e-GRO Edible Alert

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Volume 6 Number 2 January 2021

Closed-Loop Irrigation for Vine Crops

Hydroponic production systems can have open or closed-loop irrigation systems. An open irrigation system is one in which the nutrient solutions coming out of the substrate are allowed to runoff out of the production system. A **closed-loop irrigation system** (Fig. 1) is one in which the nutrient solution is captured and recirculated within the same production system. There are environmental and financial incentives to recirculate nutrient solutions. However, the two major concerns with closed-loop irrigation systems are (1) the balance of ions in the nutrient solution, and (2)the spread of plant pathogens.

In this Alert, we will cover basic considerations to design a closed-loop irrigation system for vine crops.

Figure 1. Example of a closed-loop irrigation system. The channels under the rockwool slabs collect the nutrient solutions that runoffs from the substrate (note red arrow). The solution is then treated and stored until it is pumped back into the crop.

USDA United States Department of Agriculture
National Institute of Food and Agriculture

This work was supported, in part, by the USDA National Institute of Food and Agriculture, Hatch Multistate project accession number 1020637. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author and do not necessarily reflect the view of the U.S. Department of Agriculture

The objective of designing a water treatment system is to reduce the risks associated with irrigation water sources. For our purpose, we will consider recirculated nutrient solution *a source* and assume the initial water source is pure and clean.

Recirculated nutrient solutions will carry the nutrients that leach from the substrate and can also carry plant pathogens and particles. Each of these parameters can affect the irrigation system or crop quality.

Nutrients or other salts can accumulate and result in imbalance nutrient solutions or the accumulations of salts (for example, sodium or chloride) that also affect ion balance and be toxic to the crop.

Plant pathogens can spread in the water from plant to plant or across production areas. Zoospores from *Pythium* and *Phytophthora* swim freely in solutions. Other pathogens or other life stages of watermolds move along with organic debris in the solution.

Particles in the system can be organic—for example, plant or substrate debris—or inorganic —like rockwool dust or sand. These particles can buildup and directly clog the irrigation system. Particles can also carry plant pathogens.

Agrochemical residues are the final consideration. In most cases, pesticides and fungicides are not directly applied into the irrigation. However, applications on any other parts of the plant may rinse off or leach into the water.

Consider if your system is particularly vulnerable to one of these parameters.

Water treatments help reduce the concentration of pathogen inoculum, but always consider all other factors that help promote and prevent disease development (Fig 2).

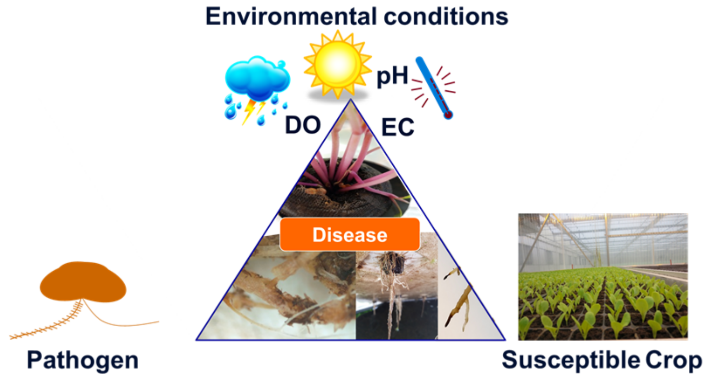

Figure 2. Disease triangle is a model that indicates that for plant diseases to occur the crop had to be susceptible, the pathogens has to be present, and the environmental conditions have to be conducive to cause disease for a period of time. To prevent diseases, consider how you can control these factors.

The **first step** in designing a closed-loop irrigation system is to **reduce the amount of solution that needs to be captured, treated, and reused**. In other systems, like subirrigation or nutrient film technique reducing the volume is challenging because high volumes are intrinsic to those systems. However, in vine crop production this is achievable and desirable. Nutrient & water uptake equates yields, therefore reduce the volume of leachate in a systematic way to not affect the yields.

