

Progressive Gardening Media Kit

Volume I Hydroponic Gardening

A Resource Guide For Understanding, Teaching,
or Writing About Hydroponic Gardening

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Earth-Friendly, Water-Wise & Organic Garden Retailing



PROGRESSIVE GARDENING

MEDIA KIT

Introduction

Progressive Gardening includes a wide array of gardening methods and products keyed to making gardening easier, safer, and more productive. Hydroponics, growing plants without soil, is just one method modern gardeners use to accomplish these goals.

Purpose

The Progressive Gardening Media Kit is designed to be used as an information and resource guide by anyone wanting to understand, write about, teach, or promote the positive aspects of hydroponic gardening. The Media Kit can also be used by PGTA members to help them deal positively with a variety of situations, or to capitalize on opportunities to promote hydroponic gardening methods, products, and services.

Education

Information is available to help teachers understand the advantages of using hydroponics as a teaching tool in the classroom. Information here can also help explain and justify expenditures for hydroponic equipment for the classroom.

Resource Guide

A guide to resources will help in finding more in-depth information. The Resource Guide includes a listing of associations, online resources, magazines, books, historical articles and other useful information.

Media Assistance

Information throughout the Media Kit can help provide information needed to create positive articles about hydroponics in general or to spotlight a specific business. An important portion of the Media Kit includes the section on “Debunking the Myths” to help eliminate some of the common misconceptions about hydroponics.

Additional Resources

In addition, the web site ProgressiveGardening.org was created to keep you abreast of the latest gardening techniques, supplies, and equipment so that everyone can reap the numerous benefits, including increased yields, reduced need for pesticides, food safety, water conservation, and more that have been made attainable through the continuing advancements in horticultural science.

Credits

The Progressive Gardening Trade Association would like to thank all the volunteers who helped put this Media Kit together. Many PGTA members provided input, knowledge, and inspiration for this project, and the PGTA Board of Directors would especially like to thank Project Coordinator Carl Anderson, as well as Jeff Edwards, Jeff Gibson, Michael Dowgert, Kathy Giovannelli, Robert LaGasse, and Harley Smith for their contributions in making this installment of the Media Kit possible.

We encourage anyone with additional input to contact the PGTA office or the PGTA Marketing, Advertising, and Promotions Committee

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Overview of Hydroponics

Definition

Hydroponics is the science of growing plants without soil. Instead of soil, plants are grown in solutions containing all the necessary mineral elements. Methods used to get the nutrients to the roots, along with the needed oxygen, include bare-root systems and systems using inert substrates to support the plants.

What Is Hydroponics?

Hydro means water. Water is a vital part of every living cell, and is the key element for life to exist on earth. Plants also need nutrient elements such as Nitrogen, Phosphorus, Copper, Iron, Boron, etc. to grow properly. Basically, plants use water to transport the required nutrient elements through their roots to feed the rest of the plant. Traditionally, these nutrient elements are obtained from the soil. The plant roots grow out searching for the nutrient elements and the water needed to take them up. However, the soil typically does not contain the precise optimum nutrients and moisture levels the plant needs. Hydroponics is all about enriching water by creating and maintaining a “nutrient solution” that is perfectly balanced for the plant. When the plant gets exactly, everything it wants, all the time, it will grow as fast, and provide the best flavor and nutritional value, that it possibly can. Hydroponics is growing plants without soil. Absolutely anything that can be grown in soil can be grown hydroponically. The key is determining the precise, ideal, nutrient solution for the specific plant, and consistently providing it to the roots. Typically, by using a general purpose hydroponic nutrient, plants will outperform soil grown plants in the same environment.

A Brief History

Ancient Origin

Hydroponics is not a recent invention. Historians have found Egyptian hieroglyphics depicting the cultivation of plants in water as far back as several thousand years BC! The Hanging Gardens of Babylon and the Aztecs Floating Gardens of Mexico City are both examples of early hydroponic gardening. Modern hydroponics made major advances in the 1930s. W.F. Gericke coined the term hydroponics from the Greek “hydro” or “water” and “ponos” or “working.” Literally, water working. Hydroponics has evolved through the use of various growing media such as sand, gravel, rockwool, coconut fiber, etc. to bare-root systems such as Nutrient Film Technique (NFT) and Aeroponics. Since launching massive amounts of soil into space is cost prohibitive (as well as dumb), hydroponics is, and will be, used to grow plants in space.

Named by Gericke
“water” “working”

science of plant nutrients

The science of hydroponics began with experiments to determine the elementary nutrient requirements of plants and how plants processed those elements. That knowledge has evolved into the desire to automate the delivery of the precise nutrient mix to the plant to optimize the growth and quality of the plants. Further, the fine tuning of varying the nutrient mix not only for specific plants, but also varying the nutrient

mix for the specific stage of growth. For example, we know plants use more Nitrogen during the green growth phase, and more Phosphorus during the flowering and fruit production stage. Additionally, plants will adapt and do what they can to survive when subjected to less than ideal conditions. These less than ideal conditions slow down the growth, and can seriously affect the quality and flavor of the plant.

ideal nutritional environment

controlled growing environment

One major objective of hydroponics is to provide the ideal nutritional environment for optimum plant performance. Although technically not part of hydroponics, hydroponic growers typically attempt to provide other ideal environmental factors as well. Plant performance can be further optimized by controlling temperature, humidity, and lighting. Using a greenhouse provides natural lighting while controlling temperature and humidity. Using supplemental lighting can also provide the ideal season for the plant performance desired. Advances in technology in lighting, nutrient delivery, and environmental control, will continue to improve productivity and quality of plant performance.

Hydroponic Benefits:

1. Healthier Plants

Plants grown hydroponically are generally healthier than their soil-grown counter-parts, since they receive a near-perfectly balanced diet. Additionally, the plants rarely come in contact with soil-borne pests and diseases.

2. Healthier Consumers

Without the use of herbicides, fungicides, and pesticides, the resulting produce is healthier to eat. Additionally, agricultural workers are not exposed to toxic chemicals, and labor costs are reduced.

3. Higher Yields

Since hydroponic systems reduce water and nutrient stress to the plants, crops grow faster and can be grown closer together without starving each other. Healthier plants also contribute to higher yields. Perfect plant conditions results in perfect plant production.

4. Conservation

Hydroponic systems conserve water by preventing evaporation and runoff. Losses due to drought and flooding are significantly reduced as well. Regions where water is scarce, or without adequate soil conditions, can grow crops using hydroponics.

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Advantages and Uses of Hydroponics

\$2.4 billion industry
expanding @ 10%/yr.

- Increased yields
 - Improved/consistent quality
 - Elimination of herbicides/pesticides
 - Extended growing seasons
 - environmentally friendly
 - Less groundwater contamination
 - Safer vegetable crops
- supplements traditional cultivation

Systems and Methods

- Bare Root Systems
NFT, deep flow, aeroponics
- Substrate Systems
NFT, flood & drain

Commercial Hydroponics

Hydroponically grown produce is available at all major supermarkets across the country regardless of the season. In North America, 95 percent of greenhouse vegetables are grown hydroponically. The hydroponic greenhouse vegetable industry is valued at over \$2.4 billion dollars and is growing at 10 percent per year. The industry is expanding because it is economically productive. Controlled environments and controlled growth techniques maximizes production and is much less labor intense. In addition, the resulting produce is clean, healthy, and nutritious, and growing hydroponically significantly conserves the earth's resources.

Increased yields, improved and more consistent quality, and elimination of herbicides and pesticides, are major advantages of using hydroponic growing methods for commercial food production. Because hydroponics is almost always used with controlled environments such as greenhouses, the additional major benefit of extending or eliminating growing seasons provides continuous crop production, which again provides extensive increases in productivity.

Runoff of phosphates, fertilizers, and pesticide residues from large commercial farms have a serious environmental impact, especially on groundwater contamination. By greatly reducing the use of agrichemicals, hydroponics is more environmentally friendly and results in safer vegetable crops as well. The economic viability of using hydroponics for commercial crop production became evident in the 1930s. The first economically viable commercial hydroponic systems were used to produce greenhouse-grown tomatoes, cucumbers, lettuce and herbs. These, along with peppers, are still the mainstays of commercial hydroponic vegetable production.

Hydroponic systems were quickly applied to cut flower production where increased yield and soil sterilization were major issues. Initially, the production of bedding plants and potted flowering plants moved from a soil based system of production to "a soilless media" consisting of a blend of peat moss vermiculite and perlite. Next, fertilization moved from mixing fertilizers in the soilless mix to applying nutrients dissolved in the water, basically hydroponics. The application of these hydroponic techniques saved on water and fertilizer and resulted in more uniform crops. More recently, the use of sophisticated flood and drain systems and crop specific nutrients means that virtually all potted flowers and bedding plants grown in the United State utilize some form of hydroponic technique.

Commercial systems can be divided into two classes, bare root systems and substrate systems. Many different methods can be used for a wide variety of crops. Bare root systems include nutrient film technique (NFT), deep flow, and aeroponic systems. Deep flow and NFT are the most popular for commercial lettuce and herb production. Substrate systems use a media such as rockwool or perlite. Other substrates include sawdust, peat, coir, sand, and technically any other media that, specifically, is not soil. Although flood and drain and NFT systems are sometimes used, drip irrigation with rockwool or perlite is the most commonly used method for the production of tomatoes, peppers, and cucumbers, as well as cut flowers. Flood and drain systems are mainly used in the production of potted flowering plants and bedding plants. Although very popular with hobbyists, aeroponics is rarely used in commercial greenhouse production.

