**How To Hydroponics, Keith Roberto, 4th edition, 2003**

**p35**

nutrients may become unavailable to the plant if the solution pH drifts from an optimal reading, which for most plants is between 6.0 and 6.5. This condition is called "nutrient lockout"

**p37**

First of all, warm water holds less disolved oxygen than cool water, so keep your nutrient temperature between 68-75 degrees F. Secondly, keep the nutrient circulating so it’s constantly picking up oxygen. Anywhere there is falling, spraying or rapidly moving water, you can assume dissolved oxygen is being added. If you have a large reservoir that circulates very slowly, adding a small aquarium pump can help supply extra oxygenation.

**p38**

However, in your greenhouse or grow room, you will need to help your plants breathe by supplying a constant exchange of fresh air, which by nature contains about 2% CO2. To determine the size of the fan that is necessary, simply multiply the length of your growing area by its height and then by its width. This number (use feet as a measurement unit) will be the Cubic Feet of your area. When buying a fan, you will notice that they are sold according to "Cubic Feet per Minute," or CFM ratings. What this means is the amount of air this particular fan will move in one minute.

**p39**

CO2 is measured much the same way as nutrient in solution, that is, PPM (Parts Per Million). Most gardens and crops will benefit significantly when the concentration of available CO2 is kept between 1000 and 1600 PPM.

**p49**

CO2 - In enclosed environments, the normal concentration of CO2 (325-425 PPM) can rapidly be depleted, resulting in slowed growth due to the lack of photosynthesis taking place. Providing plenty of fresh air or supplemental CO2 (in the range of 1000-1500 PPM) will keep chlorophyll activity constant and plants growing rapidly.

**p41**

**Duration (Photoperiod):** Most plants grow best when exposed to 16-18 hrs of light per day. Additional hours of light during the day have not been found to increase growth by any significant amount. Plants that exhibit photoperiodism, the trait that causes day length to trigger flowering, should be exposed to 12-14 hours of light once flowering is desired. Total darkness is required during the darkness.

**p42**

**Color (Photosynthetic spectrum)**

Photosynthesis is most pronounced in the red (600-680nm) and blue (380-480nm) wavelengths of light. Horticultural lighting, also know as High Intensity Discharge (HID) lighting is designed to cover these specific wavelengths, known as the PAR spectrum (photosynthetically active radiation).

**revisar p50 y p51**

**p52**

**Successful Seed Starting**

From my experience working with many different means of starting seeds, I have developed a simple and reliable method for successful germination.

1. Pre-moisten starting medium w/ 1/2 strength nutrient, pH6.0

2. Maintain a root zone temperature of 72-80 degrees.

2. Maintain air temp. at 70-78 degrees and 70-90% humidity.

3. Soft light (20 watt/sq. ft.) until most sprout, then increase.

4. Feed 1/2 strength nutrient until light intensity is increased.

5. Discard weak and slow growing seedlings.

5. Move seedlings to production area once a second set of true leaves appears.

Seedling heat mats are an excellent way to speed germination, especially when you are growing out of season. They are also useful when cloning which is discussed on the following page. I have heard that presoaking seeds in a solution of water and 10% hydrogen peroxide can get them to germinate faster too. I’ve had some success with this trick, give it a try!

**cultivo en hidroponía, José Beltrano y Daniel O. Gimenez, Facultad de Ciencias Agrarias y Forestales, Editorial de la niversidad nacional de la plata, primera edición, 2015**

**p92**

Los fertilizantes tienen un efecto considerable sobre el pH del agua de irrigación, en la que

se los disuelve. El pH óptimo de la solución del suelo está entre 5.5 y 7.0. Valores demasiado

altos de pH (>7.5) Disminuye la disponibilidad del Fósforo, Zinc y Hierro para las plantas y se

pueden formar precipitados de carbonatos y ortofosfatos de Calcio y Magnesio en las tuberías

y emisores. Cuando aumenta el pH de la solución de riego, las opciones para reducirlo son el

ácido nítrico (HNO3) o ácido fosfórico (H3PO4), con la ventaja que proveen a las plantas de

Nitrógeno y Fósforo, respectivamente. Valores demasiado bajos de pH (<7.5) Puede aumentar

las concentraciones de Aluminio y Manganeso hasta niveles tóxicos. Al mezclar dos

soluciones fertilizantes, pueden formarse precipitados.

