that surround your hydroponics garden.

We have compiled a list of troubleshooting tips, which we hope will guide you to deal with some of the common problems, which you may encounter. Keep in mind that these are just tips. They may or not work for you. Since there are many variable factors to keep in mind with hydroponics, many times a grower will have to experiment until he or she finds a solution that works for their garden.

### **Blossom Drop**

Sometimes a plant will drop blossom simply because it does not have an adequate supply of energy going to all of its areas. If your plant is going to have a problem with blossom drop, it will usually arise with its third set of blossoms. However, in extreme conditions it can occur with its first set of blossoms. Sometimes blossom drop can be corrected by adding phosphorus. You should also monitor the temperature levels between day and night conditions. If these temperatures are not satisfactory, your plant may suffer from blossom drop.

## Blossom Set

Indoor growing can sometimes create problems with vegetable blossoms. Temperature, light, humidity and nutrients all play a major part in vegetable blossoms. In regards to temperature, keep in mind that most vegetables like it cooler rather than warmer. Make sure your vegetables have the proper light. You should also take advantage of any natural light sources, such as windows. Humidity should also be monitored. Plants that dry out prior to pollination will have problems.

## Blossom End Rot on Tomatoes

Blossom end rot or black spots on tomatoes is a very lengthy topic. The basic reason that your tomatoes may suffer from spots on the blossom side is usually due to transpiration stress on the vines or a calcium deficiency. Sometimes these two problems arise at the same time. One way you can identify which problem your tomato plants are suffering from is to know whether these black spots are forming in the small tomatoes. If your small fruit is affected, it is usually a calcium deficiency. If the black spots are only showing up on your large fruit, it is probably due to a lack of moisture.

Keep in mind that hydroponic plants will grow more quickly than plants that are in soil. This means their root systems are smaller. As plants grow they use a substance called calcium pectate. Calcium pectate acts like cement in the plant's cells. If the plant is not receiving enough calcium, your tomatoes will start to produce black spots because the cells are dry. The shortage of calcium and/or water stresses a plant with a small root system. It tries to take in more water but is unable to do so.

Adding more calcium will probably not help a tomato plant at this stage. The damage will already have been done. You might want to try adding a small amount of dolomitic lime. However, you must know that there is no cure for blossom end rot. The key is in trying to prevent it from ever occurring.

If you are experiencing hot weather, pour fresh water over your growing medium to ensure that the plant's roots are saturated. You should also increase air circulation around your plants. If you do suspect that your tomato plants may have a calcium deficiency, use a foliar spray.

### **Bolting of Lettuce**

To put it simply, lettuce is a cool weather plant. Lettuce that gets too warm will bolt. You should give your lettuce all the light you can in its early growing stages. And keep it cool until it is time.

### **Bolting of Radishes**

Like lettuce, your radishes will need a lot of light in their early growing stage. When growing radishes indoors, you should plant them in their own growing planter. You should use only water during the first three weeks. Once the seedlings have developed, you can use vermiculite. Add a one half-inch layer of aggregate on the top of the vermiculite to cut down on algae building up inside the growing planter.

### **Damping Off**

Damping off is actually called root rot. Root rot is a fungus disease. It attacks seeds and causes them to mildew and fail to grow. In hydroponic gardening, dampening off is usually the result of using your hydroponic watering system too much for a particular type of seed. If you feel this is not the case, you may want to make sure that your planter is not located in an area where it is too dark, cool and damp. To fight off this condition you can apply an all purpose fungicide.

### **Droopy Leaves**

If the leaves on your plants are droopy, make sure they are getting enough water. If you are using an automatic system, make sure it is working

properly. If you are certain your plants are getting enough water, your nutrient concentration may be too high for your plants. To correct this problem, flush the plants and only use plain water for seven days. Then, start your nutrients again.

## **Misshapen/Deformed Tomatoes**

If you have tomatoes that have rough skin or are misshapen, it is usually a result of temperature factors. Unsatisfactory day-night temperature variance can make your tomatoes tough and appear like peeled oranges. Having temperatures too low during both the day and night can also cause this condition.

## **Insects**

You will probably have to deal with aphids, white fly or red spider at some point during your gardening experience. To prevent these insects from taking up residence on your plants, always remove dead leaves and do not let them simply remain in the planting container. Keep your containers clean.