Commercial hydroponic vegetable yields

- 20-25% increased production
- Double commercial volume
 - Less chemicals
 - Less water & fertilizer
- Improved consistency
- Yield of tomatoes/acre - 500,000 vs. 60,000
 - 650,000 lbs./acre
- Cucumbers, lettuce, bell peppers
 - Yield of cucumbers - 200,000 vs. 10,000
 - Yield of lettuce - 700,000 heads/acre
 - Yield, greenhouse peppers - 200,000 lbs./acre

Hydroponic vegetable greenhouse production areas

- 3,000-4,000 acres in U.S. & Canada
- Market value exceeds \$2.4 billion
 - 30,000 acres in Israel; 10,000 in Holland; 4,200 in England
 - 8,000 acres in Asia

North American production

Yields of commercial hydroponic vegetables over traditional cultivation systems

Hydroponic systems offer the commercial grower consistently higher yields compared to traditional soil production. In the research greenhouse, when environmental conditions (other than the growing medium) are similar for soil and hydroponic production, the increased production of tomatoes is usually 20 to 25% using hydroponics. However, in commercial practice over a number of years, the yields of hydroponically grown tomatoes can be more than double that of soil systems due to reduced turnover time between crops, better nutrition, and disease management of the root zone. In addition, commercial hydroponic growing systems require far less chemicals for root zone sterilization for pest control, weed control, and control of root disease. Many are surprised to learn much less water and fertilizer are used in hydroponic systems as well. Due to better nutrition and sanitation, fruit quality and consistency is also significantly improved. The advantages of hydroponics over soil culture are so great that in the United States and Canada over 95% of all greenhouse grown vegetables are hydroponically grown.

Field grown tomatoes typically yield 40,000 to 60,000 pounds per acre. Yield targets for greenhouse grown tomatoes are currently 500,000 pounds per acre. The top growers in the southwest U.S.A. and British Columbia, Canada, yield upwards of 650,000 pounds per acre. It is interesting to note that 10 years ago the top hydroponic tomato producers were yielding 400,000 pounds per acre. The hydroponic growing systems have proved amenable to more efficient utilization allowing for these significant yield increases.

The yields of hydroponically grown cucumbers, lettuce, and bell peppers are equally impressive. Hydroponic greenhouse cucumber growers produce about 400,000 cucumbers, or approximately 200,000 pounds per acre. Field production is typically 10,000 pounds per acre. Hydroponic lettuce yields exceed 700,000 heads per acre, about four times that of the field crop. Hydroponic greenhouse peppers yield about 200,000 pounds per acre, again about four times the field production. Additionally, the quality of most hydroponic greenhouse crops is significantly higher than field crops and therefore, commands a premium price in the marketplace.

Estimates vary, but most surveys indicate that there are between 3,000 and 4,000 acres of hydroponically grown greenhouse vegetables in the US and Canada with another 2,000 to 3,000 acres in Mexico. The market value of these crops is estimated to exceed 2.4 billion dollars. Additionally, recent estimates of the use of hydroponics around the world include: Israel 30,000 acres, Holland 10,000 acres, and England 4,200 acres. Australia, New Zealand and other northern European countries probably contribute about another 8,000 acres of hydroponic greenhouse production. These estimates do not include the large areas using flood and drain irrigation for potted and bedding plants, which covers about 10,000 acres in the United States alone.

The hydroponic greenhouse vegetable industry is a major player in the fresh produce market. A 2003 study by the British Columbia marketing commission found total North American production to break down as follows:

	Production area in acres			Total
	Canada	U.S.	Mexico	
Tomatoes	1190	865	1950	4005
Cucumbers	490	62	292	844
Bell peppers	430	50	520	1000
Total	2110	977	2762	5849

As with most studies of this kind, the statistics rely heavily on large-scale producers. The smaller producers tend to be missed. It is possible that the total production area reported above underestimates the actual production area by 20 percent. For example, in the U.S., small farms may add 200 to 400 acres to these totals. Small hydroponic vegetable greenhouses can be found in almost every state in the U.S. Many of these operations are run on a seasonal basis as a way to supplement income. The smaller units are niche producers satisfying demand for locally grown products. Many sell at local farm markets, specialty markets, or directly to gourmet restaurants, at premium prices. It is not possible to produce an adequate list of these small growers because they are small, seasonal and not highly visible, but most would appreciate any publicity they can get to help promote their business.

Greenhouse quite large (>10 acres) or less than 2 acres

The trend is for hydroponic vegetable greenhouses to be either quite large, over 10 acres, or smaller than 2 acres. The large units take advantage of the economies of scale as well as the ability to supply a consistent year round product. The large hydroponic vegetable producers are sophisticated high tech operations with computer controlled environmental and fertilization systems. They are impressive in terms of their size, the volume of produce that is grown and the advanced hydroponic growing systems used to produce the crop. Some of the more impressive sites are:

Impressive hydroponic vegetable greenhouses

EuroFresh	Wilcox and Snoflake, AZ	240 acres, tomatoes
Village Farms	Fort Davis, TX and Ringold PA	130 acres, tomatoes
Houweling	Oxnard, CA	140 acres, tomatoes
Sunblest	Fort Collins, CO	86 acres tomatoes, peppers
Sunco	Las Vegas, NV	40 acres tomatoes
Virginia Power	Virginia	35 acres tomatoes, herbs
Intergrow	Rochester, NY and upstate NY	34 acres, tomatoes, peppers
Nebcoop	Nebraska	30 acres tomatoes
ADM	Decatur, IL	18 acres lettuce, herbs
Decatur farms	Decatur, IL	10 acres peppers
Hollandia	Ventura, CA	10 acres cucumbers
	Fort Pierce, FL	20 acres peppers
Mascot Farms	Fort Pierce, FL	20 acres cucumbers
Nipomofarms	Nipomo Mesa, CA	7 acres tomatoes

(Note: some farms have multiple names for marketing and growing.)

Canadian sites concentrated in specific regions

In Canada the greenhouse sites tend to be more concentrated in specific regions. Of the approximately 2,100 acres 1,400 acres are in Ontario and 1,100 of those acres are in Leamington. The majority of the remaining acres are in the Niagara Peninsula area. British Columbia has about 500 acres of hydroponic greenhouse vegetables with 75% near the coast. The remaining 200+ acres are in Alberta, Quebec and the Maritimes. Of particular interest is a 10-acre site in Quebec that is growing peppers under lights. Favorable electric rates from Quebec-Hydro have made this a profitable operation. The crops produced in Canada include tomatoes (1,260 acres), cucumbers (525 acres), and peppers (210 acres)

Largest Canadian hydroponic greenhouse vegetable producers

The largest Canadian hydroponic greenhouse vegetable producers are as follows:

Mastron Enterprises Ltd.	Leamington, ON	53 acres
Great Northern Hydroponics	Leamington, ON	53 acres
DiCiocco's	Leamington, ON	49 acres
Houweling Nurseries	Delta, BC	48 acres
Amco Farms	Leamington, ON	40 acres
Sabelli Farms	Leamington, ON	38 acres
Veg Gro Inc.	Leamington, ON	36 acres
Nature Fresh	Leamington, ON	35 acres
Canagro	Delta, BC	31 acres
Suntastic Hothouse	Exeter, ON	30 acres
Mucci Bros	Leamington, ON	30 acres
Les Serres du St. Laurent	Portneuf, Quebec	30 acres
Cervini's	Leamington, ON	25 acres
Delta Pacific	Delta, BC	25 acres
St. Davids Hydroponics	St. Davids, ON	24 acres
Gipaanda	Delta, BC	24 acres
Double Diamond	Leamington, ON	24 acres
Howard Huy	Leamington, ON	24 acres
Hazelmere	Surrey, BC	21 acres
Hydro-Serre	Mirabel, Quebec	17 acres
MOS Enterprises	Leamington, ON	13 acres
MOS Capital	Leamington, ON	12 acres
Paul Dyck	Leamington, ON	10 acres
Hillcrest Farms	Leamington, ON	10 acres

Fastest growing area - Mexico

- free trade
- favorable winter conditions

The fastest growing area for hydroponic vegetable greenhouses is Mexico. Free trade and favorable winter conditions has made this area very interesting to vegetable producers. Village Farms and Houweling, both with large U.S. operations, have a large interest in several Mexican operations. Interestingly, Mexico is generally considered hot in the summer, however, when greenhouses are placed at the right altitude the summers stay cool and the winters warm so crops can be grown year-round. The current acreage of vegetable production consists of mostly low tech plastic houses that are run seasonally to take advantage of the high winter produce prices in the US. Still many of these operations use hydroponic technology to produce their crops illustrating that even in basic greenhouse growers are exploiting the advantages of hydroponics.