**p100 – p102**

Control del riego a traves del ciclo del cultivo

P1: Periodo 1.

A. Desde el primer riego hasta que empieza a drenar

B. Incremento constante de la humedad

C. Primer riego cuando la planta está en actividad

P2: Periodo 2 o periodo de drenaje

A. Desde el primer drenaje hasta el último riego.

P3: Periodo 3.

A. Desde el último riego al primer riego siguiente.

Características del riego en función del amanecer y del incremento del contenido hídrico.

Periodo 1

Inicio del Riego Tiempo en función del amanecer

0-1 horas después del amanecer Temprano

1-2 horas después del amanecer Normal

2-4 horas después del amanecer Tardío

Incremento del contenido de humedad del sustrato/día en P1

Incremento del CH en P1 Tipo de incremento

0-5% Pequeño

5-10% Normal

10-15% Grande

Periodo 2 o periodo de drenaje.

Tiempo de Drenaje después del primer riego Tiempo Relativo

1-2 horas después del primer riego Temprano

2-3 horas después del primer riego Normal

3-4 horas después del primer riego Tardío

FIN DE RIEGO TIEMPO RELATIVO

0-1 horas antes del atardecer Temprano

1-3 horas antes del atardecer Normal

3-6 horas antes del atardecer Tarde

Con muy baja radiación se puede estar sin drenaje dos días. Con alta radiación, drenaje

20%, puede aumentar la CE, cambiar el pH o generar desbalances nutricionales

Periodo 3.

Perdida del CH en % , 3 horas después del

último Riego

Causas

0-2% Riego muy tardío

2-4% Fin de riego en el momento adecuado 102

>4% Detención del riego muy temprano

Diferencia del CH en %, entre dia/noche Iinfluencia en el Desarrollo de la Planta

4-6% Vegetativa

6-8% Normal

8-12% Reproductiva

**Introduction to Controlled Environment Agriculture and Hydroponics, by Patricia A. Rorabaugh, Ph.D. Merle H. Jensen, Ph.D. Gene Giacomelli, Ph.D. CHAPTER 12 GREENHOUSE CONTROL SYSTEMS**

# Hydroponics as a Hobby: growing plants without soil, UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE EXTENSION SERVICE IN AGRICULTtJRE AND HOME ECONOMICS, This circular was prepared by J. D. BUTLER, Assistant in Horticulture, and N. F. OEBKER,

**Requirements for Plant Growth**

Hydroponic systems will not compensate for poor growing conditions such as improper temperature, inadequate light, or pest problems. Hydroponically grown plants have the same general requirements for good growth as field-grown plants. The major difference is the method by which the plants are supported and the inorganic elements necessary for growth and development are supplied.  
  
**Temperature.** Plants grow well only within a limited temperature range. Temperatures that are too high or too low will result in abnormal development and reduced production. Warm-season vegetables and most flowers grow best between 60° and 75° or 80° F. Cool-season vegetables such as lettuce and spinach should be grown between 50° and 70° F.  
  
**Light.** All vegetable plants and many flowers require large amounts of sunlight. Hydroponically grown vegetables like those grown in a garden, need at least 8 to 10 hours of direct sunlight each day to produce wells Artificial lighting is a poor substitute for sunshine, as most indoor lights do not provide enough intensity to produce a crop. Incandescent lamps supplemented with sunshine or special plant-growth lamps can be used to grow transplants but are not adequate to grow the crop to maturity. High intensity lamps such as high-pressure sodium lamps can provide more than 1,000 foot-candles of light. The serious hobbyist can use these lamps successfully in areas where sunlight is inadequate. The fixtures and lamps, however, are very expensive and thus not feasible for a commercial operation.  
  