You can use insecticides on your plants. They are safe to use and will usually break down into harmless components within a few days, although you should always try to avoid spraying insecticide on the edible parts of your plants.

Always check the insecticides label first but a general rule is to never harvest fruit and vegetables earlier than a week after your plant has been treated with an insecticide, and to always wash your crops well before eating.

If you are concerned about using chemicals, there are many organic insecticides that you can use. These are usually in powder form and are easy to apply.

When using insecticides, you may want to alternate them with each use. This is to prevent insects from building immunities against the insecticide. Also, try to keep your houseplants away from your crop plants.

Separating plants is a great way to keep insects from spreading

### **Patchy Growth**

If your plants have better growth in one area of the container than another, it is a sign that the nutrient solution you are using is not being evenly distributed.

### **Salt and Mineral Buildup**

If you see white crystals forming on your growing medium, thoroughly flush the plants and the medium.

### **Spindly Growth**

If your plants seem to be growing spindly, this is a sign that they are not receiving sufficient light.

### **Tip Burn**

If the tips of your plants are starting to turn brown, this is a sign that your plants are probably being overfed. Flush the medium and begin again.



## Conclusion

By now, you know that hydroponics is a system of using mineral nutrient solutions instead of dirt or soil.

Almost any plant that grows on land will grow with hydroponics; some may do better than others. Now that you are armed with the “what it is” and the “why” and some very basic instructions on how to start out at home, we hope you will put this newfound knowledge into action.

We hope you find this is very easy to do. You may want to take on this activity with kids as a learning activity with a few plants such as watercress or beans. Or, you can take on the world and produce extra crops to help out your local food pantry.

However you use it, we wish you success! Thank you for reading and enjoy!



## Going a step farther...



If you are now ready to use hydroponics at home and are thinking about even starting your own small business you will need to do some more investigating on your own.

Here are some resources to guide you on your way:

*The following is meant solely to help the reader understand the main features of primary regulations governing this activity, and not meant in any way to provide a legal interpretation.*

Natural Products Marketing (BC) Act:

This Act provides for a system of programs for individual commodities to promote, control and regulate production, transportation, packing, storage and marketing of natural products in the province, including prohibition of that production, transportation, packing, storage, and marketing in whole or in part.

The Vegetable Marketing Commission, established under this Act, requires producers to obtain a producer's license. As well, the commission designates the agencies through which the produce may be marketed and restricts the amount of vegetables that a farmer may send to market when supply exceeds demand.

Primary Contact (for obtaining a Producer's License):

Vegetable Marketing Commission

201 - 7560 Vantage Way

Delta, BC V4G 1H1

Tel: (604) 940-0188 Toll-Free 1-800-663-1461

Fax: (604) 940-0661

<http://www.agf.gov.bc.ca/ministry/bcmb.htm>

## Agricultural Produce Grading Act

This Act provides the legislative framework for quality control standards for specific agricultural products through the establishment of grading systems. The grading systems are established for each product by regulation under the Act. The Act may be applied to produce grown, slaughtered, produced, kept, sold or offered for sale or consumption in the province. This Act also outlines a licensing system, and the powers and duties of inspectors responsible for enforcing the legislation.

This Act may also set grade and package standards.

### Primary Contact

Ministry of Agriculture, Food and Fisheries

BC Farm Industry Review Board

PO Box 9129, Stn Prov Govt

Victoria, BC V8W 9B5

Tel: (250) 356-8945

Fax: (250) 386-513

Email: [firb@gems9.gov.bc.ca](mailto:firb@gems9.gov.bc.ca)

Website: <http://www.firb.gov.bc.ca/>



## **APPENDIX: THE BIGGER PICTURE**

Hydroponics is a great way to put a tasty and nutritious salad on your plate, but if you are engaging in soil-less gardening, you might be part of something even more consequential.

Many leading scholars argue that hydroponics has tremendous future value to the world. That's not just because apartment dwellers will have cucumbers within their reach, either! Let's take a look at the bigger picture by examining a few recent pronouncements.

### **HYDROPONICS COULD INCREASE THE WORLD'S FRESH WATER SUPPLY**

The U.S. State Department offers the following:

#### **Greenhouse Hydroponics Could Boost World's Fresh Water**

Method could reduce water needed for agriculture, prevent future water wars

A method that uses about one-hundredth of the fresh water usually needed to grow forage for livestock might leave more water available for human, residential and industrial uses, according to a September 8 press release from the Department of Energy (DOE) Sandia National Laboratories in New Mexico.