Article sources

Information for the above article was obtained from the following sources:

- Agriculture Canada, Greenhouse and processing crops research center
- Ontario Ministry of Agriculture and Food
- ATTRA, National sustainable Agriculture Information Service
- Controlled Environment Agriculture Center, Univ. of Arizona
- Hydroponic Food Production, Howard Resh
- DeRuiter Seeds, Columbus OH
- AgroDynamics, Ventura, CA

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Advantages & Uses of Hydroponics

Gardening hobby

- Fresh produce all year long
 - no pesticides
- Joy of the process reins over cost
- Expanding application to everyday use
 - Don't need a green thumb to be successful

Public perception

- Not too high tech
- More common than you know

Hydroponics in the Home Garden

Hydroponics in the home provides the pleasure of growing plants and reaping the benefits of home grown, fresh produce all year long. Knowing your tomatoes and other vegetables have never seen weed sprays or pesticides can be very reassuring, but faster growth and great taste have to be the best part. Many of the advantages of commercial hydroponics also apply to the home and hobby gardeners. In many industries, small systems are developed and then expanded for large scale use. Conversely, in hydroponics, large scale commercial production is very easy and common, while it is more of a challenge to make smaller systems economically feasible. Fortunately, hobbyists and home gardeners are not always so interested in the cost to produce, but more in the joy of the process. Additionally, the hydroponic hobbyist enjoys designing, building, and experimenting to improve the methods and performance of systems. For the hobbyist, hydroponics is a highly technical specialized form of agriculture that has an ever expanding application to everyday use. At the same time, home hydroponic gardens have become so simple that people without a green thumb can be very successful in growing flowers and vegetables in their homes. Home hydroponic systems allow home gardeners to grow the hottest pepper, or to enjoy the same tomato flavor they first experienced when Grandpa handed them their first vine ripe tomato in the garden.

Public perception of hydroponics has been a high-tech curiosity with applications only in the laboratory, or for NASA, or Epcot Center. The fact is virtually every supermarket in the United States is selling hydroponically grown produce. If you have ever purchased a greenhouse grown tomato, or a "Dutch" greenhouse pepper, or a European cucumber, it has almost certainly been grown hydroponically. Hydroponics is the dominant growing system worldwide for commercial greenhouse vegetable production. Therefore, consumers have been eating hydroponically grown produce for many years, typically without realizing it. In addition, potted flowers and bedding plants today are almost always grown in a blend of vermiculite, perlite, and sphagnum peat moss, a soilless mix, and automatically watered with a mild nutrient solution. Therefore, technically, virtually every potted plant and bedding plant in the world is grown using a form of hydroponics. This means that hydroponics touches every individual in the country who has ever purchased a live plant.

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Advantages & Uses of Hydroponics

Media & stories on children's education

Education

Many times the media likes to write about children and positive stories on children's education. The best way to get a story published on hydroponics in the classroom is to have hydroponics in use in a classroom. Second to that would be to have an article written that would encourage hydroponics be added to a classroom.

Growing plants in nutrient solutions instead of soil draws students to the sciences and technologies. It broadens and heightens their horizons, bringing them to concepts of the Space Age: feeding an ever-increasing world population, space travelers and space stations. In the process, through hands-on experimentation, they learn not only all phases of plant sciences, but also the basics of chemistry, physics, general biology, ecology, engineering, math and even computer science. Additionally, they learn about the scientific method, data collection and analysis, reports, and presentations.

Less obvious educational uses

Some uses of hydroponics in education are immediately obvious. Many applications to enhance and encourage the learning process are not as obvious, but can be very effective in providing motivation and reason to the process.

1. The Scientific Process
Understanding the process is very important. Simple principles of control, and comparisons, that can be repeated and expanded. Ensuring that only one variable is present is a major advantage of hydroponics.
2. Plant Science
This one, of course, is obvious. Observing the entire process from germination of seeds through root and leaf development and flower, fruit, and seed production is much easier with hydroponics.
3. Chemistry
Plants need (at least) 17 elements to grow at their optimum rate and performance. The amount of each of the elements affects the plants ability to use the other elements. An excess or shortage of one might preclude the plant from properly using others. With hydroponics, students can easily vary one element and control all others.
4. Physics
Fluid dynamics, the nutrient uptake process, temperature and humidity affects on transpiration, etc. are much easier to control and measure using hydroponics.
5. Ecology
Hydroponics uses much less water than soil gardening due to control of run-off and evaporation losses. Many commercial hydroponic operations incorporate co-generation where burning propane to generate electricity allows for free heat for the greenhouse along with carbon dioxide enrichment to enhance plant growth. Providing the precise nutrient requirements for the plants significantly reduces or eliminates run-off resulting in algae blooms and ground water contamination.

6. Engineering	System design and construction can be as simple as a styrofoam board float system, flood and drain system, or an elaborate aeroponics system with extensive automated controls.
7. Mathematics	Use of hydroponics gives the students a real life example of why they need to develop mathematical skills. If you need one fourth teaspoon of nutrient per gallon of water, how many teaspoons do you need for 25 gallons of water? If a PVC pipe has a two inch inside diameter and you want one fourth inch of water at the deepest point, how many gallons will be in a 20 foot length of pipe? In commercial production, they would need to calculate the cost to produce, as well as research the market value of the produce grown, to determine if the project would be profitable.
8. Computer Science	Of course, computers can be valuable in data tracking and logging information on the process. Students can develop programs or spreadsheets for graphically displaying results of the processes. Additionally, automation of controls and parameter measurement can be installed or engineered for the specific application or need of the system. Automation of timed cycles, measuring pH levels and dispensing pH adjusters, nutrient dosing, and environmental controls such as fans, etc. are all examples of computer automation applications.
9. Geography	Geography can be added to the curriculum by determining the source of a plant, finding that country on a map, and studying the typical environmental factors natural to the plant, just to start. To actually recreate or improve on the environmental conditions in the classroom or grow room, can be very educational.
10. Economics	Raising fresh herbs in the classroom and marketing those herbs to the local gourmet restaurant can bring the entire economic model to the classroom. Developing sales brochures or presentations, determining the cost to produce and appropriate profit margins, and doing the accounting to keep costs under control, inventory and supplies management, all illustrate how integrated education is a natural fit for hydroponics in the classroom.

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Advantages & Uses of Hydroponics

Meeting the Essential
Academic learning
Requirements for Life Science

Classroom Education Program

Prepared for Washington Association of Agriculture Educators
Summer Conference - June 25 -30, 2000

Hydroponics is the way of the future for environmentally controlled agriculture, and an excellent way to teach plant science in the classroom. With hydroponics, students have hands-on, minds-on involvement with every aspect of plant growth and reproduction. Students not only receive first-hand knowledge of the scientific principles that govern plant growth and physiology, but they have the opportunity to apply that knowledge to help plants reach their full potential. In a well-managed hydroponic system, plants typically mature two to three times faster than in soil, while producing a bumper crop of gourmet-quality produce. Furthermore, students can experiment with the effects of horticultural lighting, water quality, growing media, essential elements, pH, EC, carbon dioxide supplementation, and other factors that influence plant growth and vigor. The results? Students achieve a higher level of scientific literacy while learning the technical skills necessary for tomorrow's expanding job market.

A careful review of the Essential Academic Learning Requirements in Science reveals that about 75% of the general science benchmarks are addressed by a fully equipped hydroponics lab, while about 95% of the life science benchmarks are addressed. The following suggestions are designed to help science teachers focus on those objectives in a practical, hands-on manner.

Properties

1.1 Use properties to identify, describe, and categorize substances, materials, and objects, and use characteristics to categorize living things

properties of substances

Using the periodic table, identify the 17 essential elements required for plant growth and reproduction. Describe the elements' properties and explain how plants use them at various stages of growth and development. Compare Grow formula to Bloom formula.

motion of objects

Using data from the US Naval Observatory website in Washington, DC, plot the relative position of the sun at 20 minute increments for a given day at your school's exact location. Explain the changes of the seasons, and determine the best window locations for 6 hours a day of supplemental sunlight. (Optional): Design a solar tracking system using one or two axes of rotation, and use mirrors and lenses to condense and project sunlight to given locations in a grow room.

light wave behavior

Describe various wave lengths and frequencies of light needed at different stages of plant growth. For example, phototropism is influenced only by the blue end of the spectrum (460 nm wavelength) and is important at the vegetative growth stage, while fruiting and flowering is influence by the red end of the spectrum. Using the color spectrum, describe the difference between Metal Halide and High Pressure Sodium horticultural grow lamps and determine how they can best be utilized. Describe PAR watts as a way of measuring light intensity.

nature and properties
of earth materials

Compare soil to various hydroponic rooting media, and investigate the chemical composition of various hydroponic nutrient formulas. Explain the difference between photosynthesis and respiration, and show how oxygen and carbon dioxide are used by the plant.

