Inexpensive Evaporative Cooling System for Greenhouse Use

Joe Portelli – 15/07/2016

Background

I live in Riverstone in the North-West of Sydney and some (most in fact) of my orchids are currently in a double-walled polycarbonate greenhouse. The dimensions of my greenhouse are: L x B x H = 422cm x 239cm x 165cm This greenhouse works well for me in Winter as it heats the inside quite well during the day and keeps the heat (from an LPG heater) quite well during Winter night. Its main problem occurs in Summer. With all roof vents (there are four) open, entrance door open, 70%-plus shade cover and a roof fan operating 24 x 7 I can get temperatures reaching 50C during midday. To compound matters these high temperature are often accompanied by very dry conditions – not a very good combination for most orchids. This project was launched in an attempt to manage this situation. The intent was to lower temperature by forcing air flow past a water mist. The resulting evaporation, which is dependent on water droplet size (the smaller the better) and air-flow rate (the higher the better) cools down the air and increases humidity – both desirable effects in hot and dry situations.

A simple prototype of such a system was constructed and is described below. When operated on a hot dry day (temperature in the greenhouse was around 35C) this resulted in a temperature drop of from 10C to 17C. The exact temperature drop depends on the outside and inside (the greenhouse) humidity. I operated such a system through most of last Summer (December 2015 to April 2016) and saw a significant improvement in the growth\flowering of the plants. A worthwhile investment for the $AU50 (approx) it cost to build the system.

There were downsides to its operation. The increased humidity\lower greenhouse temperatures seemed to attract more scale and red spider mite – I seemed to have more of these last Summer. The higher humidity also lowered evaporation rates after watering and some of the leaves which were in contact with other leaves developed fungal diseases and, I suspect that, in some of these this then led to viral problems. Finally the potting mixes containing coconut husks seemed to decompose quicker as did sphagnum moss. I believe all the above issues are manageable by better horticultural practices and the advantages of the system far outweigh its disadvantages.

The following describes how I constructed a simple prototype evaporative cooling system. Later on I describe how solenoid-valve operation (to switch water flow ON or OFF by activating\deactivating a 24V solenoid valve) was added to allow timer based operation. The timer being referred to is a 230V unit which can be obtained from any hardware store. This allowed me to turn ON and OFF the system at set times without me having to be there to do it.

6-In-A-Row Greenhouse Evaporative Cooler

I've tried several evaporative cooler designs using misting nozzles and currently this is the most

effective configuration I made. It is designed to attach to a smallish desk fan (diameter: ~330 mm) and uses the fan to disperse and vaporise water mist over a more-or-less horizontal area effectively covering most of the growing areas in the greenhouse including the mounted orchids on the walls inside the greenhouse. The forced airflow over the mist greatly enhances evaporation of the water droplets. Under a normal Summer's day (humidity: ~50% to 60%; temperature ~30C). this unit will cool the air temperature by 15C or more. On a humid day (humidity: 70%; temperature: 30C) a 9C-to-10C drop is realisable. Under higher humidity conditions plants loose less water to evaporation and so can tolerate a higher temperature. Thus a 9C to 10C temperature drop in humid conditions may be no worse than a 15C to 17C temperature drop under dry conditions.

Safety Considerations

NOTE: The following construction involves using water near equipment operating with 230V AC (the fan used to force air past a set of misting heads). Great care needs to be taken to ensure that no water can ever get in contact with parts carrying 230V AC. It is the responsibility of the person(s) constructing and operating this equipment to ensure that this condition can be fully met.

As this project was intended to be a prototype system I used an ordinary 330 mm desk fan for generating air movement. I've ensured that water and electricity stay separated and have had no issues with it's operation. However a more professional method would use an IP65 or IP66 rated industrial fan which are designed to allow water contact without compromising safety. These units are standard equipment in horticulture where air movement is required.