The potential savings in water is particularly important in New Mexico, a state in the water-parched American Southwest, which shares the same resource shortage problems with other dry regions of Mexico, the Middle East, India, Pakistan and even northern China, where underground water supplies used intensively for agriculture are dipping lower, says lab researcher Ron Pate. "In all these places, the majority of water use is for

irrigated agriculture rather than direct human consumption and other productive uses."

The method is being tested by 42 wireless sensors being installed in a forage-growing hydroponic greenhouse built near the U.S.-Mexico border under the supervision of Sandia, a U.S. national security lab. Sandia is interested because, says Pate, "Disputes over water are possible, if not likely, causes for war in the 21st century."

The difference between traditional agriculture and hydroponics is that the greenhouse plants do not draw nourishment from the earth. This experiment relies on the nutrition present in seed that is germinated, precisely watered, and harvested after about 10 days of growth. More seed is required to produce an equivalent amount of forage (compared to that traditionally grown in open fields) but with far less water use.

Preliminary indications are that hydroponic greenhouses in New Mexico, for example, could reduce the current 987,000 cubic meters of water used in agriculture to 13,500 cubic meters to produce an equivalent amount (dry weight) of livestock forage. This equivalent yield could be produced on less than 404 hectares instead of more than 105,000 hectares -- the current amount used for New Mexico production of alfalfa. Eighty percent of New Mexico's water use is agricultural. More than half goes to grow forage, mostly alfalfa. Similar water-use conditions exist in many countries.

Conventional farming methods in arid regions lose huge amounts of water through evaporation and over-absorption by soil. Over time, this can also cause soil salination and loss of agricultural productivity. Neither occurs in hydroponic greenhouses, which do not require high-quality arable land to function.

The hydroponic greenhouse, also known as "protected agriculture" or "controlled-environment agriculture," also controls and modifies light reaching the plants. These experiments will reduce light intensity and restrict certain frequencies, using a variety of shading mechanisms to avoid overheating and improve plant growth.

Sensors in the 8-meter by 18-meter greenhouse will monitor light, temperature, relative humidity and air pressure. The data, collected every few minutes, will be sent by phone line to a remote computer for analysis. The sensors and computer simulations will tell researchers how to grow crops more efficiently.

The project also serves as a model for a joint laboratory with Mexico to work on border-related scientific problems, says Gerry Yonas, Sandia principal scientist and director of the Labs' Advanced Concept Group (ACG). "Because the ACG looks to future global security issues, we advanced the idea of a binational lab between Mexico and the U.S. to deal with border issues that have a potential for conflict. This [greenhouse] project is the first fruit of that idea."

Information about Sandia National Laboratories is available at <http://www.sandia.gov>

## **HYDROPONICS COULD LESSEN PESTICIDE USE**

Many advocates of hydroponic cultivation argue that its use will decrease reliance on potentially dangerous and destructive pesticides. Although, as noted, hydroponics may not eliminate the use of pesticides altogether, it can be an effective way to minimize the problem.

This is especially true with respect to plants like strawberries. Studies in the Netherlands demonstrate that one can avoid a reliance on fumigants used in the growth of the popular fruit if hydroponic methods utilized.

The United States Department of Agriculture reports that hydroponic strawberry production is going very well--without the use of those dangerous pesticides:

### Hydroponic Strawberries Avoid Soil Pests

The first recorded use of hydroponics is in one of the seven wonders of the ancient world: the Hanging Gardens of Babylon where, historians say, plants were grown in a steady stream of water. Centuries later, U.S. troops

stationed on infertile Pacific Islands during World War II ate fresh fruits and vegetables produced by hydroponics.

Hydroponics from the Greek words hydro (water) and ponos (labor) is the science of growing plants without soil. Nutrients that plants usually get from soil are added to water.

Scientists with USDA's Agricultural Research Service successfully using this time-honored way of producing crops at the Appalachian Fruit Research Station in Kearneysville, West Virginia.

There, they are using hydroponics to grow strawberries without soil and even more, without pesticides.

But why hydroponics?

"Strawberry growers worldwide fumigate the soil with methyl bromide before planting to control soilborne insect pests, diseases, and weeds," says Fumiomi Takeda, an ARS horticulturist at Kearneysville. "This fumigation is essential to get high yields and high-quality fruit.

