Water Storage and Conservation on Nurseries: The SEEDA Water Champion Project©

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INTRODUCTION

Water is a valuable resource which will become scarcer in south east England with changes in climate and increased pressure from population, housing development, and industry. The U.K. Environment Agency is therefore promoting alternatives to using clean mains water or abstracting from aquifers and rivers. Nurseries have a unique opportunity to recycle or capture their own water and to become self sufficient.

For nurseries currently relying on mains supply there are significant financial drivers and rapid payback periods on investment in water capture, storage, and recycling. For those using boreholes the drivers are water quality and crop benefits. In both cases, investment will also help growers to stay ahead of legislative developments. For example, closed irrigation systems help prevent nitrate release into ground waters.

In 2010 the South East England Development Agency (SEEDA) appointed the author to undertake the role of "water champion," funded by the Environment Agency. The aim of the role was to look at the future of water for horticulture in the U.K., assess the impact of irrigation water use on future supplies, and to see whether there are better ways in which water can be sourced and used by growers and what reductions in use can be gained by changing application methods.

This research included a number of case studies of nurseries which have already made significant investments in water capture and recycling, some of which are presented here. Each has seen good savings in water used and in many cases significant improvement in crops, particularly through reduced disease incidence.

There is a wide range of ways to clean water once it is harvested before application or re-application to the crop. Many work well but it would seem that with an environmentally sound concept such as water harvesting we should seek out biological systems wherever possible. A survey of these is included in the full project report, available from the author, along with a review of how a new water capture and recycling system was installed and demonstrated at Lowaters Nursery in 2010.

CASE STUDIES

Allensmore Nurseries, Worcestershire. Capillary beds have been built using a simple, easy to maintain capillary mat (Florimat 2). Each bed slopes towards a central drain point and water is applied to the top of the slope via a seep pipe which produces a pulse of water passing down the matting. The height difference from the edge of the bed to the drain point is 30 cm (the beds are double, 25.6 m across in total). These beds are used effectively for pots of up to 7.5 L. Water from the beds is channelled into a ditch with a gravel base which acts as a biological filter and drawn out through a pipe at the base — if the water greens then calcified sea weed is added to clear this.

From the ditch the water passes into a storage reservoir and is oxygenated on the way in using a pump fitted with a venturi and two pipes circulating oxygenated water into the base of the reservoir.

Barcham Trees, Cambridgshire. This large container tree grower was totally dependant on mains water but cost drove it to review its system. In 1994 it started to consult with its local water board about building a reservoir. The nursery had an area of 4.5 ha, which had been designated for water storage but to avoid the need for civil engineering planning consent, two reservoirs of 36,000 m^3 were constructed and lined using on-site clay.

The reservoirs are filled from a neighbouring dyke and the company has a license to collect water from October to the end of April. The water is checked annually once the reservoir is filled in May for *Pythium* and *Phytophthora* and the water chlorinated (1 ppm) — this has proven to be successful in removing all spores. Water is drawn from the reservoir as required and passed through a fast sand filter and then into the nursery irrigation system.

This project has freed the nursery from mains usage — though there is a back-up facility in place to use mains water if required. The project had a 3-year payback period and received grant funding of 30% for one of the reservoirs.

Boningale Nurseries, Worcestershire. Boningale has installed an area of capillary bed using Florimat 2 matting. The site is on a gentle slope so to overcome this, the matting is laid only on the used bed area where the plants are grown, not on the pathways. The mat has a strong enough hold on the water that none is seen to flow out. The beds have been constructed using a thick layer of plastic liner, a layer of Florimat 2, and woven geotextile as the cover. Irrigation water is applied via seep hoses while the overhead pin-jets have been kept to provide overhead irrigation to periodically flush any accumulated salts back through the compost.

Plants such as hebe, which are very water sensitive, are being grown on the beds and the foliage looks healthy. Since installing the new area no issues have been noticed other than the growers becoming accustomed to using significantly less water on the crops — to start with the same amount of water was applied as through the overhead system but this over-wetted the crop: a balance has now been found. All water on the site is from a borehole with a very high alkalinity, it was felt that in time this may block up the matting and mixing with collected rainwater would offer long-term benefits.

Hillier Nurseries, Romsey, Hampshire. Hillier Nurseries embarked on a water recycling and rainwater harvesting project in 1994 to improve its security of supply, reduce costs, and reduce its environmental impact.

