

RECIRCULATING HYDROPONICS

MAINTENANCE AND BEST PRACTICES



Hydroponics is a term inclusive of many different, highly-varied systems of plant nutrient feeding. Some may classify hydroponic growing as any method utilizing soilless media, including peat-based potting mixes and coco coir. For the sake of this content, “hydroponics” will refer to systems that are recirculating in nature and utilize soilless, inert or inorganic media. Recirculating hydroponic operational systems include flood tables, “Dutch buckets”, and undercurrent or nutrient film technique (“NFT”) feeding structures.

Hydroponic crop production has many benefits over traditional, soil-based farming. Increased water conservation, reduced fertilizer use and enhanced disease control are just a few of the reasons many farmers may choose a closed-loop, hydroponic cultivation operation. While the convenience of automatic plant watering and increased resource conservation make hydroponic systems attractive, recirculating systems require very specific management protocols to ensure success.

TYPES OF HYDROPONIC GROWING SYSTEMS

DUTCH BUCKET HYDROPONICS: Also known as deep water culture (DWC); This system consists of a main reservoir that pumps liquid nutrient solution to individual buckets containing one plant each. Top- and bottom-feeding can be used as long as the requisite equipment is in place. The residual solution post-feeding is siphoned back to a central reservoir and recirculated throughout the system at the next feeding. The main reservoir and the individual buckets may be aerated to increase the levels of dissolved oxygen available to plant roots.



Figure 1



Figure 2

FLOOD TABLE HYDROPONICS: Also known as ebb and flow structures, these systems require specifically-engineered tables, pumps and drainage equipment working in concert on a timer. This design, while more capital-intensive than DWC, allows for individual feeding rates and formulas at each table. The nutrient solution is pumped onto the table and saturates the plants before draining back into the reservoir. The expense of operating multiple individual pumps and timers can become quite high and should be considered before implementation into large scale production.



Figure 3

NUTRIENT FILM TECHNIQUE: This is a very similar concept to deep water culture. The key difference is the lack of media; roots are exposed to the air in a shallow trough or tube with a steady flow of nutrient-enriched water flowing over them.

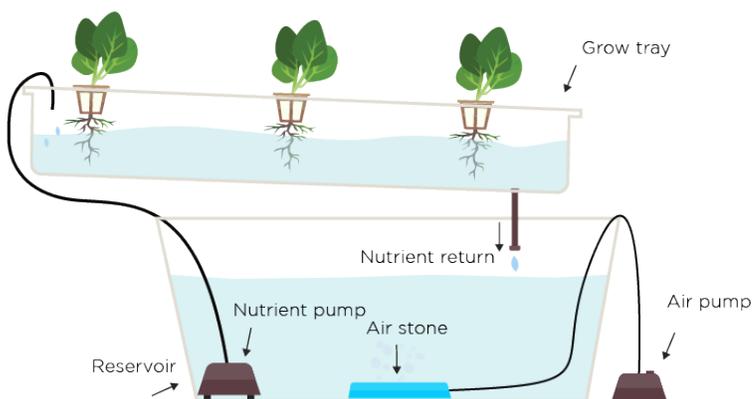


Figure 4



Figure 5

BENEFITS OF HYDROPONIC GROWING

Water conservation is one of the most important benefits of hydroponic cultivation, but nutrient and labor efficiency savings are also of great importance. In a recirculating hydroponic system, water is continuously recaptured and recirculated to the plants, with nutrients injected as needed (as determined by frequent monitoring). Water loss and extraneous costs are mitigated, especially when compared to traditional soil-based agriculture. Recapturing the water also allows for a potential reduction in environmental pollution that can be caused by excess nutrient material in soil and ground water.

The high solubility of liquid nutrients in a hydroponic system allows for less nutrient material to be used, further reducing input costs and potential pollution from waste water. Eliminating soil from a growing system also greatly reduces the chances of soil pathogens invading host plants and causing crop losses. Weed pressure is nonexistent in hydroponic growing, meaning no chemical or mechanical weed control is required. Overall, recirculating hydroponic cultivation allows for increased nutrient regulation, decreased nutrient and labor input, and increased plant density (which may correlate with increased yield).

PROBLEMS WITH HYDROPONIC GROWING

Contrary to popular belief, recirculating hydroponic systems are not an “easier” solution as compared to drain-to-waste irrigation. These systems require special practices to provide optimal growing conditions. Knowledge and regular maintenance of all system components is required in order to prevent system failures. Without proper protocols in place, crop losses may occur as a result of poor system management.

WATER QUALITY: Water quality is one of the most important components of an effective hydroponic system. The makeup of the starting water should be known, and can be obtained through a simple water analysis (please contact Rx Green Technologies for a complementary test and follow-up analysis). A thorough water analysis will show hardness, alkalinity and mineral content. These factors are important to understand, as they all interact with the nutrient solution in different ways and can limit the effectiveness of the hydroponic system if not considered carefully.

Water with a high level of electrical conductivity (“EC”) will require more frequent reservoir changes in order to avoid toxic salt levels. High levels of alkalinity will cause rapid pH fluctuations and may lead to nutrient lockout and corresponding deficiencies.

