UV for sterilisation of water for soilless systems (II)

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Ultra-violet (UV) radiation is a very effective method of water disinfection. A dose of UV radiation can eliminate pathogens (disease-causing organisms) in water and hence prevent the spreading of diseases. UV is often used to sterilise drain water (run-off) of soilless cultures before re-use, and some growers use UV to treat raw water as well. In the previous article we described the principles and techniques of UV treatment, including the need for pre-filtration and the importance of transmission.
In this article we discuss the UV dose recommended for disease prevention, as well as the types of UV systems that are available. There are some cheap small UV systems on the market. Unfortunately some UV manufacturers are not familiar with the particular conditions in horticulture. They may sell too small systems and advise too low UV doses, thinking that drinking water standards are high enough. Also the simple systems don't have automatic cleaning and monitoring facilities built in, which can lead to disappointing results due to 'aggressive nature' of nutrient solution. Fortunately there are also excellent UV installations for horticulture on the market. They can do the job when used in the right way.

Drinking water standards not enough
There are many different guidelines around as to how much UV is needed for water treatment. But many guidelines are inadequate: some are based on one or another outdated experimental report, and other recommendations are based on guidelines for drinking water. Many people think that drinking water requires the highest possible level of sterilisation. But the production of drinking water only deals with destruction of diseases for humans. These are often bacteria, which are easy to kill. Water for horticultural purposes has to be cleaned from plant pathogens, including bacteria, fungus spores, viruses and/or nematodes. Some plant viruses are very hard to kill, and some fungi produce 'survival structures' that are designed to withstand all sort of harsh conditions. Especially drain water (run-off) can contain high concentrations of plant pathogens. If drain water is to be re-used, it has to be disinfected extremely thoroughly, much more rigorously than water for human consumption.

Recommended dose
For horticulture, there are generic recommendations originating from the Netherlands and now adopted in many countries. They are based on work by Runia of the Research Station (PBG) in Naaldwijk, the Netherlands (now Bleiswijk, and part of WUR). She carried out a series of comprehensive scientific experiments over several years. The outcome of the research was put into recommendations that have been applied for many years now. They are discussed at scientific conferences and proven by thousands of growers. Runia carried out some new experiments recently to determine the required UV dose for control of Pepino Mosaic Virus, a new tomato pathogen in Europe. The up-to-date recommendations for pathogen control in (drain) water are**:** 100 mJ/cm^2 UV-C for water that contains no viruses, 150 mJ/cm^2 UV-C for water with Pepino Mosaic Virus and 250 mJ/cm^2 UV-C for water containing other viruses. Nematodes are controlled by 100 mJ/cm^2 too. Runia found that, although nematodes are not killed by this dose, they get damaged and infertile.

Dose and transmission

The recommended doses (100, 150 and 250 mJ/cm^2) are the UV-C radiation levels to which the water has to be exposed to. Some UV users think they can increase the flow rate when the water 'looks clear'. But this is a dangerous practice. The flow rate should be set by somebody who completely understands the system. After all, the UV dose is based on a combination of factors: strength of the UV lamp(s), penetration of UV radiation (i.e. the transmission of the water), thickness of the water layer, turbulence and flow rate of the water. The UV transmission of the water must be properly measured in the laboratory (see previous article). The transmission of drain water can vary from one place to the other, or from time to time, and thus the transmission measurement should be repeated now and then. Some very advanced UV-installations have a transmission meter built in, and the flow rate (or the lamp strength) is regulated based on the transmission reading. Each system requires a transmission above a certain minimum level (e.g. above 20% or 35%). If water has a lower transmission than the minimum level that the installation can handle, the water must first be diluted with clear water.

Low-pressure UV systems

UV sterilisation is used a lot in the food and beverage industry, and hence there are numerous brands and a wide range of UV systems available. Most UV systems are so-called low-pressure UV systems, characterised by a low-pressure mercury vapour lamps (LP-UV). A system can contain only one LP-UV lamp or a whole bundle of many LP-UV lamps (e.g. 4 or 28 or more). Such multi-lamp systems are designed to treat a huge amount of water.

In most systems the UV lamp(s) are placed in a quartz sleeve (each lamp in its own sleeve) in a stainless steel housing, and the water flows between the sleeves and the housing. In some other systems the water flows through the sleeves, while the lamps are outside the sleeves. This latter system has sleeves made from other material.

The simpler systems need to be checked very frequently (every few days) to see if the quartz sleeves need cleaning, and the lamps need to be replaced after a certain period. Without proper servicing, the system can be wasting electricity without actually doing what it should do, and a disease outbreak can occur.

The more advanced LP-UV systems have some essential extras built in, for instance monitoring and automatic sleeve cleaning. The sleeves can be cleaned by acid-washing or by a an automatic wiping action or both. Monitoring can be done by measuring the UV output from one lamp, or by electrical monitoring of the whole system, or both. Measuring the UV from one lamp does not guarantee that all other lamps perform well, as they can be of different age and quality. Electrical monitoring of the whole system does not tell if all lamps indeed produce sufficient UV. Only a particular HP-UV systems with one lamp (see below) provides certainty that everything works well. Nevertheless, a more advanced LP-UV installation containing at least automatic acid washing and some sort of monitoring is excellent for water treatment in horticulture.

High-pressure UV installations

High-pressure UV installations contain high-pressure mercury-vapour lamps (some lamp manufacturers call them medium-pressure lamps). HP-UV systems are large installations with a huge capacity and are dearer than the large LP-UV systems. A HP-UV lamp is very powerful (up to 8 kW). Thus a HP-UV installation usually contains only one HP-UV lamp. Some may contain two lamps but they are placed behind the other (in a series), and not in a bundle (parallel). The single lamp(s) can be monitored very precisely, and that is the advantage of this system. The UV radiation is measured through the (drain) water. If not enough UV radiation is coming through, a series of actions is undertaken automatically. Firstly, the water that was insufficiently treated is sent back to the dirty water tank. Then the lamp is cleaned. If possible, the HP-UV is switched to a higher output (as HP-UV lamps can produce different output levels). If these actions fail to improve the UV action, an alarm signal is produced. HP-UV installations are often powerful enough to treat water with a very low transmission. The built-in features make HP-UV a very effective and reliable system for water treatment in horticulture.

Please not that this article was written in 2000. New developments have been made since, and new systems are on the market.

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