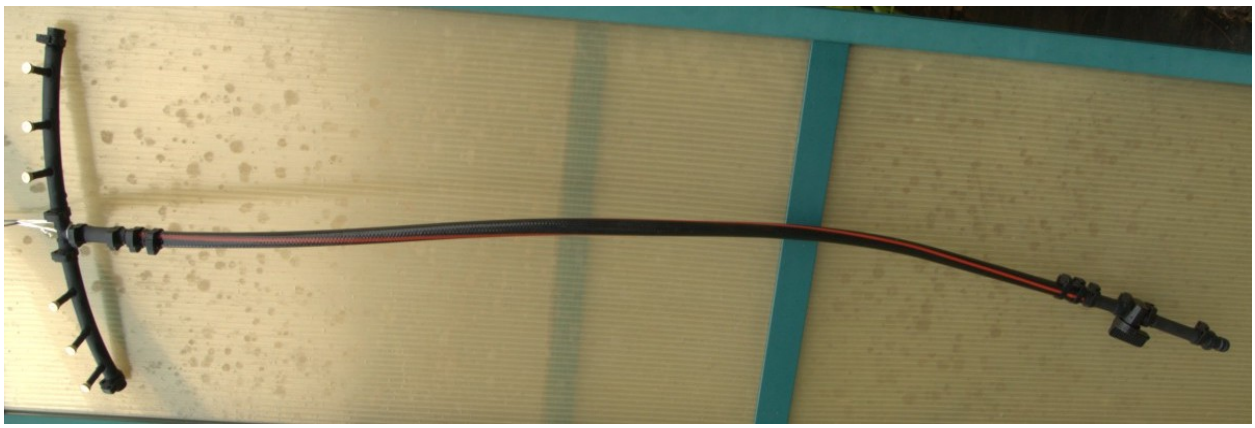
Construction

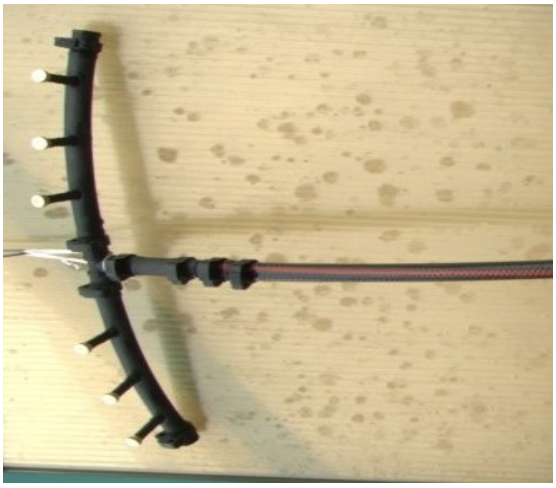
The following describes how the unit was made starting with the finished product. All the tubing and accessories are 13mm irrigation poly parts. 'Normal' water hose was used to connect some parts in the assembly.

Most parts are available from any good hardware outlet. For better quality parts a specialised irrigation supplier would be a better choice. Some parts, like the misting nozzles, require access to a specialised supplier. Following the construction description is a '**Sources**' section which details where I obtained the required parts from.

Finished Unit

The first shot below shows the finished unit and second and third shot below show the top- and bottom parts of the assembly.





Construction of Top Part

Which to call the top part and which to call the bottom part is arbitrary. I chose to call the part with the misting nozzles (the brass parts with a 0.3mm hole) in it the top part and the part with the tap (or valve) and hose attachment the bottom. The two parts are joined by conventional garden hose (for flexibility) in the above diagrams.

The 13mm parts needed and the partly finished top part are as shown in the following shots.