PATHOGENS: The source of pathogens in hydroponic production can come from various places, including insect vectors, water and contaminated plants from outside sources. An environment that is not often cleaned can be a breeding ground for these unwanted pathogens. See Appendix A for a complete table of recommended protocols for reducing pathogens. The goal is not complete sterilization, but rather the removal high levels of harmful pathogens. Plants are also made of biological matter, and complete sterilization would significantly reduce plant growth and performance.

pH FLUCTUATIONS: Potential hydrogen (pH) is the measure of hydrogen ions (H⁺) in a solution. The pH scale is used as an indicator of acidity or basicity of a solution. A pH from 0-7 is considered acidic, while a pH from 7-14 is considered basic. A pH of 7 is neutral. According to Dr. Bruce Bugbee of Utah State University (see references), plants will grow equally at a pH of 4 or 7, as long as the requisite nutrients are available in solution.

Plants uptake minerals at different pH levels depending on the ionic charge and balance of the minerals in the root zone. It is natural for the pH in the rhizosphere to fluctuate as the plant is feeding, which allows a full spectrum of nutrient uptake for the plant's metabolism. These fluctuations interfere with nutrient uptake, generate biofilm, and increase algae buildup that may clog drip emitters and pumps. Fluctuations in pH also form insoluble salts as a result of chemical interactions between nutrients and the other components of irrigation water.

Neglecting regular reservoir changes may result in more drastic pH fluctuations and an uneven balance of individual nutrients, or ions, in the solution. If there is an abundance of a specific ion remaining in the solution, this may cause an antagonistic reaction and limit the availability of other ions.

BIOFILM: Biofilm is a term that describes a visible 'film' that forms on a nutrient solution as a result of bacteria growing and forming a complex film on the surface of the solution. Biofilm typically forms on the surface, but may also coat the sides of the reservoir. It typically has a slimy consistency, and can cause problematic clogging of drip lines, pumps and emitters. If not caught early, the clogging limits or eliminates nutrient and water flow to individual plants, causing crop loss. The biological activity that causes the biofilm to form also causes the pH to rise quickly, leading to additional complications from reduced nutrient availability.

ALGAE: Algal growth is another biological factor that can affect the proper function of hydroponic systems. Algae is known to consume trace minerals and other nutrients, and will also attract pests. Excess phosphorous in a nutrient solution can encourage algae growth. Algae also produces oxygen in daylight conditions, but depletes oxygen during nighttime hours or dark periods, which leads to pH fluctuation and lack of nutrient availability.

Light pollution in a reservoir will encourage rapid growth of algae, as will infrequent reservoir changes. Growing media will also attract algal growth, including coco cubes, grow stones and rock wool.

BEST PRACTICES TO MINIMIZE PROBLEMS WITH PRODUCTION

GROWING MEDIA: Growing media for recirculating hydroponics should be inert, or have a very low cation exchange capacity (CEC). CEC is a characteristic of soil and other types of growing media, including peat and coco coir, that indicates the capacity of the medium to hold on to interchangeable cations. The higher the CEC, the greater the buffering capacity and interference with nutrient availability to the plant.

Ideal substrate sources for recirculating hydroponic cultivation do not hold onto nutrients and make recirculating systems easier to manage and include rock wool, perlite, grow stones, and clay pebbles. A variety of pots may be used in conjunction with the grow media, such as perforated hard plastic or fabric; in some cases, systems will have built-in rooting perforations that require no adjacent containers whatsoever (NFT, etc.).

Shading the surface of the grow media will prevent excessive algal growth, as will watering below the surface of the growing media. Mechanical filtration with fine mesh or disk filters can help to reduce the algae entering a reservoir or drip irrigation. Allowing the top of grow media to dry between feedings can also reduce the growth of algae. Plastic covers for grow cubes can provide a higher degree of algae growth prevention by covering the entire media surface (see reference page).

RESERVOIR MAINTENANCE: Blocking light from the reservoir can help to discourage growth and reduce existing algae. White irrigation tubes and tanks that are in direct light may experience higher rates of algae growth than darker colors. Mechanical filtration will not control pathogens in a system, so biological filters must be in place. Slow sand filtration is an example of a biological filter; that said, these systems may be cost prohibitive. Installing UV filters within the recirculating system is a very effective (and reasonably priced) control for algae and bacteria, as are certain chemicals that are safe for plants and can be used in the nutrient reservoir (see Water Treatment Chemicals document).

If using a DWC system, aerate the individual buckets but do not aerate the main reservoir. This will provide the necessary oxygen to plant roots but will help to minimize pH fluctuations in the main reservoir.

SANITATION: When flushing out the system and replacing with clean water or fresh nutrient solution, it is important to clean and flush all parts in the system, including water filters and in-line filters. Consider the following protocol for cleaning flood table systems: if floor drains are available, redirect/bypass the flood table inlet and run the pump system with a hose in the drain to empty and clean the reservoir. Keep an extra length of hose on hand in the same diameter as the feed system for an easy switch. The waste water can also be cycled through a filter or into a waste tank for disposal. Another alternative for waste water is to dispense to a patio or outdoor ornamental garden. If floor drains are not available, water can be manually moved from the system with sump pumps, buckets or vacuums. Once water is drained, remove all parts, clean hoses and pumps, soak in H_2O_2

or bleach solution to disinfect, and scrub out reservoirs with the same solution. Rinse all parts and reservoirs very thoroughly before mixing fresh nutrient solution.