Adequate spacing between plants will ensure that each plant receives sufficient light in the greenhouse. Tomato plants pruned to a single stem should be allowed 4 square feet per plant. European seedless cucumbers should be allowed 7 to 9 square feet, and seeded cucumbers need about 7 square feet. Leaf lettuce plants should be spaced 7 to 9 inches apart within the row and 9 inches between rows. Most other vegetables and flowers should be grown at the same spacing as recommended for a garden.  
  
Greenhouse vegetables, whether grown in soil or in a hydroponic system, will not do as well during the winter as in the summer. Shorter days and cloudy weather reduce the light intensity and thus limit production. Most vegetables will do better if grown from January to June or from July to December than if they are started in the fall and grown through the midwinter months.  
  
**Water.** Providing the plants with an adequate amount of water is not difficult in the water culture system, but it can be a problem with the aggregate culture method. During the hot summer months a large tomato plant may use one-half gallon of water per day. If the aggregate is not kept sufficiently moist, the plant roots will dry out and some will die. Even after the proper moisture level has been restored, the plants will recover slowly and production will be reduced.  
  
Water quality can be a problem in hydroponic systems. Water with excessive alkalinity or salt content can result in a nutrient imbalance and poor plant growth. Softened water may contain harmful amounts of sodium. Water that tests high in total salts should not be used. Salt levels greater than 0.5 millions or 320 parts per million are likely to cause an imbalance of nutrients. The amateur chemist may be able to overcome this problem by custom mixing the nutrient solutions to compensate for the salts in the water.  
  
**Oxygen.** Plants require oxygen for respiration to carry out their functions of water and nutrient uptake. In soil adequate oxygen is usually available, but plant roots growing in water will quickly exhaust the supply of dissolved oxygen and can be damaged or killed unless additional air is provided. A common method of supplying oxygen is to bubble air through the solution. It is not usually necessary to provide supplementary oxygen in aeroponic or continuous flow systems.  
  
**Mineral Nutrients.** Green plants must absorb certain minerals through their roots to survive. In the garden these minerals are supplied by the soil and by the addition of fertilizers such as manure, compost, and fertilizer salts. The essential elements needed in large quantities are nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Micronutrients - iron, manganese, boron, zinc, copper, molybdenum, and chlorine are also needed but in very small amounts.

**Controlled environment Agriculture (Scopyng Study), september 1996, Cornell University, Louis D. Albright, Robert W. Langhans**

|  |  |
| --- | --- |
| **TERMINOLOGÍA DE REQUERIMIENTOS AMBIENTALES** | |
|  |  |
| **REQUERIMIENTOS AMBIENTALES** | **RANGO** |
| Temperatura alta | 75 - 80 F day, 65 - 70 F night |
| Temperatura intermedia | 70 - 75 F day, 60 - 65 F night |
| Temperatura baja | 65 - 70 F day, 55 - 60 F night |
| Dióxido de carbono alto | 1000 ppm |
| Dióxido de carbono intermedia | 600 ppm |
| Dióxido de carbono bajo | ambient (350 ppm) |
| Humedad relativa alto | 70 - 90 % |
| Humedad relativa intermedia | 50 - 75 % |
| Humedad relativa baja | 30 - 50 % |
| Iluminación alta | > 20 mol/m2-day |
| Iluminación intermedia | 15 - 20 mol/m2-day |
| Iluminación baja | 10 - 15 mol/m2-day |

**4.3 IRRIGATION**

The frequency of irrigation cycles depends on the nature of the plant; plant stage of growth; weather conditions (greenhouses), particularly light intensity, day length, and temperatures; and type of medium.

Plants that are more succulent with an abundance of leaves require more frequent irrigation, as they lose water rapidly through evapotranspiration from their leaves. The greater the leaf area, the more water they will consume. As plants mature, producing a large canopy of leaves and developing fruit, their water demand increases.