The parts are:

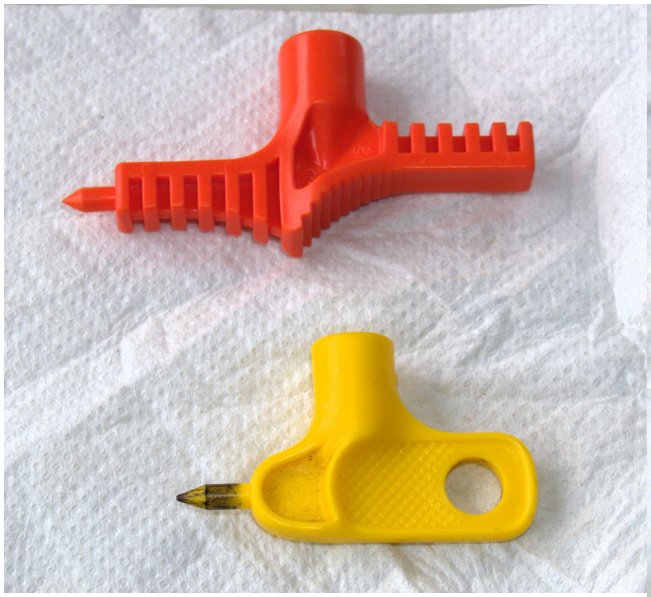
- 2 x 13 mm end caps
- 6 x 13 mm clips (only 2 shown in top left shot as its purpose is mainly to illustrate the type of parts used)
- 1 x 13mm T-piece
- 1 x straight 13mm barbed connector.
- 2 lengths of 13 mm poly tube.
- 6 x 0.3 mm brass misting nozzles with a barbed fitting (see details below).
- Lengths of poly tube to connect the parts.

The lengths of poly tube used for the misting nozzles depend on the fan you are going to use to vaporise the mist (see pictures and descriptions below) and it is best to have access to the fan to complete this stage. In my case I used a 330 mm (approx) fan (diameter of fan blade cage) and the lengths of poly tube required were approx. 190 mm. Adjust your lengths according to your requirements – if you ensure that that the ends of the top part protrude (including end caps) by about 15 mm from the edges of the fan blade cage you'll be OK. Remember that the tube will curve naturally around the front of the fan cage which has a curve in it.

Fit the parts together as illustrated in the shots above. Note it is best to connect the T-piece to a straight barbed connector (using a short piece of poly tube and 2 clips). The garden hose connecting this (ie the top) part to the bottom part of the misting system will then connect to the lower part of the straight barbed connector. This is needed if the unit needs to be taken apart for cleaning as it makes it **far easier** to take apart.

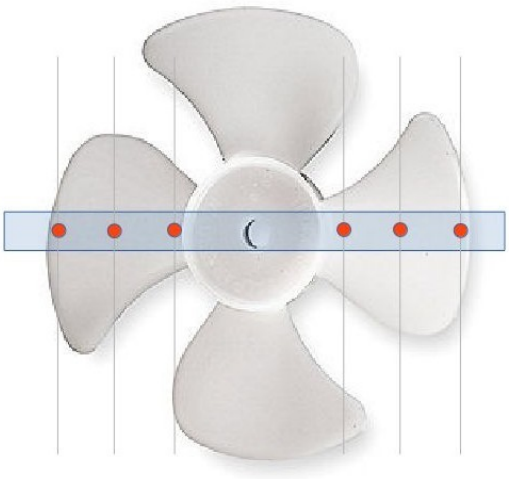
Next the misting nozzles need to be fitted into the 'arms' of the top part. The misting nozzles that are easiest to use are those ones with a barbed end (shown in the following images). The ones featured in some of the following images (such as the ones in the first image above) are not of this

type. The reason is price. However the ones I suggest you initially use are the ones in the following images as they are **by far** the easier to use – you just punch a hole and insert. And they are not that expensive anyway – about $AU2.5 each.



To punch holes in poly tube you **MUST** use the proper hole punch tool. Use anything else and, unless you are an experiences horticultural irrigation installer, you'll end up with a leaky join. Using a tool like those shown on the above left will give you a perfect join. Place the tube on a firm surface, hold the sides where the hole is going to be punched and **push down squarely** into the tube – try not to push the punch tool to the side. I've now done this about 20 times and I am getting leak free joins 100% of the time. Some practice beforehand may help – use tube you a re prepared to throw away for this. A heat gun helps greatly to soften the poly tube for ease of extraction of nozzles.