"But with the fast-approaching ban on use of these chemical, growers are anxiously looking for alternatives. It is estimated that banning methyl bromide will cut in half the annual production of field-grown strawberries in California and Florida, our major producing states."

But growing strawberries hydroponically eliminates the need for methyl bromide on this crop.

As for foliage pests, Takeda says, "Two-spotted spider mites, thrips, and powdery mildew were the major problems we encountered in our greenhouse production of strawberries. We used beneficial predatory mites to control the thrips and two-spotted mites. The mildew problem can be resolved by moderating the humidity level in the greenhouse and by growing varieties that resist mildew infection," he says.

In the Kearneysville greenhouse, Takeda grew strawberries in round pots, vertically stacked square pots, and horizontal troughs similar to rain

gutters. [See "Trading Wastewater for Crops," Agricultural Research, February 1995, pp. 10-11.]

He used both established plants and runner tips from greenhouse-grown Chandler and Camarosa, strawberry varieties developed in California; Sweet Charlie, developed in Florida; and Tribute and Primetime, developed by ARS in Beltsville, Maryland. He also included freshly dug Canadian nursery plants of Chandler, Camarosa, and Sweet Charlie.

"We controlled temperatures at 68oF during the day and 57oF at night, and we preconditioned transplants for 150 degree-hours of chilling at or below 45oF. Combining this with the natural photoperiod and supplemental lights during overcast days produced plants that yielded lots of good-sized fruit," Takeda says.

Camarosa proved to be the most productive variety. "We picked over 2 pounds of marketable strawberries from each Camarosa plant," Takeda reports. In soil fumigated with methyl bromide, Camarosa and Chandler will each yield over 2 pounds of high-quality fruit.

In late August 1997, Takeda set runner tips in bedding plant containers with peat mixture to produce "plug" plants. He misted the plants intermittently until they had well-developed roots. On October 1, plug plants and fresh-dug plants shipped from Canada were placed in the hydroponic growing systems.

Takeda subjected plants in troughs to a continuous flow of recirculating nutrient solution. He fed the plants in pots intermittently with a nutrient solution and also transplanted plug plants to pots stacked to form towers.

"We harvested ripe fruit twice a week from December to May, the period when shipments of California strawberries slow down. Fruit quality and taste were excellent," he says.

Transplants or plug plants produced more fruit than field-nursery plants. According to Takeda, the root system of both types of plants remained healthy throughout the 7- to 8-month growing period, with no appearance

of root diseases. However, in the stacked-pot towers, the top sections got more light and therefore bore healthier plants and more fruit.

Light intensity greatly affects strawberry growth and development. Since light levels reaching the plants at the lower section of the towers were only 20 percent of levels measured at the top, fruit production was reduced. "Slightly taller pots spaced farther apart on the towers would reduce this problem," says Takeda.

Bruce Pape, an organic grower of herbs and ornamentals on Maryland's Eastern Shore, has been experimenting with pot-grown strawberries as ornamental plants. "We have some specialty market outlets that would probably be able to sell ornamental strawberry plants quite well," he says. "Consumers would not only get a beautiful ornamental hanging basket, but a way to grow a few strawberries in the winter months as well." Pape and his wife Carmen have experimented with several strawberry varieties.

Hydroponic systems reduce space requirements and growing time needed to produce a crop. Since there is no soil involved, no tillage is necessary and there are no weeds to contend with. The amount of chemicals needed is reduced, since biocontrol measures work better in the controlled environment of a greenhouse and there are fewer pests.

Environmental factors aren't a problem in greenhouses since lighting, temperature, humidity, and irrigation can be controlled. Nutrients used for plant growth are recyclable, to be used again and again.

Using hydroponics also reduces the cost and increases the efficiency of labor. Field-harvesting strawberries involves back-breaking labor, since laborers must stoop to pick the crop. Hydroponically grown berries can be harvested from a standing position.

"Although initial set-up costs for hydroponic farming are high, growers may recoup that cost by producing a higher value product, increasing yields, and spending less money to control pests and diseases," says Takeda. "Our research demonstrated that two California strawberry varieties can be grown by soilless means. However, we need more research to measure the

performance of other strawberry varieties and to investigate the influence of plant type--plug, fresh-dug, dormant, or single or multiple crown as well as planting dates."