Components/Structure/ Organization

1.2 Recognize the components, structure, and organization of systems and the interconnections within and among them.

systems	Analyze various types of closed loop hydroponic systems, and determine which varieties of plants could best be grown in each one. Describe the strengths and weaknesses of each system and suggest improvements.
energy sources and kinds	Describe how solar energy is the source of all life on earth. Compare solar radiation as a source of heat and light with various artificial light sources. Describe effects of light and temperature on plant growth and vigor, and determine the most efficient light sources to best meet the plant's needs. Explain the exponential fall-off of light and show the benefits of using lamp movers.
energy transfer and transformation	Explain why burning wood is releasing stored sunlight. Explore alternative energy sources such as solar, wind, hydro and biomass. Show how heating a hydroponic reservoir can be more energy efficient than heating air. (Optional): Design a windmill turbine that can help pump water or power a solar tracker.
structure of matter	Understand that all matter is made up of atoms. Explain how plants take up elements in their ionic form. Compare "chemical" fertilizers to "organic" fertilizers. Explain why hydroponic nutrient solutions must be mixed to exact proportions. Show how too much of one element, such as phosphorous, can block the input of other elements, such as zinc, iron and magnesium.
physical/chemical changes	Show the relationship between the strength of the nutrient formula (EC) and the sugar content in the fruit. Explain why plants require slightly acidic conditions at the root zone. Show how temperature and aeration of the hydroponic nutrient solution can increase the metabolism of the plant.
structure and organization of living systems	Describe the anatomy of the plant at the micro and macro levels. Show response of various cellular structures to environmental stimuli. For example, expose seedlings to metal halide light and examine the increased density of stomata on the developing leaves. Expose seedlings to high-pressure sodium light (or red filtered light) and show the stretching effects in the stems. Explain the mechanisms of phototropism and photoperiodism.
molecular basis of heredity	Compare sexual to asexual reproduction. Select seeds from different varieties of plants and explain differences. Produce clones from cuttings or tissue culture and explain similarities. Show how clones react differently to different environmental stimuli. Write a report describing a hypothetical "vegi-factory" that uses plants from test tubes and pre-programmed environmental control parameters to achieve reproducible results. (Optional): Using an environmental control chamber, determine optimum environmental conditions for a single cloned genotype.
human biology	Compare essential elements for plants with essential elements for humans. Research the various vitamins, enzymes and amino acids produced by plants, and determine their role on human health. Grow a garden of medicinal herbs in a hydroponic system and study their history and applications.

Interactions

life process and the flow of matter and energy

1.3 Understand how interactions within and among systems cause changes in matter and energy.

Grow plants in hydroponics and in soil and chart the differences in growth rates, harvested dry weight, essential oil content or other characteristics of your choice. Choose one variable, such as day length or the difference in temperature between day/night, and determine its effect on plant growth.

biological evolution

Subject plants to a stress factor (such as increased temperature, drought, or a specific pathogen) and select surviving plants for cloning or cross-breeding. Explain how conventional agricultural breeding techniques and modern biotechnology techniques are accelerated forms of evolution.

interdependence of life

Construct an aquaponic system in which the water from a fish tank is used to fertilize plants, and the plants are used to remove excess nitrates from the water. Describe role of nitrifying bacteria in an aquaponic system. (Optional): Design and construct a mycoponic system in which the waste heat and humidity from plants are used to grow mushrooms, and mushrooms are used to produce increased carbon dioxide for the plants. Show how fungi accelerate the composting process.

environmental and resource issues

Show how a recirculating hydroponic system is environmentally friendly, conserving water and natural resources. Describe a zero runoff system and consider possible complications that could occur. Design a rooftop hydroponic garden that could be used in third world countries to supplement the nutritional needs of undernourished people.

Scientific Inquiry

2.1 Develop abilities necessary to do scientific inquiry

questioning

Develop a list of questions that must be answered in order to increase productivity from season to season, while reducing energy costs. For example, what is the ideal pH and EC levels for a specific variety of mint at various stages of growth. What varieties can tolerate higher summertime temperatures without bolting, or cooler winter temperatures without becoming stunted? What is the point of diminishing returns when adding supplemental lighting? What are the optimum carbon dioxide levels under specific lighting and temperature conditions?

designing and conducting investigations

Using the hydroponic system and environmental controls, design and perform experiments with EC, pH, water quality, nutrient deficiencies, nutrient toxicities, lighting cycles, temperature, humidity, aeration, carbon dioxide supplementation, irrigation cycles, trace element foliar feeding, and other factors that influence plant growth and vigor. Keep a journal and emphasize the necessity of making careful observations.

explanation

Formulate and revise scientific explanations using data gained from experimentation with hydroponics. Compare your explanations with other scientific theories and devise follow-up experiments to test theories.

modeling

Use computer software or manual plotting techniques to create productivity curves and determine the point of diminishing returns under various hydroponic growing conditions.

communication

Publish the results of hydroponic experiments in various ways, such as written reports, slide shows (or videos), or on the Internet. (Optional): Create a common hydroponic website in which experimental data can be shared between schools. Devise "group" experiments that can maximize the collection of data in the shortest period of time.

Science Knowledge/Skills

identifying problems

2.2 Apply science knowledge and skills to solve problems or meet challenges

Identify rare or endangered plant species (local, national, and international) that can be propagated and grown hydroponically. (Alternative): Identify culinary herbs that are in short supply in the off season at local restaurants.

designing and testing solutions

Design specific biomes for growing endangered species, both hydroponically and in various soil substrates. (Alternative): Create a business plan to grow culinary herbs for the local market, and specify equipment and supplies necessary to meet those needs.

evaluating potential solutions

Work with local, state or national parks to propose reintroduction of native species. Propose goals and objectives and evaluate possible logistical constraints. (Alternative): Test economic feasibility of growing culinary herbs. Investigate codes and regulations that could help or hinder production and distribution.

Understanding Scientific Inquiry

3.1 Understand the nature of scientific inquiry

intellectual honesty

Debate organic growing methods vs. hydroponic growing methods. Determine how presuppositions and prejudices can affect open-mindedness and color perceptions.

limitations of science and technology

Determine how a small hydroponic system can be scaled up using larger reservoirs, controllers and automation. Explore the “limiting factors” for increasing crop production, such as energy budget, labor budget, and market constraints.

dealing with inconsistencies

Compare computer models, projected productivity curves and business plans with actual production data. Attempt to objectively explain inconsistencies, and propose possible improvements.

evaluating methods of investigation

Using new data, revise computer models and/or business plans. Propose new hydroponic experiments with more specific controls, or perform experiments with interrelated variables. For example, it may be better to increase light levels and carbon dioxide supplementation, while reducing or maintaining ambient temperatures; as opposed to evaluating each variable independently.

evolution of scientific ideas

Test, revise, improve or discard ideas. If growing a plant crop becomes unfeasible due to unforeseen problems or market changes, grow something else. If you find a crop or product whose demand outstrips supply, investigate ways of producing more. There are no absolutes in science or in real world applications. Also, test and apply new hydroponic products or production techniques as they become available. For example, new discoveries are being made in the field of hydroponics using natural and synthetic plant growth regulators, co-enzymes, and trace elements, challenging some of the accepted beliefs about plant growth and development.

Science & Everyday Life

all people contribute to science and technology

3.2 Know that science and technology are human endeavors, interrelated to each other, to society, and to the workplace

Study the history of hydroponics, and use the internet and trade publications to find out more about how hydroponics is being used around the world. For example, in the Netherlands it is illegal to produce commercial greenhouse crops unless grown in hydroponic, recirculating systems. In Japan, computer controlled vegi-factories can produce hydroponically grown lettuce and herbs in only 30 days. A hydroponicum in Northern Scotland, further north than Moscow, is growing tropical fruits year round in highly insulated grow rooms. Contact your hydroponic supplier for trade magazines, books, internet links and other pertinent resources. Write reports to share your findings.

relationship of science and technology

Investigate how hydroponics fits into the bigger picture of plant biotechnology. Debate the development of biologically engineered plants and animals for food and fiber. What ethical considerations and constraints, if any, should be implemented in future research and development in hydroponics and biotechnology. Does science have a moral obligation to society, and is there any scientific research that should be censored or repressed? Should the profit motive be the driving force for product development, or are humanitarian concerns more important?

careers and occupations using science, mathematics, & technology

Hydroponics is the way of the future for plant biotechnology and environmentally controlled agriculture. First we had the agricultural revolution, then the industrial revolution, and now we are in the information revolution. If the prognosticators are correct, the 21st century will begin with the biotechnology revolution, which will have far reaching effects on agriculture, medicine and renewable resources for business and industry. Along with increased job opportunities comes the need for increased education in the life sciences. Students interested in careers in plant biotechnology should have a strong foundation in genetics, microbiology, hydroponics, environmentally controlled agriculture, and phytochemical processing. If teachers and administrators at the state and local levels rise to the challenge and provide students with the hands-on resources that they need, the future of US bio-science should be very bright indeed.

Information

For more information on hydroponics and plant biotechnology, please contact:

Harley N. Smith
Educational Projects Manager
Superior Growers Supply, Inc.

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Advantages & Uses of Hydroponics

Science Project Ideas

Comparison Hydroponic Science Project Suggestions

Feeding the plants

- Nutrients - with and without trace elements
- pH - nutrient uptake at various pH levels
- Oxygen levels - aeration of the nutrient solution
- Nutrient temperature (ice bag - heat pad)

Environment

- Temperature
- Humidity
- Carbon Dioxide deprivation
- Carbon Dioxide enrichment

Light

- Light intensity levels - distance of light from plants
- Light spectrum comparisons (types of lights) (Kelvin Color Temperature)
- Light color spectrum- cellophane - red, green, blue, etc.
- Day lengths - 6 hours of light, 12 hours, 24 hours, etc.
- Strobe light - bright flashing light - flash rates

Growing Methods

- Active vs. Passive systems
- Bare Root vs. Substrate
- Capillary vs. Flood & Drain
- Raft with aeration vs. Raft without aeration
- Nutrient Film Technique vs. Aeroponics

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Associations

Progressive Gardening Trade Association (PGTA)

Founded to promote the future of the earth-friendly, water-wise, and organic home gardening.