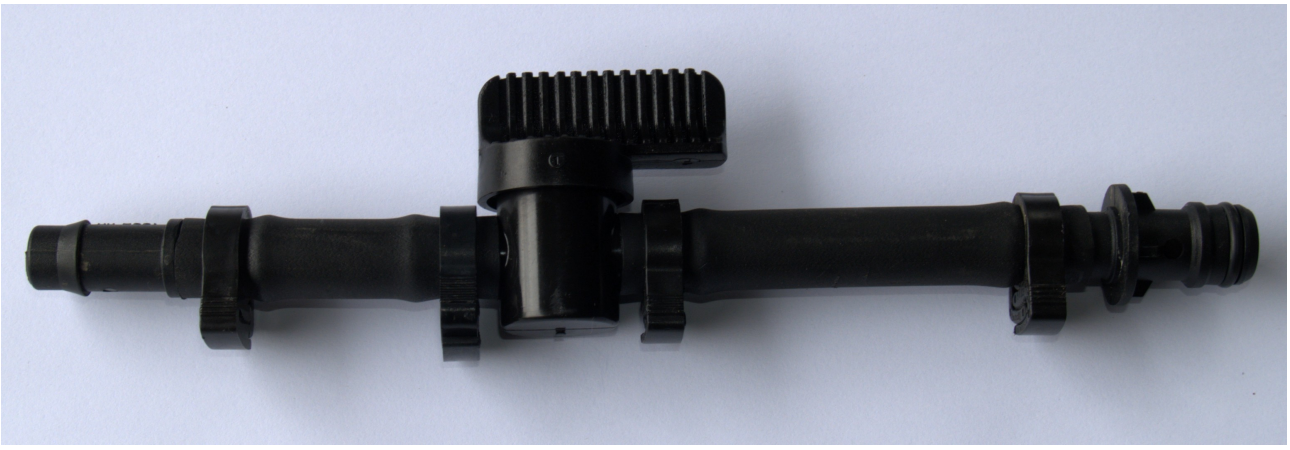
The location in the tube where the holes are located is important as well. Again it is best to have access to the fan to complete this stage. The holes where the nozzles fit need to be over the fan blades. Fans usually have a sort of a cap in the centre of the front of the blade cage – there is no air flow over this area. I punch 3 holes in each arm of the the top part such that the hole farthest away from the centre is just over the tip of the fan blades or maybe ~10mm towards the centre. The hole closest to the centre of the top part I locate over where the fan blades are connected to the central hub of the blades or maybe ~5 mm further away from the centre of the fan. The last of the three holes is located in between the other two. The following diagram illustrates the ideas of how to locate the misting nozzle holes.



Once the holes are punched into the poly tube fit the misting nozzles. These nozzles have a 0.3 mm hole (orifice) through which water is squeezed resulting in it being misted. **This is the smallest diameter orifice nozzle which operates under normal mains pressure**. Misting nozzles with smaller orifices do exist and these produce fine mist which is better for this application but these need a high pressure pump to operate them. The nozzles selected have the orifice located in a stainless steel plug inside the nozzle body. These type of nozzles last longer and block less than units made entirely of brass. At 'normal' water pressure each nozzle consume approx 1.0 L of water per hour. So a 6 nozzle system consumes around 6 litres per hour. This was confirmed during my operation by actual measurements.

Construction of Bottom Part

This is the part which attaches to the 'normal' water hose (via the bayonet fitting) and supplies water to the misting head (ie top part) via a valve to turn the water ON or OFF to the misters.



The parts required are:

- 1 x Male bayonet connector to 13 mm adaptor (rightmost item in above image)
- 1 x 13 mm valve
- 1 x 13 mm straight barbed connector

- 4 x 13mm clips
- Lengths of poly tube to connect the parts together.