--By Doris Stanley, Agricultural Research Service Information Staff.  
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Pesticide use has been so worrisome that some products have been banned. Methyl Bromide, for instance, was a commonly used pesticide that has been scheduled for a phase out in the U.S. after researchers and others convinced officials of its risks.

Research is beginning to demonstrate that hydroponic growing may serve as an alternative to Methyl Bromide reliance.

The United States Department of Agriculture explains:

Perlite and Hydroponics: Possible Substitute for MeBr?

Worldwide, methyl bromide is used primarily as a soil fumigant to eliminate soilborne pathogens and to control weeds. Since methyl bromide will no longer be available to U.S. growers after 2005, scientists are persistently seeking alternatives to this chemical that has been so widely used for decades.

George J. Hochmuth has been researching the idea of growing crops hydroponically in a soil-less mixture, eliminating the need for methyl bromide. Collaborators include Tim Crocker—who along with Hochmuth, is an extension specialist with the University of Florida's Horticultural Sciences Department—and Bob Hochmuth, with the university's Suwannee Valley Research and Education Center.

"On research plots at the University of Florida, we've been growing muskmelons in walk-in and low tunnels using perlite in a soil-less culture system," George Hochmuth reports. "Our data show that this is a possible

alternative to fumigating the soil with methyl bromide. We've also successfully grown strawberries in an outdoor hydroponic system using perlite bags."

Each year, about \$4 billion worth of horticultural crops are produced worldwide with soil-less cultures. According to Hochmuth, although these technologies are widely used around the world, they aren't used as extensively in the United States.

This is primarily because U.S. land available for agriculture is becoming more and more expensive. In 1988, U.S. growers produced about \$32 million worth of crops with soil-less mixtures, while in 1992, growers in Holland alone accounted for about \$1.6 billion. Today, the estimated value of Florida's greenhouse vegetable industry is \$20 million. However, with the impending ban on methyl bromide, U.S. growers need viable options to stay in the business of producing the nation's winter supply of fresh fruits and vegetables.

"The impending loss of methyl bromide will almost certainly lead to reduced yields under soil-based fruit and vegetable production in environments such as we have in Florida where soil pathogens, if left uncontrolled, can severely affect crop growth," Hochmuth says. "The good news is that in our research experiments, we got higher yields in tunnels planted with perlite than in those planted with soil."

Perlite is a unique volcanic mineral that has been used for years to amend professional potting soils made from peat moss. It retains and holds substantial amounts of water, which can be released as needed. The research was collaborative with the Schundler Company, Metuchen, New Jersey—a member of the Perlite Institute, New York City, which funded the research along with Airlite Products, Vero Beach, Florida.

## Strawberries

Produced on 6,000 acres and valued at over \$100 million each year, strawberries are important to Florida growers. Essentially all Florida strawberries are grown using plastic mulch culture in fields, with little chance for crop rotation. Each year, the soil must be fumigated with methyl

bromide to control diseases, weeds, and nematodes before new mulch is applied.

"We placed perlite and a peat mix in layflat bags about 3 feet long and 10 inches in diameter. We placed the bags end to end on a level area of soil covered with black plastic," Hochmuth says. After three fertilizer treatments, Hochmuth and colleagues planted six plug plants per bag and managed disease, insects, and mites by integrated pest management. On a per-acre basis, perlite bags allowed twice the numbers of plants that could be accommodated by typical field culture with plastic mulch.

"We harvested an average of just under a pound per plant, not significantly different from the yield achieved with methyl bromide fumigation in soil," he reports. "Considering that on a per-plant basis we achieved the same yields, we actually produced twice the yield of the field system since we had twice the number of plants, per acre, in the perlite bags." However, Hochmuth says that further refinement of the amount and timing of the controlled-release fertilizer applications is needed before large-scale adoption of this technique.

## Muskmelons

Using perlite, Hochmuth and colleagues planted Galia muskmelons in walk-in tunnels and low tunnels during the winter/spring and fall/winter growing seasons in 1997 and in the winter/spring season in 1998. Colleagues include Eric A. Waldo, Daniel J. Cantliffe, and Steven A. Sargent, all with the University of Florida at Gainesville.

Walk-in tunnels are quonset-style structures covered with a single layer of polyethylene film, heated and cooled passively without powered equipment; and low tunnels are simply row covers.