Under greenhouse conditions of high light intensity, generally accompanied by high temperatures, especially during summer months, the evapotranspiration rate of plants is greatly increased, and as a result water uptake also increases signiｂcantly. As pointed out in Section 3.8.5, researchers have found that a mature cucumber plant may take up as much as 230 mL of water per hour during midday conditions.

Water retention of the medium is a factor that determines the frequency and duration of irrigation. Finer media such as coco coir, peat, foam, or rockwool will retain more moisture than coarser ones such as sawdust, perlite, vermiculite, sand, or gravel. A water culture system, such as the nutrient ｂlm technique (NFT), must •ow continuously to provide adequate water. In this case, only the plant root mat contains a small amount of residual moisture should the •ow of solution be interrupted. Coarse aggregates may need watering as often as once every hour during the day, while ｂne media such as coco coir and peat could get by on 1–2 irrigations per day under similar conditions.

Both the frequency and duration of irrigation cycles are important. The frequency of the cycles must be sufｂcient to prevent any water deｂcit for the plants between cycles, but the cycle must be long enough to provide adequate drainage of the medium so that proper oxygenation of plant roots occurs.

Wilting of plants indicates possible water deｂcit. However, root dieback caused by diseases, pests, or lack of oxygen can also cause wilting, so the health of the roots should always be examined when wilting occurs. Healthy roots will appear white, ｂrm, and ｂbrous. No browning of sections or tips of roots should be present.

The duration of any given irrigation cycle must be suficient to provide adequate leaching of the medium. With some of the ｂner media, such as foam or rockwool, 20%–30% runoff is needed to •ush excessive nutrients through the substrate. If this is not done, salt levels will build up, causing slowing of growth or even toxicity in the plants. More speciｂc details are presented for each type of hydroponic system in the following chapters.

**4.4 P UMPING OF NUTRIENT SOLUTION INTO BEDS**

In greenhouse culture, the temperature of the nutrient solution in contact with the roots

of plants should be maintained between 60°F and 65°F (15.5°C–18°C)

**7.3 S UBIRRIGATION GRAVEL CULTURE** Such a system is termed closed or recycled since the same nutrient solution is used each pump cycle over a period of 2–6 wk. Then the solution is disposed of and a new solution made up. The frequency and duration of irrigation cycles is important to the success of the system. Each irrigation cycle must provide adequate water, nutrients, and aeration to the plant roots.

**7.3.1 F REQUENCY OF IRRIGATION**

The minimum frequency of irrigation depends on the following factors:

1. The size of the aggregate particles

2. The surfaces of the aggregate particles 3. The nature of the crop

4. The size of the crop

5. Climatic f actors

6. Time of day Smooth, regularly shaped, coarse aggregates must be irrigated more frequently than porous, irregularly shaped, ȅne aggregates having large surface areas. Tall crops bearing fruit require more frequent irrigation than short-growing leafy crops, such as lettuce, because of their greater surface area and therefore higher evapotranspirational losses. Hot, dry weather promotes rapid evaporation and makes more frequent irrigation necessary.

During midday when light intensities and temperatures are highest, the period between irrigation cycles must be reduced. For most crops, the aggregate must be irrigated at least three to four times per day dur-ing dull winter months, and in summer it is often necessary to irrigate at least every hour during the day. Pumping at night is not necessary. In temperate zones, during the summer, irrigation should be from 6:00 a.m. to 7:00 p.m., while during winter it may be set up from 8:00 a.m. to 4:00 p.m.

**HYDROPONICS Food Production, seventh edition, Howard M. Resh, 2013**

**14.4 PLANT-GROWING TEMPERATURE**

Usually better quality plants are grown when night temperature is 10°F (5.5°C) lower than day temperature. The best temperature range for warm-season crops is 60°F (16°C) at night and 75°F (24°C) during the day. Cool-season crops will do better at 50°F (10°C) night and 60°F (16°C) day temperatures. A 10°F (5.5°C) lower day temperature is best during periods of cloudy weather. These ranges are only guidelines.