There are two ways to reduce the volume that leaches out from the substrate:

1. Raise the electrical conductivity (EC) of nutrient solutions and reduce the volume of water. This is especially applicable in areas with temperate climate where plants take up lower volume of water in colder months. This practice also helps improve fruit quality because it improves fruit formation and increases the turgidity during colder months.

2. Increase the frequency and reduce the volume of irrigation events. If the water pressure and the pump allow it, avoid long irrigation events and replace them with shorter and more frequent events.

Both of these strategies will result in feeding the crop the right amount of nutrients & water.

Treatment of recirculated nutrient solutions begins with **coarse filtration** (Fig 3). The purpose of a coarse filter is to remove any large organic debris—typically leaves or roots (Figure 4). This filter can be >500 µm (35 U.S. mesh). Coarse filters allow fast water flow so usually it can be done inline.

The next step can be to put the solution in a **catchment tank**. Tanks are used not only to store solutions, but also to slow down the flow rate. If you have a highly pressurized system, you could avoid it. However, tanks give you a lot of control to keep batches separated if needed. For example, a spill of pesticide that might have contaminated the water or a section with high disease pressure. This first tank will be the "dirty tank".

Figure 4. Example of a coarse filter (>500 µm (35 U.S. mesh). Coarse filters are used to remove large organic particles such as plant leaves and roots, or large particles of substrate.