PGTA
10210 Leatherleaf Court, Manassas, VA 20111
Tel: (703) 392-5890 • Fax: (703) 257-0213
www.pgta.org

National Gardening Association

The National Gardening Association is a nonprofit organization established in 1972 to help gardeners, and to help people through gardening. NGA's mission is to renew the fundamental links between people, plants, and the Earth. Through exemplary programs in schools and communities nationwide to promote environmental stewardship, advance standards-based learning and science literacy, and create partnerships that restore and enhance communities.

NGA
1100 Dorset Street
South Burlington, VT 05403
Tel: (802) 863-5251 • Fax: (802) 864-6889
www.garden.org
www.kidsgardening.com

The Garden Writers Association (GWA)

The GWA is comprised of garden professionals including book authors, staff editors, syndicated columnists, free-lance writers, photographers, landscape designers, television and radio personalities, consultants, catalog publishers, extension service agents and more. GWA is the nonprofit association that provides leadership and opportunities for education, recognition, career development, and a forum for diverse interactions for professionals in the field of garden communication. No other organization in the industry has as much direct contact with the buying public as GWA.

Garden Writers Association
10210 Leatherleaf Court, Manassas, VA 20111
Tel: (703) 257-1032 - Fax: (703) 257-0213
www.gardenwriters.org

American Society for Plasticulture

The use of plasticulture in the production of horticultural crops helps to mitigate the sometime extreme fluctuations in weather during the growing season that can kill or injure the crops, or reduce marketable yield. Row covers, low tunnels and high tunnels all have the potential to minimize the effect of these extreme weather events on the crop and optimize plant growth and development in a protected environment. The Air-Inflated Double-Layer Polyethylene Greenhouse has become common in commercial growing facilities. The term plasticulture is defined as the use of plastics in agriculture. This broad term would include plastic film mulches, drip irrigation tape, row covers, low tunnels, high tunnels, silage bags, hay bale wraps, and plastic trays and pots used in transplant and bedding plant production.

American Society for Plasticulture

Patricia E. Heuser, Executive Director
526 Brittany Drive
State College, PA 16803
Tel: (814) 238-7045 • Fax: (814) 238-7051
info@plasticulture.org
www.plasticulture.org

American Society for Horticultural Science

1903 - 2003 “100 Years and Still Growing” ASHS is a cornerstone of research and education in horticulture and an agent for active promotion of horticultural science.

ASHS
113 South West Street
Suite 200
Alexandria, VA 22314-2851
Tel: 703.836.4606 • Fax: 703.836.2024
www.ashs.org

Institute For Simplified Hydroponics

The Institute for Simplified Hydroponics is a U.S. 501(c)(3) nonprofit organization and international NGO formed in 1995 whose mission is to support efforts to reduce hunger and poverty through the introduction of simplified hydroponic gardening techniques to developing communities.

Institute of Simplified Hydroponics
Executive Director Peggy Bradley
Post Office Box 644
Seaside, Oregon 97138
Telephone: (In Mexico) 0052 238 39 21601
info@carbon.org
http://www.carbon.org/

Australian Hydroponics & Greenhouse Association

Representative body for the Australian Hydroponic industry.

AHGA
PO Box 538
NARRABEEN NSW 2101
AHGA Tel/Fax 02 9939 5993
Saskia Blanch: Administrator
administrator@ahga.org.au
www.ahga.org.au

International Society for Soiless Culture

ISOSC, the International Society for Soiless Culture, is a nonprofit, international non-governmental organization (INGO), founded in 1955 under the name International Working Group on Soiless Culture, IWOSC. The purpose of ISOSC is a worldwide promotion of research and application of soiless culture (hydroponics). ISOSC operates as an information centre for research and application of soiless culture. As far as possible the secretariat and the official representatives of ISOSC in several parts of the world provide information on detailed technical questions about hydroponics. About every four years ISOSC organizes an international congress on soiless culture and publishes proceedings of these congresses.

International Society for Soiless Culture
P.O. Box 52
6700 AB Wageningen
Tel: +31 317-413809
Fax: +31 317-423457

International Society for Horticultural Science

Founded in April 1959 as a global network of horticulturists and horticultural scientists seeking international cooperation, today the International Society for Horticultural Science (ISHS), with more than 5,000 members from all over the world, has become the largest and most important international framework for horticultural science.

Through its sections & commissions, working groups, symposia, publications, mailing lists, online services, ISHS membership allows you to develop information networks with colleagues who have similar interests and concerns. Discover job opportunities fast, learn of new techniques and breakthroughs first, and increase your access to scientists who may have solutions to the questions you need to answer today. The ISHS provides its members with a platform allowing them to share knowledge on an international scale.

International Society for Horticultural Science
P.O. Box 500
3001 Leuven 1
Belgium
Phone: +32 16229427 • Fax: +32 16229450
info@ishs.org
www.ishs.org

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Gardening Publications

Hydroponic Gardening Publications

The Growing Edge Magazine

News & Information for Indoor & Outdoor Gardeners. Free subscriptions for teachers and educators.

<http://www.growingedge.com>

Maximum Yield

International hydroponic gardening magazine.

<http://www.maximumyield.com>

Practical Hydroponics & Greenhouse Magazine

The Soilless Culture & Growers Magazine Online. A bimonthly magazine dedicated to soilless culture and protected cropping techniques. This magazine keeps growers, researchers, educators, and allied trades up-to-date with the latest research and product developments, and profiles soilless culture techniques and enterprises worldwide.

<http://www.hydroponics.net.au>

Other Gardening Publications

Dirt Doctor

Howard Garrett, the Dirt Doctor, hosts the popular radio show on WBAP, The Natural Way, and writes a weekly column for the Dallas Morning News, which is featured in the House & Garden section each Friday. He is the producer of the Dirt Doctor's Dirt which is a monthly magazine devoted to organic living.

<http://www.dirtdoctor.com>

Garden Design magazine

Discover Garden Design magazine, the definitive source for down-to-earth style. If you consider your garden an outdoor living room, you'll love *Garden Design*. Free trial issue available.

<http://www.gardendesignmag.com>

GreenPrints

There are over 100 how-to gardening publications in the United States. Only *GreenPrints* shares the human side: the joy, humor, frustrations, and heart in fine prose and fine art. It's the best personal garden writing, old and new. It's funny. It's tender. It's truthful. It's inspiring. There is absolutely no other gardening magazine like it. It's the most unique, most joyful, and most stimulating magazine of them all. If you love to garden, you'll love to read *GreenPrints*!

<http://www.greenprints.com>

Farmers Almanac

America's favorite almanac since 1818.
<http://www.farmersalmanac.com>

Mother Earth News

Lots of home information including the garden.
<http://www.motherearthnews.com>

Organic Gardening

Published by Rodale Press, this is the biggest and most widely read organic gardening publication for modern day organic farming.
<http://www.organicgardening.com>

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Current Book List

**Beginning Hydroponics
Soilless Gardening**
by Richard E. Nicholls

A beginners guide to growing vegetables, houseplants, flowers and herbs without soil. While hydroponic gardening has received much attention in some quarters, it is still an unfamiliar practice to many gardeners. This book is designed to introduce you to the principles and methods of hydroponic gardening. Softcover. 127 pages.

How-To Hydroponics
by Keith Roberto

The complete guide to building and operating your own indoor and outdoor hydroponic gardens. Includes detailed instructions, photos and step-by-step plans. Soft cover. Copyright 1994-2003. 100 pages.

**Hydroponics Questions
& Answers for
Successful Growing**
by Howard M. Resh

A practical Q & A Seminar offering the hands-on experience of a leading hydroponics grower, author and teacher. 287 questions with answers on topics such as plant nutrition; nutritional disorders; essential elements; sterilization methods; greenhouse site, water; backyard greenhouses; physiological disorders; irrigation methods; plant diseases and cures; European cucumbers; environmental needs; herbs; harvesting and storing; baby salad greens; marketing; lettuce and peppers; trends and future needs; tomatoes; and much, much more including an extensive glossary and index.

**Hydroponic home
Food Gardens**
by Howard M. Resh

Howard Resh's bestselling guidebook for home hydroponic gardeners. Tells, and shows, how to grow many fruits and vegetables in a clean, nutritionally enriched, soilless medium ... how to say goodbye to problems of infertile or infested soil, weeds and pests ... how to give plants super nutrition for super growth, appearance and quality.

Scores of photographs, drawings and diagrams make it easy to have a variety of gardens — a simple hydroponic window or deck trays or containers, or full-scale, productive hydroponic gardens or home greenhouse projects. Soft cover. 159 pages.

**Hydroponic Tomatoes For
The Home Gardener**
by Howard M. Resh

Homegrown tomatoes... large, red-ripe, deliciously aromatic and full of flavor. They can be yours again. No previous experience necessary. This book makes growing fantastic hydroponic tomatoes much easier. Presented with easy-to-use terms and procedures. A fine manual for producing home-grown tomatoes hydroponically, with automated procedures that minimize work, problems of weather, plant disease and pests so you can enjoy a bountiful, flavorful crop. Many illustrations help to show the way. Soft cover. 142 pages.