Attach the parts together as per the above image using short pieces of 13 mm poly tube and clips.

Another part which is required is a

- 200 micron inline water filter.

Its use is discussed below.

Completing and testing the unit

Attach the bottom part to the top part using 2.0 m to 3.0 m of ordinary garden hose and a couple of 13mm clips (see first image in this article). Garden hose is used for this as it is flexible and can be easily guided as required even under water pressure. A longer length of connecting hose is better than a shorter piece as it allows fan placement flexibility.

Before connecting the unit to a water hose it is **highly advisable to use an inline water filter** somewhere in your water line. If this is not done your 0.3mm misting nozzles will block. The unit appropriate for 0.3 mm (300 microns) nozzles like the ones used here is one with a 200 micron filter mesh. One of these will set you back $AU15. All it needs is a cleanup once a year to remove any accumulated debris. I only use one of these in the water line going into the evaporative cooler.

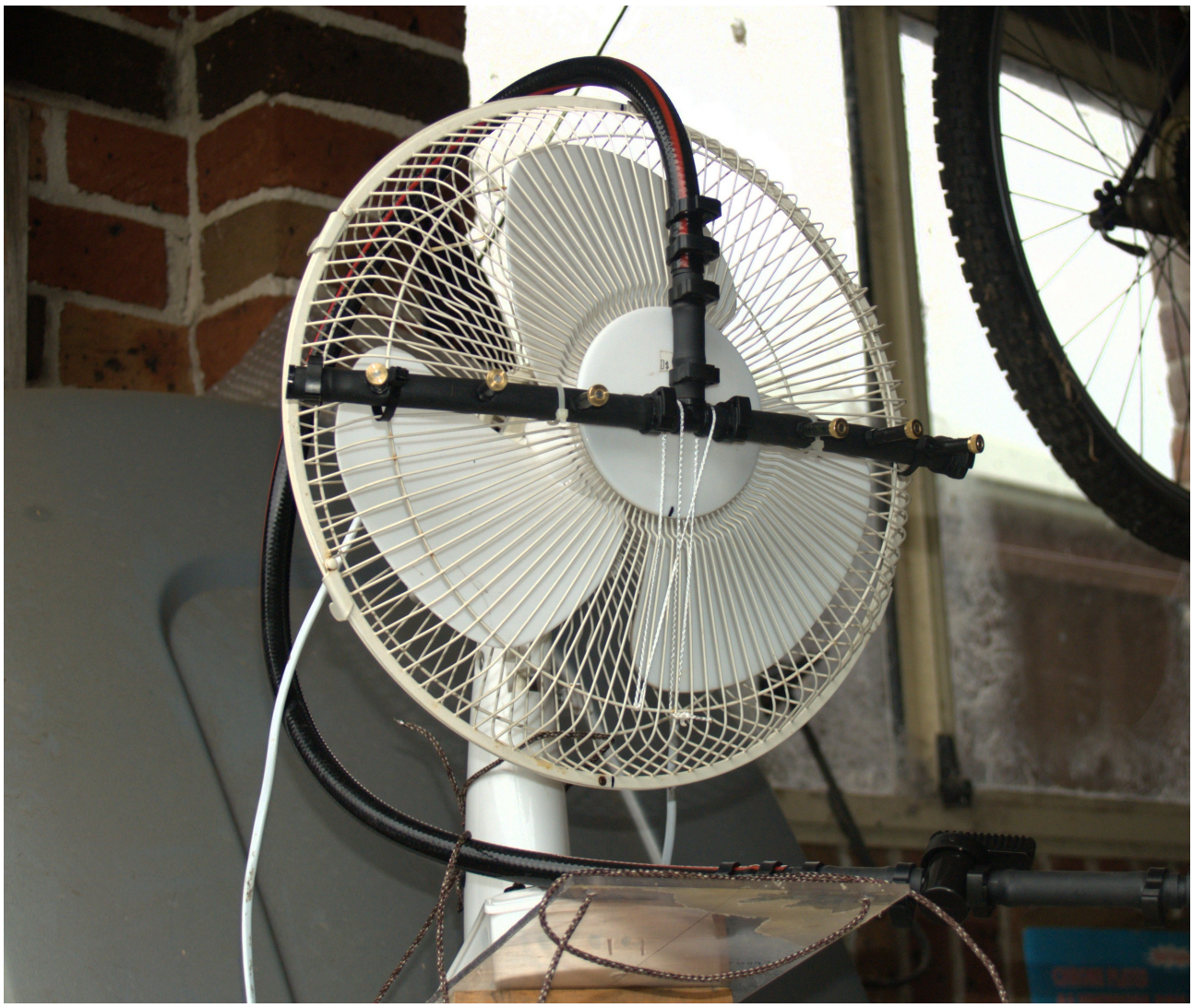
Test the unit by connecting it to a garden hose and opening its valve.