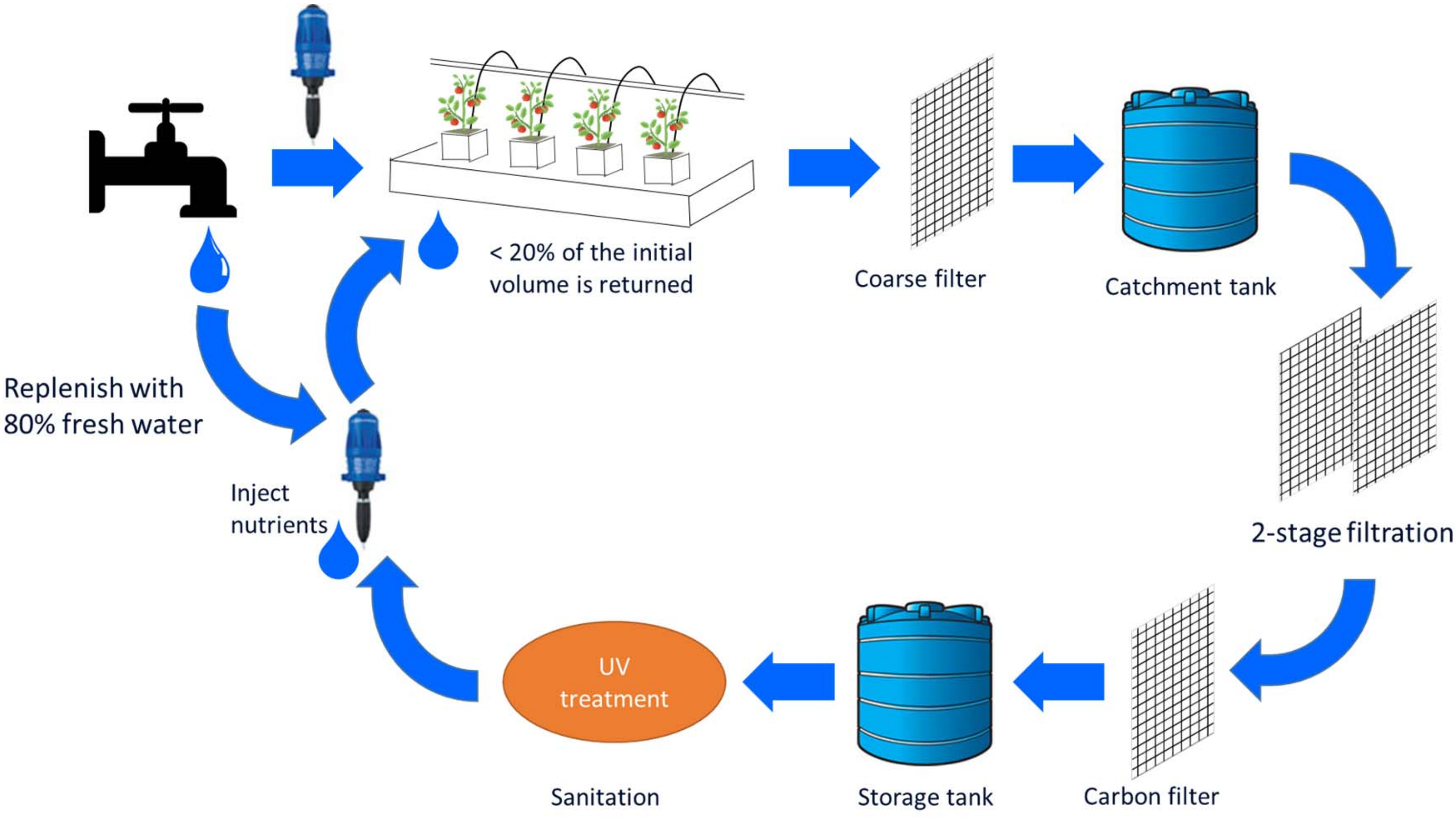

Figure 3. Diagram of a closed-loop water treatment systems for vine crops.

Then include a **fine multi-stage filtration system**. Each filtration stage should go from a bigger pore size to smaller (typically in the range of 150– 50µm). Small pore sizes or dirty samples will result in slow flow rate and the filters require frequent maintenance. The multiple stages of filtration reduce the need to change filter cartridges or clean membranes too often. Figure 5 is an example of two stages of filtration.

Figure 5. Two-stage filtration. After the storage tank, the nutrient solution passes through two staged of filtration. The filters in this examples are commonly known as "*paper filter*". Following filtration is the UV treatment system.

In the next step you can add another tank or directly pass the solution through a **granular activated carbon filter**. Granular activated carbon filters remove pesticide residues that might be present in the nutrient solutions, reducing risks of phytotoxicity or toxic residues to workers or consumers.

Granular activated carbon filters also remove organic compounds such as chelates. Therefore, replenish chelated micronutrients (Fig. 6).

Figure 6. Granular activated carbon (GAC) filter in the metal housing. Next to the filtration system (blue tank) are chelated micronutrients which are injected to replenish the elements removed by the GAC filter.

Sanitation comes after filtration. Ultraviolet (UV) radiation is commonly used to sanitize water or nutrient solutions in hydroponic production systems. UV radiation is a contact treatment—meaning it treats the solution as it passes through the system and leaves no residual activity. The benefit of point treatment is no risk of toxicity to the crops or workers. UV radiation is only effective when the water is clear from particles, because particles will block the reach of the radiation to the organism.

UV radiation—similar to the granular activated carbon filter—removes organic chelates. Keep that in mind when you select the injection point, replenish the chelated micronutrients after these two treatment points (Fig 3).

Finally, since the volume of water returning from vine crops is typically less than 20% of the initial volume applied. Growers can **add fresh nutrient solutions and irrigate as needed**.

It is important to emphasize that closed-loop systems will magnify problems. For example, if your initial water source has sodium, this will accumulate over time. **It is for this reason that the number one thing to do is to reduce the amount of water that needs to be captured, treated, and reuse**. The most efficient growers have less than 10% returned water.

The closed-loop irrigation system requires constant monitoring.

Monitor:

1. That each treatment step is working as planned.
2. The quality of the nutrient solution is on target for the crop.
3. Crop health will reveal if the system is effective.

Adjust: There will be times when the nutrient solution requires that you adjust the nutrients and not just replenish with fresh solution. Keep good records of how many cycles this might take and do it proactively and informed (with a nutrient analysis at hand).

In extreme cases when some ions are too high (for example, sodium or chloride) diluting the recirculated nutrient solution with fresh water might not solve the problem and you might need to discard the solution. Avoid discarding by reducing the amount of initial water and adjusting essential elements as needed.

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