"In half of the rows under both types of tunnels, we used perlite for our growth medium. For the other half of the plants, we used raised beds of soil, polyethylene mulch, and drip irrigation," Hochmuth explains. They also placed thermal tubes in half of the walk-in tunnels. These tubes, which are about 12 inches in diameter and hold water, act as solar collectors during the day and release the energy as heat during the night.

According to Hochmuth, the tunnels and thermal tubes protect crops from cold temperatures, which can extend the growing season. "This gives the grower the advantage of premium, off-season prices."

### Soil-less Culture

Using soil-less mixtures such as perlite, Hochmuth says, eliminates the need for methyl bromide: since there is no soil, there is no soil borne pathogens or weeds. "In addition, as issues such as land availability and water use become more important, soil-less culture may prove to be an acceptable alternative to traditional soil-based crop production," he says.

Hydroponics offers many benefits. For example, nutrient runoff from growing crops can be captured and reused by growers as fertilizer for pastures or other crops. This can prevent the problem of excess fertilizer leaching into groundwater from the soil.

And as land prices increase, growers need to optimize use of their land. Soil-less mixtures maximize crop yield per acre.

With soil-less mixtures, plants get water and nutrients through a nutrient solution and are physically supported by a soil substitute such as rockwool or perlite. Soil-less mixtures have good aeration and drainage capacities. "Perlite is also sterile, has a neutral pH, and is readily available, nontoxic, safe to use, and relatively inexpensive," says Bruce Schundler, president of the Schundler Company. "Also, it can be used in the greenhouse or in outdoor plantings. It's ideal for water conservation and expands from four to 20 times its original volume when heated quickly. Plants grown in perlite take up water as needed; they don't suffer from too much or too little water."

This is because the surface of a particle of perlite contains tiny cavities that hold moisture and nutrients which are available to plant roots. The particle's shape lends itself to numerous air passages, which provide optimum aeration and drainage. Since it is sterile, perlite is free of diseases, seeds, and insects.

"Perlite's ability to cling to plant roots and root hairs helps reduce transplant shock and production time. It is being used for propagation and seed cultivation, plug production and transplants, interiorscape and planter growing, composting, hydroponic cultures, turf and lawns, and placement around shrubs, trees, and landscaping," Schundler reports.

In addition to aiding drainage, perlite eliminates soil crusting in heavy clay soils. Also, plant roots more easily penetrate the perlite growing media.

Tomato plants grown hydroponically in perlite have produced average yields 7 percent higher than tomatoes grown in other soil-less mediums. In Holland and, to a lesser degree in the United States, commercial cut flowers, strawberries, and orchids are being grown in 100 percent hydroponic perlite, Schundler says.

"A grower who wants to use perlite to grow crops should follow a few basic guidelines," Schundler iterates. "The first criterion is to carefully plan the nutrient solution system and the second is to frequently monitor irrigation, temperature, and nutrient levels throughout the season, then adjust the systems as necessary."

Growers should develop backup systems and procedures to ensure an adequate water supply to administer the nutrient solution system. "Careful consideration should be given in selecting the optimum nutrient program appropriate for the particular crop being grown" Schundler says.

### Walk-in Tunnels

What exactly is a walk-in tunnel? A portable, walk-in, greenhouse-like structure without a permanent electrically powered heating or ventilation system, covered with one layer of plastic, and sited on field soil, says Hochmuth. "These tunnels can't protect crops from temperatures to the same degree that heat-equipped greenhouses can. But, they cost a lot less to build and operate, and they're effective.

"Walk-in tunnels have been used extensively throughout the Middle East, Asia, and southern Europe to grow vegetables. And some tomato growers in the northeastern United States have used this practice since about 1992.

"Laying clear polyethylene tubes filled with water along crop rows has effectively moderated cool temperatures and led to increased early yields of peppers, compared to black polyethylene tubing," Hochmuth reports. "We add chlorine bleach to keep algae from growing in the water."

To deter insects, Hochmuth's team used an insect screen that covered the entire side of the tunnel from the ground to about 70 inches high and was buried in the ground to provide additional anchoring for the tunnel structure.

Understanding the dynamics of humidity and the temperature of air and growing media in the tunnels is of utmost importance to the success of the project, Hochmuth says. The effect of outside temperatures on inside temperature and humidity levels is also important.