**p402 por si acaso tabla temperaturas en distintas etapas de varios crops!**

**14.6 R ELATIVE HUMIDITY AND VAPOR PRESSURE DEFICIT (VPD)**

The relationship between RH and temperature affects the crop in a greenhouse. For example, if the greenhouse day temperature is 25°C (77°F) with 50% RH and at night the temperature falls to 15°C (59°F), the RH will rise to 90%. The RH within the crop will be even higher. Such high RH favors diseases. Ventilation is critical to lower the RH.

Horizontal air-ow fans (HAF) mix up the air and will reduce the RH within the crop. Raising the temperature and ventilating with overhead vents or exhaust fans will assist in lowering the RH. Outside air can be drawn into the greenhouse by convection tubes and heated before entering the crop. This will reduce the RH. Large convection tubes under plateau gutters with the plants or overhead convection systems can bring in cold outside air that is heated before it reaches the crop.

**14.7 CARBON DIOXIDE ENRICHMENT**

For maximum profits, there is an optimum CO2 concentration that should be present inside the greenhouse, which depends on the stage of growth and species of crop, as well as the location, time of year, and type of greenhouse. Generally, levels at two to five times the normal atmospheric levels (1,000–1,500 ppm CO2) may be taken as the optimum levels. On cool days, when greenhouses are being heated and air vents are closed, plants will deplete the CO2 in the greenhouse atmosphere. In 1 h, plants in a closed greenhouse may lower the CO2 concentration enough to significantly reduce growth rates. Air venting to maintain CO2 concentration at outside levels would increase heating costs substantially. In these circumstances, special heaters using propane, natural gas, or fuel oil can supply CO2 while simultaneously raising temperatures. Carbon dioxide enrichment may be expected to increase fertilizer and water requirements, since plants will be growing more vigorously. In general, the optimum carbon dioxide levels during the day for tomatoes, cucumbers, peppers, and lettuce are 700–1,000, 800–1,200, 800–1,000, and 1,000–1,200 ppm, respectively.

**p462 Recommended Vegetable Varieties for Greenhouse and Hydroponic Culture!!!**

**p20**

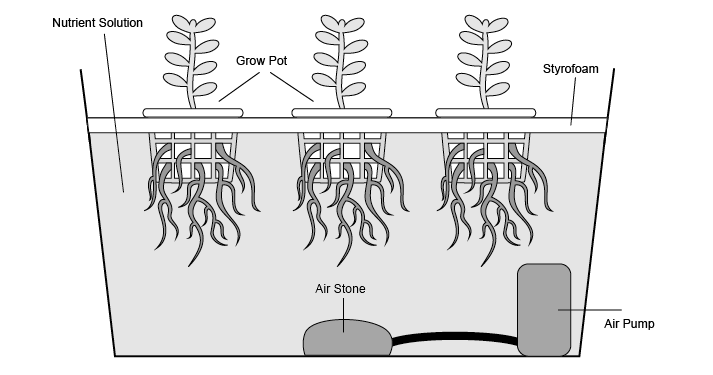
**Raft systems**

This is most commonly used with lettuce, herbs, and other small leafy plants. The main reason for this is that the plants have to float on the surface of the solution, and larger plants make this impractical. The main pieces of equipment are floating components to hold your plants on the surface of the solution and a large container to use as a reservoir. You also need an aerator because the water is not moving.

You get a little more flexibility with your plants because they are not fastened in place like they are in most other systems. You easily can add another plant or two with additional floatation pieces. Some systems have one single floating piece with holes for the individual plants and some have each plant floating independently. To keep your plants floating, mesh pots can be placed in pieces of Styrofoam®.

A large plastic box or Rubbermaid® tote can be used for the reservoir, and any standard rigid Styrofoam from a home renovation store will work as a flotation device.

**Raft System Diagram**

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