See Water Treatment Chemicals document for a thorough list of chemicals that are recommended for use in hydroponic systems.

WATER FILTRATION: Reverse osmosis filtration will provide the optimal results for recirculating systems, but may not be necessary if water quality is within reasonable standards. When using tap water for irrigation, take regular measurements of your water's calcium content, as Ca may accumulate quickly and limit the uptake of other ions.

Contact Rx Green Technologies for a complementary water test and review of results. See Appendix A for suggested treatment protocols for water hardness and other water quality conditions.

MEASUREMENTS: A pH and EC meter are essential for managing nutrient solution and understanding changes that occur as a result of plant interactions. Monitor pH and EC/ppm daily, adjusting as needed. Keep a log of pH and ppm readings and any changes that are made.

Add water or nutrients to adjust the EC up or down. Add acidic nutrients or acid to lower pH, and add water or alkaline pH adjusters to raise pH. Maintain solution pH above 3.0 and below 6.0 for best results with Rx Green Technologies nutrients. This will provide the best environment for optimal nutrient availability. If pH rises above 6.0, adjust down to 5.5 or below, based on preference. If topping off a reservoir to lower the EC, plain water is all that is needed. If topping off with a nutrient to increase EC, make sure the reservoir is still clean and there are no signs of salt buildup or microbial growth. If either of these issues are present, empty and clean the reservoir and fill it with fresh solution.

Water temperature is an important thing to watch and keep in range with recirculating systems. The ideal range is 66-72°F in order to maintain optimal levels of dissolved oxygen and prevent growth of harmful pathogens.

NUTRIENT RESERVOIR: Water levels need to be adequate for plant saturation levels, so take care to keep a minimum of 70% of total water volume needed. Simply topping off the reservoir every week with fresh nutrients and/or water can lead to an imbalance of nutrients available to the plant. Topping off the reservoir with a diluted concentration of the original feed can be an effective method for providing a constant supply of nutrients until the next full reservoir change. Weekly reservoir changes will prevent most problems from occurring.

According to Dr. Bugbee, plants have evolved to tolerate large nutrient imbalances in the root zone, but in recirculating hydroponic systems, these imbalances are cumulative. The imbalances are a result

of the specificity for different groups of plant nutrients that the plant will use in varying concentrations. This may be detrimental to plant growth and performance over time. For example, plants will uptake nitrate (NO₃) at a higher rate than calcium (Ca) (see Table 1). This will lead to an accumulation of Ca in the reservoir, which may then have antagonistic effects on the availability of Mg and P (see Nutrient Antagonism paper).

Table 1. Approximate uptake rates of the essential plant nutrients.

Group 1. Active uptake, fast removal	NO ₃ , NH ₄ , P, K, Mn
Group 2. Intermediate uptake	Mg, S, Fe, Zn, Cu, Mo, Cl
Group 3. Passive uptake, slow removal	Ca, B

Nutrient Management in Recirculating Hydroponic Culture.

Constant replenishment of a reservoir contributes to these cumulative situations in which some elements build to excess levels, limiting total nutrient availability. Regular reservoir changes with fresh water and nutrients provides ideal conditions for plant growth uninhibited by nutrient antagonism.

Beneficial organisms can be added to a nutrient reservoir with the proper application methods. If proper methods are not used, these organisms may contribute to biofilm and clogging issues within the system. Microbes should only be added after flushing a disinfectant through the system. This disinfects the system and clears out any potentially harmful pathogens. The best application timing for beneficial microbes is 24-36 hours before the system is emptied and cleaned, as this will prevent any biofilm buildup.

CONCLUSION

The biggest problems in recirculating hydroponic systems can almost all be attributed to human error. These problems can be avoided by incorporating the checks and balances discussed in this document. It is important to include the water source, holding tanks, irrigation pipes, grow media, greenhouse surfaces and the plants themselves when troubleshooting.

Recirculating hydroponic cultivation has many benefits including water and energy conservation, decreased nutrient runoff and reduced environmental pollution. In order to fully appreciate these benefits, follow the guidelines highlighted in this paper to enjoy successful system operation and optimal plant performance.

INFORMATION RESOURCES

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IMAGE SOURCES

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- Figure 2: <https://www.marijuanaventure.com/wp-content/uploads/2017/03/vaco-5-16-edited-7.jpg>
- Figure 3: <http://www.atlantishydroponics.com/product-p/v4x4comp.htm>
- Figure 4: <https://www.greenandvibrant.com/sites/default/files/inline-images/NFT-Nutrient-Film-Technique.png>
- Figure 5: Courtesy of Rx Green Technologies
- Figure 6: Courtesy of Rx Green Technologies
- Figure 7: Courtesy of Rx Green Technologies

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