"We had to reduce high humidity levels in the tunnels because fungal and bacterial diseases as well as some insect pests thrive in this environment. We simply lowered the sides of the tunnels when night temperatures were predicted to be below 50°F and raised the sides on cloudy days when outside temperatures were above 65°F. On sunny days, we raised the sides when outside temperatures were above 50°F. For our row-cover tunnel crops, we'd apply floating row covers over crops when outside temperatures were expected to drop to around 36°F."

This regime was used for muskmelons; strawberries will thrive under much cooler conditions, he says.

"Based on our research results with winter production of Galia muskmelons and with strawberries, we feel that using protective structures and soil-less mixtures is a viable option for growers faced with the loss of methyl bromide," Hochmuth says. "At the University of Florida, we're using this system as well as soil-based cultivation systems to grow a variety of crops without methyl bromide."

## **HYDROPONICS COULD FIGHT GLOBAL HUNGER**

Hydroponics uses less than half of the water usually necessary for plant growth and produces as much as a 400% yield increase. Those two facts make the hydroponic solution attractive to those concerned with world hunger.

By decreasing the need for often scarce water and increasing plant productivity, it may be possible to put a significant dent in world hunger, allowing for production of food in spots that are currently incapable of doing so in sufficient quantity.

This potential has led many to being investigation of how we might use soil-less agriculture to feed the world.

USAID reports on one such study:

### **HYDROPONICS**

Farmers in Sri Lanka face the dual challenge of land fragmentation and inadequate irrigation. From an environmental perspective, nutrient runoff from irrigation contributes to a host of water quality issues. Under these conditions, affordable, high-efficiency, high-yield agriculture systems can benefit farmers, the environment and provide sustainability.

Dr. Susil Liyanarachchi, Projects Director of Intermediate Technology Development Group, believed that traditional cultivation and animal husbandry could be adapted to increase productivity, food security and environmental integrity if biological, land, and labor resources were used efficiently.

Consequently, he started experimenting with hydroponics, a soil-free growing technique that uses 60% less water while producing four times the yield.

USAID has been a longtime supporter of industrial level hydroponics development in Sri Lanka; the iceberg lettuce used at local McDonald's restaurants, for example, is grown hydroponically in large, computer

controlled farms. While this method is too expensive to be feasible for independent farmers, Dr. Liyanarachchi was confident the systems could be scaled down into an affordable version.

In conjunction with a local university, he tested several systems for suitability to agricultural micro-enterprises. He discovered the main barriers to hydroponics adoption were the existing "one-size-fits-all" nutrient mix, rather than one specifically designed for Sri Lankan needs, and the cost of greenhouses. In addition, greenhouse seeds are expensive, but don't always grow.

Searching for solutions, Dr. Liyanarachchi began a dialogue with Peggy Bradley, Executive Director of the International Institute for Simplified Hydroponics. He believed their method had the potential to address some of the barriers to simplified hydroponics in Sri Lanka. US-AEP subsequently funded training in Mexico for Dr. Liyanarachchi to help equip him to promote simplified hydroponics into community development while helping with natural resource management.

Dr. Liyanarachchi experimented with simplified hydroponics systems in conjunction with two national universities to grow non-"greenhouse" plants in an open environment. He built hydroponics stands using wooden pallets, filling them with inert material such as rice husks or river sand. These modifications made small hydroponics farming feasible for low cost micro-agriculture.

Dr. Liyanarachchi also founded the Lanka Institute for Simplified Hydroponics, with the goal of further adapting this technology to Sri Lanka, and training others on the application of the technology. His work has been accepted by the Department of Agriculture as having potential to be used in Sri Lankan micro-gardens.

## PRINTABLE LABELS



### Tomatoes

Tomatoes are high in antioxidants and help ward off cancer. The main antioxidant found richly in tomatoes is Lycopene. Everyone loves to grow tomatoes in their summer garden, but with the power of Hydroponic gardening, you can enjoy the wonderful health benefits provided by tomatoes year round. Consider donating the overflow of your crop to neighbors, friends, family members, and community food pantries. Tomatoes are highly nutritious, range in variety, (many gardeners enjoy growing a number of different types of tomatoes), and are beneficial in reducing heart disease. They contain vitamins and minerals such as: Vitamin C, Vitamin A, Vitamin K, Molybdenum, Potassium, Manganese, Fiber, Chromium, Thiamin, Pyridoxine, Folate, Copper, Niacin, Riboflavin, Magnesium, Iron, Vitamin B5, Phosphorus, Vitamin E, Tryptophan, and Protein. PH Balance: Tomatoes 5.5-6.5

Tips to Grow Hydroponically: Without pollination, the tomato does not have seeds and it grows to a dwarf size. Outside hydroponics might be best for long-term tomato growers.