VERY IMPORTANT - there should be no leaks or drips from anywhere in the system.

Only a fine mist coming out of the six misting nozzles.

Attaching the Unit to a Fan

Attach the top part of the mister arrangement as shown in the following image.



Note that the hose connecting the top of the unit (misters part) to the bottom part goes over the top of the fan. The reason is that the fan is going to be mounted upside-down as shown in detail below. The reason for this is also explained later.

The top part is attached to the fan blade cage using cable ties and is arranged so that it is across the centre of the fan to catch as much of the fan's airflow as possible. The T-section of the top part is also tied to the blade cage (white string) so that when the unit is turned upside down the weight of the hose and bottom parts are supported by this tie. This will become clearer when the mounting of the fan is shown in the next section.

The fan was also attached to a base (transparent perspex). This was so that the mounting of the fan would be via this base. Again this will be clarified in the next section.

Mounting the Misting Unit – Fan Assembly

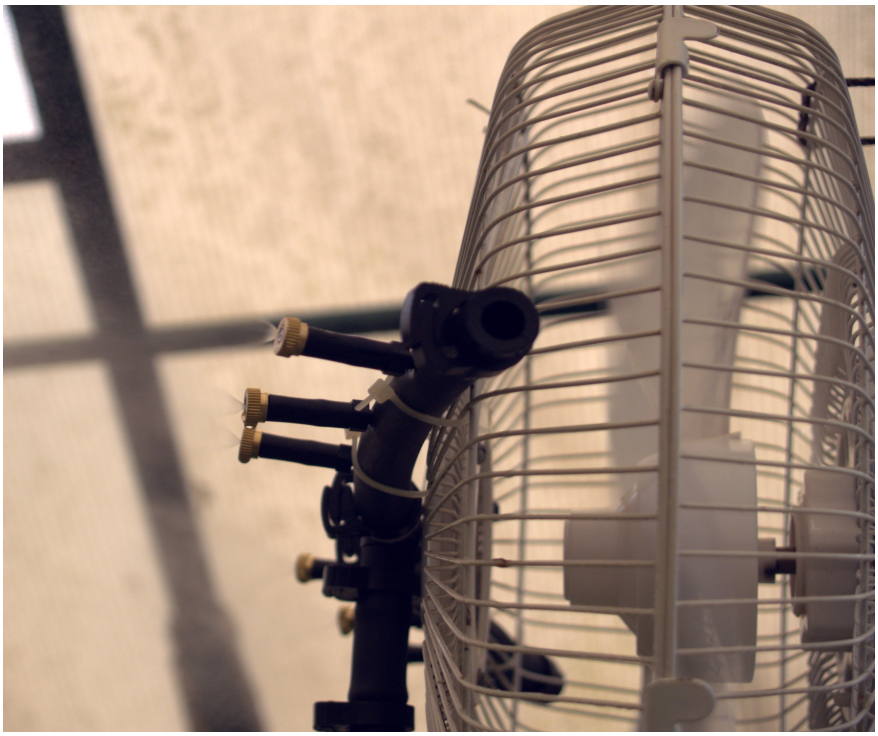
The assembly was mounted on a 'beam' that is attached to the top ridge of the greenhouse and runs centrally across the length of the greenhouse. The following images illustrates this attachment.