Hobby Hydroponics
by Howard M. Resh

The latest book by Howard M. Resh, the author of the internationally recognized work "Hydroponic Food Production." Hobby Hydroponics is an overview and evaluation of various indoor commercially available hydroponic units. The objective is to inform the reader of the growing aspects of hydroponics at the home level. This includes some of the cultural practices to care for your plants indoors and how to provide them with adequate light, temperatures, etc. to obtain productive plants. The book also describes the types of crops specific hydroponic hobby units are best suited for. Copyright 2003. 161 pages.

Hydroponic Gardening
by Stephen Carruthers

Hydroponic Gardening, designed for beginners of all ages, teaches the basics of hydroponic gardening - how to grow hydroponic plants from seed, and to feed them with naturally balanced nutrients. It also shows you how to transplant plants from soil to hydroponics and how to take clones from valuable plant stock for hydroponic cultivation. Once your hydroponic garden is established, learn all about the fundamental principles of nutrient management and nutrition; how to recognize and remedy nutritional disorders; how to combat pests and diseases the natural way; how to maintain an ecological balance in your hydroponic garden; and lots more. Soft cover. 64 pages.

Hydroponic Capsicum Production
by Dr. Lynette Morgan, Ph.D.

Is it capsicums or peppers; chilli or chili? I suppose it depends on what neck of the woods you come from. Capsicums have also become an increasingly important commercial hydroponic crop, which is the basis for Dr Lynette Morgan's second book, *Hydroponic Capsicum Production*. Using hydroponic and protected cropping techniques, capsicums can be produced year-round, with the benefits of faster, cleaner production and a premium quality end-product.

This comprehensive book is designed to provide essential cultural information of a practical and scientific nature for existing and intending hydroponic capsicum growers. The author writes that the pungency of any chili plant is influenced greatly by environmental conditions, with the concentrations of capsaicin increasing with plant stress factors, such as drought and high temperatures.

Illustrated throughout with color photographs and line drawings, *Hydroponic Capsicum Production* represents an essential handbook for hydroponic capsicum production. Its publication coincides with the recent introduction of new colored capsicum varieties rich in Vitamin A and C, which have energized fresh produce markets at a premium price. 128 pages, soft cover.

Hydroponic Lettuce Production
by Dr. Lynette Morgan, Ph.D.

The hydroponic production of lettuce has revolutionized the salad industry worldwide. Crops can be produced year round, with the benefits of faster, cleaner production and a premium quality end-product. At the same time, newer varieties of lettuce, with improved colors and leaf shapes, have seen the market expand dramatically.

This book is designed to provide essential information of a practical and scientific nature for current and prospective hydroponic lettuce growers. While hydroponic salad crops are often seen as being easier to produce than fruiting crops, such as tomatoes and cucumbers, the degree of skill required to produce a quality product and effectively utilize hydroponic technology is still high. The text explores everything from the background physiology of the lettuce plant, to the details of growing systems and management, raising seedlings, selecting cultivars, nutrition, pests and diseases, and harvesting.

Hydroponic Lettuce Production represents an essential handbook for salad production in the 21st Century. 114 pages, soft cover.

Hydroponic Food Production - Sixth Edition
by Howard M. Resh

The most concise textbook on hydroponic food production available. A comprehensive guide to soilless culture, the new sixth edition, published in 2001, is extensively new and updated with 450 photographs, drawings and tables plus directories, addresses, references, bibliography and a complete index. This deluxe hardcover edition explains all facets of food production and hydroponic gardening. A complete review of nutrients, mediums, plant varieties and techniques used for the commercial grower and advanced home hobbyist.

Topics include Plant Nutrition; The Nutrient Solution; The Medium; Water Culture; Nutrient Film Technique; Gravel Culture; Sand Culture; Sawdust Culture; Rockwool Culture; Other Soilless Cultures including peat, vermiculite, pumice, synthetic foams, coco coir, peatlite, rice hulls, perlite, slabs, bato buckets, sack culture; Tropical Hydroponics and Special Applications; Plant Culture and much, much more. Hardcover. 567 pages.

Hydroponic Tomato Production

by Jack Ross

A Practical Guide To Growing Tomatoes In Containers. For greenhouse growers and hobbyists alike, hydroponics has become recognized as a way of producing tomatoes with flavor. Hydroponic Tomato Production looks comprehensively at the range of soilless techniques available and how to manage them successfully. Jack Ross compares different media, nutrient levels and irrigation regimes and includes the results of numerous experimental research trials into tomato cultivation. Chapters on the physiology of tomatoes, nutrient and pH requirements, growth factors, pests & diseases, harvesting and packaging also feature. The book includes a listing of 20 of the best tomato varieties for hydroponic production in containers, and how to grow them successfully. Soft cover. 207 pages.

The Insatiable Gardener's Guide — How to Grow Anything & Everything Indoors, Year 'Round

by Susan M. Brackney

Do you mean I can grow a banana tree in my house? And what about orchids? Or cucumbers or basil or tomatoes? Indoors? Absolutely! It's easy with The Insatiable Gardener's Guide. You can grow all that and more - 365 days a year. You can create the garden of your dreams - no matter where you live! This is a fun and easy to read book with excellent information. Soft cover. Copyright 2003. 143 pages.

The ABC of NFT

by Dr. Allen Cooper

Dr. Allen Cooper devised the Nutrient Film Technique (NFT) and perfected its practical application through his research work at the Glasshouse Crops Research Institute in the UK. The development of commercial NFT cropping enterprises around the world has been mainly due to the work contained in this visionary book. But even today, the full scope of Dr. Cooper's vision for NFT has not been fully explored. When first published in 1979, The ABC of NFT quickly established itself around the world as the "hydroponic NFT bible". Now reprinted, it remains the expert text on the practical application of the nutrient film technique in horticulture. Soft cover. 172 pages.

Nutrients - The Handbook to Hydroponic Nutrient Solutions

by Dr. Carl Barry

An authoritative text on the hydroponic nutrient solution. In six chapters, this book looks at the difference between liquid and powdered nutrients, single-packs or twin-packs, grow and bloom formulations, and organic nutrients. A premiere force in the development of hydroponic nutrients for both the hobby and commercial markets, Dr. Carl Barry examines nutrient concentrations and the availability of nutrient elements to plants, and looks in detail at chemical tests, reverse osmosis, disinfestation of water, and the importance of aeration.

In addition, the author explores the importance of nutrient solution temperatures, nutrient strength (electroconductivity), and the acidity (pH) of the nutrient solution. Dr. Barry also describes in detail a new non-chemical method of pH control for the nutrient solution. Nutrient solutions develop imbalances over time - there is no nutrient solution that will not do this. The author outlines 10 steps to determine nutrient deficiencies, and examines common nutritional disorders. He also provides expert advice on how to correct nutritional problems. Well illustrated with photographs, charts and tables, this book is as much for the beginner as it is for the commercial grower. Soft cover. 54 pages.

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Internet Resources

Antarctica Hydroponics

Hydroponics in Antarctica is as unique as the continent itself. The extreme environmental conditions found here make the process of growing food a formidable challenge. Four months of solid daylight, four months of total darkness, and unpredictable winds and temperature changes present a unique growing situation. One cannot simply build a glasshouse, set up a system, and expect tasty produce to grow! However, in Antarctica, successful harvests are achieved on a daily basis.

<http://www.antarctichydroponics.com>

History of Hydroponics by Gary V. Deutschmann, Sr.

An excellent article covering the history and future of hydroponic gardening.

<http://archimedes.galilei.com/raiar/floricul.html#hydroponics>

HydroponicVegetableGar- dening.com

Jim Taylor offers practical advice, free hydroponic system plans and visual results of his hydroponic gardening research. Jim demonstrates some pretty awesome results, and you can purchase all of his research material for a very reasonable price.

<http://www.hydroponicvegetablegardening.com>

Growing Hydroponic Tomatoes

This interactive web site by the University of Arizona provides practical, accurate information on growing hydroponic tomatoes for students, hobbyists, and beginning growers.

<http://ag.arizona.edu/hydroponictomatoes>

Cornell University Controlled Environmental Agriculture (CEA)

Cornell's information gateway for Controlled Environment Agriculture. A program of the College of Agriculture and Life Sciences in the Department of Biological and Environmental Engineering. Includes individual electronic handbooks for the production of CEA hydroponic lettuce, spinach and Pak choi. Also contains information on opportunities regarding the study of CEA at Cornell University.