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### Lettuce

Lettuce is a favorite crop for many Hydroponic gardeners. Hydroponics allows you to grow many vegetables in a fast amount of time. Lettuce is a vegetable that is eaten most everyday in salads and on sandwiches. Hydroponic Gardening enables gardeners to grow all the lettuce they want in a relatively short amount of time. Lettuce also has many health

benefits; such as it can help aid digestion and promotes a healthy liver. Lettuce is very low in calories and comes in a number of varieties- all, which can be grown hydroponically. Lettuce contains Vitamin E, Iron, Folate, Potassium, Vitamin C, and Carotenes.

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## Cauliflower

Cauliflower is low in calories and makes it a great food choice. It provides essential vitamins and minerals such as Vitamin C, Vitamin K, Folate, Fiber, Vitamin B6, Tryptophan, Manganese, Vitamin B5, and Potassium. Cauliflower has been linked to a decreased chance of heart disease and cancer. When Cauliflower is grown hydroponically, you can ensure that your vegetables will receive all of the nutrients needed to deliver a plant that is superb in minerals and vitamin content.

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## Peppers

Bell Peppers come in a variety of colors, such as green, red, yellow, and orange however they are all high in antioxidants. Bell Peppers fight free radicals, cardiovascular disease, and cancer. Their nutritional content includes: Vitamin C, Vitamin A, Vitamin B6, Fiber, Molybdenum, Vitamin K, Manganese, Folate, Potassium, Vitamin B1, Vitamin E, Tryptophan, and Copper.

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## Green Beans

Green Beans are a great choice for those who are looking for vegetables to grow hydroponically. Green Beans are surprisingly rich in Vitamin K. That Vitamin K makes them perfect for protecting people from heart disease, high blood pressure, heart attack and even stroke. Green Beans are also known for having a wide variety of minerals and nutrients- more than other vegetables contain. Green Beans are a good source of: Vitamin K, Vitamin C, Manganese, Vitamin A, Fiber, Potassium, Folate, Tryptophan, Iron, Magnesium, Riboflavin, Copper, Thiamin, Calcium, Phosphorus, Protein, Omega 3 Fatty Acids, and Niacin.

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## Fennel

Fennel is rich in Vitamin C and Phytonutrients. The Vitamin C in Fennel is antimicrobial which makes Fennel an excellent choice for strengthening the Immune System. Fennel is also a good choice of food for those who are looking to improve their cardiovascular systems and Colon health. Fennel is a rich source of: Vitamin C, Fiber, Potassium, Manganese, Folate, Molybdenum, Phosphorus, Calcium, Magnesium, Iron, Copper, and Niacin.

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## Oregano

Oregano is a favorite herb in Spanish, Italian and Mexican dishes. Its hot flavor works well with tomato dishes such as pizza, spaghetti, meat loaf, hamburgers, stews and stuffing's. Oregano oil is known for its medicinal qualities which serve as an anti-bacterial and anti-spasmodic.

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## Parsley

Parsley is a very carefree crop and tends to be slow to germinate. Parsley helps to underline the taste of food. Parsley is also known for its ability to neutralize strong mouth odors. When used in large amounts, parsley can act as a tranquilizer. Parsley can be added at the beginning of cooking to bring out flavors during cooking. Parsley can also be used to garnish foods after they are cooked shortly before they are served. At first, you may think of Parsley as a simple table garnish and not realize the amazing health benefits packed into Parsley. Parsley is an antioxidant and fights cancer. It is high in Vitamin K, (2 Tablespoons of fresh Parsley meets more than 100% of the daily recommended requirement of Vitamin K), Vitamin C, Vitamin A, Folate, and Iron.

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## Sage

Sage aids in digestion and is a great herb for pork and fatty meats. Sage can be used as a mint in tea, or it can be added to everyday dishes. No Thanksgiving or Christmas turkey would be complete without sage being added to the stuffing mix.

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## Thyme

Thyme is sometimes used on the body as an antiseptic. It is also used in soaps, stuffing and sauces. Thyme works well with sage and the two are often used together because they complement each other. Thyme is a must have herb for anyone who is preparing lamb, pork or chowder.

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