The second image below and the one further down show the unit in operation – misters running and fan blowing air past the misters.

The reason the fan was mounted upside down is so that if the misters drip, as they do when the water is turned off and the water inside the tubing leaks out of the nozzles, **it does not drip onto the fan base which contains the electricals**. Using this method no water\moisture ever got inside the fan base or inside the fan motor housing.

Also the above attachment method allowed the assembly to be tilted up or down to direct the cooled air and moisture optimally over the plants.

Note also that the nozzles shown in these images are not the ones recommended above (they stand out from the tube on which they are installed). The ones recommended are just as effective and far easier to use.



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Conclusion

In this article I described a prototype simple evaporative cooling system which fulfilled most of my cooling and humidification greenhouse needs for Summer. Given that the total parts cost was under $50 is also notable. (As I intended this to be a prototype I purchased the fan from an op-shop for $6.00 – that fan is still being operated, without the misting being operated during the Winter, 24 x 7 for air circulation). I have extended the above system to include timer based operation. This allowed me to turn the misting ON or OFF as required without needing my presence. I'll discuss these changes in another article.

Sources

Most of the items used for this project are easily obtainable from horticultural irrigation suppliers and general hardware suppliers with the former offering better quality items. The items I had some difficulty in locating were the misting nozzles. The following list sources for these and other related items.

Disclaimer: I have no financial relationship with any of the business listed below. My recommendations are based purely on the experiences I had dealing with them.

- **Brass barbed misting 0.3 mm nozzles**
  (These are the ones I recommended for use in this project)
  - Ebay Item Listing: http://www.ebay.com.au/itm/Brass-Barbed-Misting-Nozzle-0-3mm-x-10pcs-/121980721216?hash=item1c669e1840:g:HZYAAOSwnGJWS2nv
  - Ebay Store: **allsort-imports** - http://stores.ebay.com.au/allsort-imports?_trksid=p2047675.l2563
  - Ebay Vendor Name: **nato-86**
  The seller lives in the North-West of Sydney and sells a range of misting irrigation items. It's possible to contact the seller for direct pick-up and to discuss application possibilities of their misting nozzles.

- **Netafim** - http://www.netafim.com.au
  Make a range of quality agricultural watering systems including misting nozzles. I tested their CoolNet Pro nozzles and found them very good. They have a higher flow rate than the one I recommended. Over a larger area these may be appropriate. One really nice feature about their misters is that they can be disassembled for cleaning. These items can be sourced from Irrigation suppliers. Their misting nozzle range is as follows:
  - *CoolNet Pro* (http://www.netafim.com.au/product/coolnet-pro-) - A “super-fine static mister especially designed for cooling and humidifying greenhouses and livestock, and for irrigating over rooting tables.”
  Flow rates of 5.5 l/h (light green) or 7.5 l/h (silver gray).
  - *MistNet* (http://www.netafim.com.au/product/ag-mistnet-) - A “Super-fine static mister

especially designed for under canopy cooling and humidifying greenhouses and for irrigating over rooting tables”
Flow rates of 15 l/h (yellow) or 25 l/h (brown).

- **Hawkesbury Valley Irrigation**
  This is where I get most of my horticulture irrigation supplies (the 13 mm poly tube, the 13mm parts, inline filter, … etc.). Besides selling products they offer professional services to local growers and installation services. Also found them very helpful in giving over the counter advice.
  52 Mileham Street, Windsor NSW 2756
  http://www.hvi.com.au/index.htm
  Tel.: 02 4577 6222