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Cooling with Water: An Economical Alternative for Plant Growth Chambers

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http://www.usu.edu/cpl/research_environmentalcontrol.htm#cooling

The most expensive component of a growth chamber is the cooling system. When the compressor fails, replacement can cost \$2,000 to \$3,000. The age of a growth chamber or the availability of funding may make replacement of the compressor impractical. Such a growth chamber is the ideal candidate for conversion to water-cooling. While the chamber will not be capable of cooling to near freezing temperatures, a fully functional chamber can be up and running for a few hundred dollars, and it will serve fully 90% of experiments commonly done in growth chambers.

Conversion

To convert the cooling system to water, the compressor and condenser are usually removed, and water is supplied directly to the evaporator coils inside the growth chamber. Water flow through the coil is regulated by a rotameter and the chamber fans move air across the coil for cooling. Water from the tap in Logan, UT. is a fairly consistent 8°C and provides enough cooling to maintain chamber temps of 15 to 20°C, depending upon the heat load created by lighting and the ambient temperature of the room in which the chamber is located. The water temperature from the tap used will be the average ground temperature in your area. This may be higher or lower than our water temperature and will have a corresponding effect on the cooling capacity of your system.

Control Systems

Depending upon the make and model of growth chamber, the original timer and temperature controls may still be suitable. If not, two options exist for replacement of the control system. Each is straightforward, though the second option offers much greater precision in both monitoring and control.

Option One: Basic Control

Temperature and light controls can be replaced with a seven day programmable electromechanical timer that has a single-pole, double-throw relay (Paragon EC7000/120, \$147.60 from [Grainger Industrial Supply](#)) and two electronic temperature controllers (Ranco ETC-111000-000, \$53.78 from [Grainger Industrial Supply](#)). The timer selects the controller for the day or night set point and the switches off the other controller. These controllers retain their memory with the power off, and have a differential range as small as 1°F.



Electronic temperature controllers are connected only to the heating elements in the chamber, while the water flow through the coil remains at a fixed rate (the minimum amount of water required to provide cooling during the day with the lights on).

Option Two: Tighter Temperature Control

Temperature control is accomplished by measuring temperature with a small diameter thermocouple connected to a datalogger. We use fairly thin, type E thermocouple wire (0.5 mm diameter; AWG 24) to measure the chamber temperature and a control signal is sent from the datalogger to the heating elements via relays that convert the 5VDC output signal from the datalogger to 120VAC line power (we have used Croydom D-1240 relays

from [Digi-Key Corp.](#)). Temperature control with this system provides peak-to-peak temperature control as low as 0.1°C and cycle times as short as 10 seconds. We use dataloggers from [Campbell Scientific, Inc.](#).

The same electromechanical timer listed in option one controls the lights and photoperiod. A pyranometer or quantum sensor connected to the datalogger is placed in the chamber to switch day/night temperature set points at the exact time the lights come on or go off.

Crydom D-1240
Solid State Relay



Advantages

The advantages of the water cooling system are not limited to the economical repair of an otherwise unusable growth chamber.

For example:

- Temperature control in a water-cooled chamber is more stable than that obtained with a compressor and refrigerant.
- Very little heat is dumped into the room housing the growth chamber. Heat produced by a room full of plant growth chambers using conventional refrigeration systems is substantial and chambers must work harder to cool in an environment with a high ambient temperature. Cooling the room is also expensive.
- Leaking refrigerant gasses can damage plants and confound measurements of gasses (such as ethylene) using gas chromatography.
- Water-cooling is quiet.
- Cooling with water is often more economical than electricity, even in areas of the country with relatively high water costs.

Upgrades

There are several possible 'upgrades' from the basic system. One modification we have done is to mount a second rotameter and a pair of normally closed solenoid valves controlled by the timer to provide day and night flow rates. The timer energizes the first solenoid valve and rotameter (set at a higher flow rate) in the daytime to remove heat generated by the lights. At night, the second solenoid and rotameter (set at a low flow rate) are selected to maintain the lower night set point. This is particularly helpful if the chamber has a small evaporator coil, requiring high water flow to remove heat generated by the lamps in the daytime.

Cooling capacity can be enhanced by switching to a larger fan that moves more air across the evaporator coils.

A two-speed fan may be used, selected by the timer to run on 'high' during the day when maximum cooling is needed and 'low' at night.

Construction of a 'hybrid' system that would greatly enhance cooling capacity and reduce water usage involves cooling a barrel of water with a remotely located refrigeration unit (perhaps on a rooftop) which would in turn chill water for two or three water-cooled growth chambers in a closed system. This option allows reduced maintenance cost for a single refrigeration unit and keeps the refrigerant (except what's in the cooling coil in the barrel) outside of the research area, greatly reducing the risk of plant damage or contamination of results.

Disclaimer: Mention of trade names is for information only and does not indicate endorsement to the exclusion of other products that might be equally suitable.