<http://www.bee.cornell.edu/extension/CEA/indexV4.htm>

Handbook for the Production of CEA-Grown Hydroponic Lettuce

This handbook is designed to be a comprehensive manual for the production of pond-grown CEA (Controlled Environment Agriculture), or greenhouse, lettuce. More importantly thanks to the innovation of the world wide web, it is designed to be interactive. From Cornell University.

http://www.bee.cornell.edu/extension/CEA/Lettuce_Handbook/introduction.htm

**Handbook for the
Production of CEA-Grown
Hydroponic Spinach**

This handbook is designed to be a comprehensive manual for the production of Nutrient Film grown CEA (Controlled Environment Agriculture), or greenhouse, spinach. More importantly, it is designed to be interactive. From Cornell University.
http://www.bee.cornell.edu/extension/CEA/Spinach_Handbook/sp_introduction.htm

**Handbook for the
Production of CEA-Grown
Hydroponic Pak choi**

This handbook is designed to be an introductory manual for the production of Nutrient Film (NFT) grown CEA (Controlled Environment Agriculture), or greenhouse, pak choi. More importantly, it is designed to be interactive. From Cornell University.
http://www.bee.cornell.edu/extension/CEA/Pakchoi_Handbook/pc_introduction.htm

Hydroponics As A Hobby

This circular was prepared by James C. Schmidt, Assistant Extension Horticulturist, John M. Gerber, Assistant Professor of Horticulture, and J. W. Courter, Professor of Horticulture, University of Illinois at Urbana-Champaign, based on an earlier edition prepared by J. D. Butler and N. F. Oebker.
http://www.ag.uiuc.edu/~vista/html_pubs/hydro/hydrotoc.html

**Hydroponics - The
Weedless Garden**

Hydroponic hobby guru Ray Schneider shares his ongoing backyard hydroponic gardening adventures. Rays' take on hydroponics? "Is this a great hobby or what?"
<http://users.adelphia.net/~schneirj/hydro.htm>

**Role Of Perlite In
Hydroponic Culture**

A research report issued by the Perlite Institute, Inc. by Dr. David A. Hall, Principal of the Pershore College of Horticulture in the United Kingdom.
http://www.perlite.org/perlite_info.htm

**Horticultural Uses Of
Perlite And Vermiculite**

The Perlite Institute and The Schundler Company have developed an extensive file of brief, but useful Plant Guides on the many uses of perlite and vermiculite.
<http://www.schundler.com/hort.htm>

**Crop Physiology
Laboratory - Hydroponics**

From Utah State University, a site dealing with recirculating nutrient management, with an emphasis on wheat and soybean production.
http://www.usu.edu/cpl/research_hydroponics.htm

ProgressiveGardening.Org

ProgressiveGardening.org was created to keep you abreast of the latest gardening techniques, supplies, and equipment so that everyone can reap the numerous benefits, including increased yields, reduced need for pesticides, food safety, water conservation, and more that have been made attainable through the continuing advancements in horticultural science.
<http://www.progressivegardening.org>

**CuisinArt Resort
Hydroponic Farm**

We invite you to enjoy a guided tour of the CuisinArt Hydroponic Farm with Dr. Howard Resh. Unique to CuisinArt Resort, the trend setting Hydroponic Farm produces fresh vegetables, edible flowers and herbs daily.
<http://www.cuisinartresort.com/view2.php?catID=39&pID=59>

Hydroponics; Information on Commercial and Non-Commercial Hydroponic Vegetable Production

This site contains information on commercial, home and hobby vegetable production. Much of this information comes from the TAEX publication on Greenhouse Vegetable Production. From Texas A&M University, Aggie Horticulture.
<http://aggie-horticulture.tamu.edu/greenhouse/hydroponics/index.html>

Budget For Greenhouse Tomatoes

The business of raising greenhouse crops, or hydroponically grown plants such as tomatoes, is popular among small producers who want to diversify their farms, or for landowners looking for supplemental income. Before breaking ground for a new greenhouse, you must understand the major time commitment and amount of work involved.
<http://msucares.com/pubs/publications/p2257.pdf>

The Hydroponic Vegetable Program

The Hydroponic Vegetable Program is designed to foster hydroponic greenhouse vegetable businesses in Ohio by providing horticultural, marketing, business planning and greenhouse design support. The support is provided by direct contact with individuals, seminars, tours, interactive Internet websites and demonstration greenhouses at the Toledo Botanical Garden, Toledo, Ohio and The Agricultural Incubator Foundation, Bowling Green, Ohio.
<http://www.oardc.ohio-state.edu/hydroponics/ABE/abe.htm>

Grow Your Own Vegetables Without Soil

Growing plants without soil is often called hydroponics. The name implies that the plants are grown in water containing dissolved nutrients. However, pure water culture is only one of the many methods employed. All of the other methods might simply be grouped as “soilless” culture, which would include sand culture, gravel culture, and culture utilizing other soil substitutes such as sawdust, wood shavings and vermiculite. The information reported here in “Grow Your Own Vegetables Without Soil” should be beneficial to the gardening enthusiast who wishes to try hydroponics as a hobby. From The Florida Cooperative Extension Service
http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_VH030

Institute For Simplified Hydroponics

The Institute for Simplified Hydroponics is a US 501(C)(3) nonprofit organization and international NGO formed in 1995 whose mission is to support efforts to reduce hunger and poverty through the introduction of simplified hydroponic gardening techniques to developing communities.
<http://www.carbon.org>

Progressive Gardening Media Kit

Historical Books List

Soilless Growth Of Plants:

Use of Nutrient Solutions,
Water, Sand, Cinder, Etc.
by Carleton Ellis &
Miller W. Swaney

Copyright, May 1938; Reinhold Publishing Corporation

Carleton Ellis was a prolific inventor of his day with over 750 patents in his name, the third largest awarded to any single person at that time. Some of his more famous inventions include vegetable oil margarine, polyester copolymers, and many others.

**Chemical Gardening For
The Amateur: Gardening
Without Soil Made Easy**
by Charles H. Conners
& Victor A. Tiedjens

Copyright, 1939; Wm. H. Wise & Co.

— *Dr. Charles H. Conners was a Professor of Ornamental Horticulture at Rutgers University and Ornamental Horticulturist at the New Jersey Agricultural Experiment Station.*

— *Dr. Victor A. Tiedjens was an Associate Professor of Vegetable Gardening in the College of Agriculture of Rutgers University and Associate Olericulturist at the New Jersey Agricultural Experiment Station. Dr. Tiedjens went on to found Growers Chemical Corporation (which was later changed to Growers Nutritional Solutions) in 1955 with Joseph P. Henry and George B. Ward. Dr Tiedjens also pioneered hydroponics growth techniques while working for Standard Oil of New Jersey in Aruba and Curacao in the West Indies. He authored many articles and books regarding horticulture as well.*

**Growing Plants In Nutrient
Solutions or Scientifically
Controlled Growth**
by Wayne I. Turner &
Victor M. Henry

Copyright, 1939; John Wiley & Sons, Inc., New York, NY U.S.A.

Senior author Wayne Turner was recognized as one of the finest rose growers in the country.

Gardening Without Soil
by A. H. Phillips

Published, October 1939, C. Arthur Pearson Ltd., Great Britain

**The Complete Guide to
Soilless Gardening**
by Dr. W.F. Gericke

Copyright, March, 1940; Prentice-Hall, Inc., New York, NY U.S.A.

In the late 1920s and early 1930s, Dr. William F. Gericke of the University of California extended his laboratory experiments and work on plant nutrition to practical crops growing outside for large scale commercial applications. In doing so he termed these nutriculture systems "hydroponics". The word was derived from two Greek words, hydro, meaning water and ponos meaning labor - literally "water-working". His work is considered the basis for all forms of hydroponic growing, even though it was primarily limited to the water culture without the use of any rooting medium.

Soilless Culture Simplified

by Alex Laurie

Copyright, 1940; McGraw-Hill Book Company., Inc., New York, NY U.S.A.

— **Professor Alex Laurie** was born in France in 1892 but was brought to America in 1903. He emigrated to this country where he graduated from Townsend House High School in New York City. He received his B.S. degree at Cornell University in 1914 and his M.A. from Washington University in St. Louis, Missouri in 1917.

Professor Laurie became instructor of horticulture at the University of Maine in 1914. However he went to the Missouri Botanic Garden in St. Louis in 1916 where he remained until 1920. After five years in commercial floriculture (1920-25) he became Assistant Professor of Horticulture at Michigan State College in 1925. In 1929 he became Professor of Horticulture at The Ohio State University and Associate Horticulturist of the then Ohio Agricultural Experiment Station. He retired in 1952 and became Emeritus Professor. In 1952 he went into private business in Florida.

He was president of the American Society for Horticultural Science in 1936. He was also a member of the Royal Horticultural Society of London. For some years he was secretary-treasurer of Roses, Inc.

Growing Plants Without Soil

— The A.B.C. of Plant Chemiculture (Soilless Agriculture, Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture)

by D.R. Matlin, M.A.

Copyright, 1940; Chemical Publishing Co., Inc., Brooklyn, NY U.S.A.

D.R. Matlin, M.A., was the Professor of Plant Chemiculture at the Belmont Evening High School in Los Angeles, California.

Chemical Gardening:

Latest Developments in
Soilless Culture of Plants

by D.R. Matlin, Ph.D.

Copyright, 1942; Chemical Publishing Co., Inc., Brooklyn, NY U.S.A.

D.R. Matlin, Ph.D. was the Professor of Plant Chemiculture at the Belmont Evening High School in Los Angeles, California and a Plant Technologist at the Palos Verdes Hydroponic Gardens in Palos Verdes, California.

Success Without Soil:

**How to Grow Plants by
Hydroponics**

by Charles C. Gilbert

Copyright, 1948, Charles C. Gilbert & Company, San Diego, CA U.S.A.

Mr. Gilbert was one of the first to commercially exploit the popularity of hydroponics at the time by marketing the first nutrient solutions to commercial and hobby growers.

The Tanks Are Coming:

Practical Hydroponics

by Earle A. Spessard

Copyright, 1948, Earle Augustus Spessard, Little Rock, AR U.S.A.

Published by Hydroponics, Inc., Little Rock, AR U.S.A.

Mr. Spessard was a Professor of Biology at Hendrix College, Little Rock, AR U.S.A.

Hydroponics:

The Bengal System

by J. Sholto Douglas

Copyright, 1951, Oxford University Press, London

James Wilfrid Eric Hamilton Sholto Douglas is the originator of the Bengal system of hydroponics.

Successful Gardening

Without Soil

by C.E. Ticquet

with a foreword by Professor R.H. Stoughton D.Sc.

Copyright, 1952, C. Arthur Pearson Ltd., Great Britain

Soilless Culture

by T. Saunby

Copyright, 1953, W. H. & L. Collingridge, Ltd. (The Hamlyn Group), Great Britain
Mr. Saunby was a commercial grower in Cornwall who had been practicing methods of soilless cultivation for some years.

Progressive Gardening Media Kit

Debunking the Myths

Myths & Misconceptions

Hydroponics is a term that is recognizable to many people, mostly because they have been exposed to it at school, or at Disney's EPCOT Center. However, the use of hydroponics in commercial food production and home gardening is not well known. As a result, many myths and misconceptions have arisen around the use of hydroponics. Some of these myths are amusing, while others maliciously malign the gardening method and those in the hydroponic industry. Here is a sampling of some of the more common misconceptions.

Complicated

MYTH: Hydroponics is complicated.

Although this one used to be true, a wide variety of simple, off-the-shelf, ready-to-grow systems, are now widely available. Pre-mixed nutrients have made hydroponics easy. Years ago, you almost had to be a chemist to get all the nutrient elements mixed in the proper amounts for optimum growth. Now you just add pre-mixed nutrients to the water according to the label. With simple systems complete with seeds, you just add water and sunshine (or water and a grow light). It is now possible for consumers with no hydroponic experience to have success, the first time out.

Too scientific

MYTH: Hydroponics is too scientific.

It doesn't have to be. Scientists do use hydroponics as a research tool for finding the precise nutrients and growing conditions for optimum plant production. As a result, considerable reporting is done on the science of hydroponics. This reporting can leave the impression of being complex and scientific. However, simple hydroponic systems with pre-mixed nutrients can make gardening very easy. No more over-watering or under-watering the soil. Hydroponics can also eliminate fighting soil-borne weeds and pests. In addition, gardening indoors can eliminate fighting the weather and eliminate seasonal restrictions.

Tasteless/full of water

MYTH: Plants grown hydroponically are full of water and tasteless.

Hydroponics helps plants grow to their fullest genetic potential. They may grow faster, mature earlier, and produce higher yields, but the plants will look and taste the same as those grown by other methods, provided they get all the nutrient elements they need.

Bigger & more potent

MYTH: Plants grown hydroponically are super plants that are bigger and more potent.

You harvest what you plant. If you plant Cherry Tomato seeds you cannot harvest Better Boy Tomatoes, no matter what gardening method you use. Hydroponics can help make the tomato taste as good as it can taste. Hydroponics will help the plant perform the best it can, but it cannot make a tomato look, or taste, like a cucumber.

Absolutely any plant that can be grown in soil, can be grown hydroponically. It is just a different way of feeding the roots. The key to hydroponics is a COMPLETE nutrient. That is, a nutrient with ALL the trace minerals that plants need to grow, such as copper, iron, zinc, boron, calcium, etc. Using a complete nutrient ensures the plant gets everything it wants, without excessive amounts of any elements.

If you plant a tomato seed in soil, and you have the perfect soil conditions, the perfect environment, the right amount of water, fertilizer, and aeration of the soil, the right amount of sunshine - if everything is just perfect, your tomato will taste just as good as a tomato grown hydroponically. Of course that assumes you had the perfect conditions for the hydroponically grown tomato, as well. And, of course, hydroponic gardeners know creating the perfect conditions for the plants is much, much easier when you eliminate all the guesswork and variables inherent in a soil garden.

Chemical taste

MYTH: Plants grown hydroponically have a chemical taste.

Whether grown in soil or hydroponically, when a plant gets the right amount of each and every nutrient element it wants and needs, it will taste as good as it possibly can. The mineral nutrients added to water in hydroponic production are exactly the same chemicals taken up by the plant from the soil. Thus, the taste of the fruit will be the same, or even better in hydroponics, because the growing conditions are better. In fact, because you know exactly what you are adding to the nutrient mix in hydroponics there is much less chance of having unwanted chemicals, such as lead, or other heavy metals, that may be present in the soil.

Organic tastes better

MYTH: Organically grown plants taste better than those grown hydroponically.

Taste and flavor are most often memories from our youth. When Grandfather first handed you a vine ripe tomato from the garden and declared it to be a great tasting tomato, he created the standard by which all future tomatoes are judged. Whether grown in soil or in hydroponics, if the plant gets everything it wants, it will reward you with great taste and nutritional value. Hydroponic growers tend to have more precise control to optimize flavor and nutritional value of the produce.

Not organic

MYTH: Hydroponic nutrients are not organic.

A wide array of organic nutrients are readily available to the hydroponic gardener. In early plant research, scientists used precise amounts of chemical elements to determine how each element affected plant growth. This has left the mistaken impression that only chemical elements work in hydroponics. Many gardeners still prefer the precision and repetitiveness they get by using pre-mixed hydroponic nutrients.

Never grown organically

MYTH: Plants grown hydroponically are never organically grown.

Organic is a term with many definitions and opinions. Technically, plants cannot be grown totally organically. Plants must have copper, iron, calcium, zinc, boron, etc. These are inorganic mineral elements. In some opinions, if those elements are available in a nutrient derived from bat guano, fish water, or other plant or animal sources, then the nutrient would be considered organic. Therefore the produce could also be certified as organically grown. This would be true whether the organic sourced nutrient was poured onto the ground near the plants, or delivered through a hydroponic system. Since weed sprays and pesticides are normally not used on organically grown nor on hydroponically grown produce, either method could be certified as organically grown.

Chemical is bad

MYTH: Organic is good, chemical is bad.

Neither organic Ecoli nor the chemical Arsenic are good for us. Whether a product is chemical based, or organic based, does not make the product good or bad. It is the use or misuse of the product that makes it good or bad. Hydroponic gardening actually reduces the need for harmful pesticides and weed sprays. Hydroponic gardeners can use either organic or mineral based nutrients, or a combination of both.

Hydroponic seeds are best

MYTH: Hydroponic seeds are best to grow hydroponic plants.

Anything that can be grown in soil, can be grown hydroponically. Hydroponics is a gardening method. There is no such thing as a hydroponic seed.

**Only works indoors
& under lights**

MYTH: Hydroponics only works indoors and under lights.

Hydroponics is a growing method and is often used outdoors where climates are compatible to grow plants for longer times. Controlling the environment to increase crops per year productivity typically goes hand in hand with control of the nutrients for optimum growth. Greenhouse production allows for plants to grow all year long while still using sunlight. Greenhouse production also helps control pest damage without the use of pesticides. Greenhouse growers often use grow lights to extend the day length to further control the seasons for best plant performance.

Bringing the plants totally indoors allows for even better control of seasons and light and dark idiosyncracies of particular plants. Most homes already control the environment to make it more comfortable for the people who live there. Basically, if it is comfortable for you, it is comfortable for your plants. It is often easier to bring your plants into your home than it is to build a greenhouse or create a separate comfortable place for your plants.

Increases power bill

MYTH: Gardening with grow lights will dramatically increase my power bill.

Your power bill is based on kilowatt hours (1000 watts for one hour). Looking at your power bill should tell you the cost per kilowatt hour (KWH). In many areas of the U.S. a 1000 watt light will run for less than ten cents per hour. A 250 watt light will run for four hours for less than ten cents on your power bill. The total wattage used will determine your power bill. High intensity grow lights are the most cost efficient lights to operate in terms of lumens of light emitted per watt of power consumed. For example, incandescent grow bulbs put out about 17 lumens per watt, while a high pressure sodium grow light will put out about 140 lumens per watt. Much more performance for your energy dollar.

24-hour light operation

MYTH: Grow lights must be operated 24 hours a day.

The length of light and dark are one of the main factors plants use to determine the season, and therefore adjust their growth cycle. Long days mean summer while shorter days mean fall and that winter is approaching. Most plants accelerate flower and fruit production in fall, to prepare for winter. With grow lights, you can control the season and have a long, long summer days, everyday of the year.

Damages eyes

MYTH: High intensity lights will damage my eyes.

Looking directly at the Sun will hurt your eyes. It is not comfortable to look at any very bright light. A grow light can be considered indoor sunshine and is very bright by design. Indoor gardeners learn very quickly not to look directly at the light bulbs.

Get a suntan

MYTH: I can get a good suntan when gardening under high intensity lights.

High intensity garden lights have the best color spectrum for growing plants. Plants do not need massive amounts of light in the Ultra Violet range. Therefore, good grow lights do not have the light spectrum needed to burn human skin.

**Higher voltage,
less power bill**

MYTH: Changing my lights to run at 240 volts rather than 120 volts will cut my power bill in half.

Your power bill is based on kilowatt hours. Ohm's Law of Power says volts times amps equals watts. Although doubling the voltage will cut the amperage in half, the watts remains the same. A 1000 watt light bulb will use 1000 watts regardless of the voltage used to drive it.

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2007-2008

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