The nursery had a summer surface abstraction license for the local river, although this alone would not have been sufficient so a storage, recycling, and treatment system was designed with help from consultant and IPPS member John Adlam. There was space for a 16-million-L reservoir and water usage models for the nursery, coupled with local rainfall information demonstrated that this would be sufficient in most years. The maximum nursery use is 1.4 million L per day and the design allowed for 450,000 L per day of nursery run off to be collected and 450,000 L per day of abstraction.

If no further water is collected then the reservoir has a storage capacity at peak use of 1 month. If this exceeded then mains water is used temporarily to maintain supply (the reservoir is never allowed to go totally empty so that there is an emergency store maintained in case of mains problems). The annual water bill was £70,000 to 80,000 compared with a project cost of £120,000.

All water that falls onto the nursery is routed into open block-built channels which work with the natural gradient of the site to feed back to the reservoir which is at the lowest point. Built into the system is a trash separator and silt trap to prevent debris from reaching the main storage reservoir. The reservoir is lined with low density polythene and has an overflow that runs into a stream via a small holding pool.

Water is drawn from the reservoir through a self cleaning centrifugal pump which separates out debris and then goes through a sand separator. To prevent disease the water is chlorinated at 5 ppm. The water then passes through three in-line high-pressure sand filters. Pumping to the nursery is via two pumps, one variable speed and one fixed speed, to deliver a wide range of different pressures and keep the system pressurised over the large site even when water demand is very low. There are various sensor and fail-safe mechanisms built in so that in the event of the cleaning system breaking down it will automatically switch to mains supply.

The water is regularly tested and no pathogens have been found in the water post cleaning. The chlorine appears to break down on its way through the sand filters and no build up has been seen on the nursery or in the recycled water. The water has also been tested for build-up of EC and herbicides and none detected. Nursery records show that between 40% and 60% of the water applied annually is recycled.

To enable the water to be properly used and channelled, nursery beds have been re-laid with a plastic lining to feed all run off to central collection. These are plastic laid direct onto levelled soil with geotextile covering. Irrigation is by sprinklers placed round the bed edges to give even distribution and avoid dry spots.

John Richards Nursery, Malvern, Worcestershire. The nursery is on a site which has always been short of space and with limited water availability, initially from a single small mains pipe. Even after a second pipe was installed capacity was soon overtaken by demand.

In 1985 a closed system was installed to catch and recycle all run-off. This recaptured 30% of the water applied and this water was being reused within an hour. The water was cleaned by means of a fast sand filter, then chlorination and acid dosing to amend the pH levels.

In 2005 a new system was put in place including a lagoon at the lowest point into which all run-off (except from lorry and car park areas) was fed. Water from the lagoon is circulated through a reed bed to remove chemical impurities and then stored in a 23-million-L puddle-clay reservoir — close to a year's water requirement for the nursery. From here it is pumped through a fast sand filter, then a mesh filter and finally a bag filter before it is fed through an iris bed with a capacity of 13 $m^3 \cdot h^{-1}$. Trials using a slow sand filter showed that on this site it blocked in a matter of hours because of the amount of suspended clay particles in the water. The clean water is stored ready for use in a 205,000-L tank inside a barn and kept oxygenated.

This system is producing what nursery owner Richards describes as biologically active water which is clean, free from pathogens, and has shown itself to be well suited to the crops on the nursery. The iris bed has been shown to reduce levels of filamentous fungi and bacteria as well as reducing the bicarbonate concentration and pH — water analysis is showing similar results to those expected from a fully operational sand filter.

Richards says that aeration to maintain aerobic conditions for beneficial organisms in the water is key to the process and air is incorporated at every possible point in the system. The size of the main reservoir was also felt to be a key part of the water cleaning process as its population of beneficial microbes and invertebrates will consume pathogenic resting spores while the time spent in the water will be long enough to kill the motile zoospores of pathogens through UV action.

The lagoon is kept quite empty to ensure it has enough capacity to cope with heavy rain. The reed bed is a large butyl lined pond with *Phragmites australis* planted on gravel banks with patches of clear water between to reduce the risk of sediment blocking water flow.

The iris bed is a 10 m × 10 m sloping area with a sequence of tiered butyl-lined channels 60 cm wide at the top, 60 cm deep and 30 cm wide at the bottom. The iris were sown into compost in polystyrene trays which float on the water in these channels. The trays have holes through which the roots pass to form a curtain in the water,. The water is cleaned as it flows past the roots. A three-stage mechanical filtration system is used to ensure that no particles of debris reach the iris bed.

Lansens Nursery Spalding, Lincolnshire. The nursery was established in the late 1990s by a Dutch grower to produce perennials and shrubs on 4.8 ha outside and under 5000 m^2 Venlo glass. The entire site uses ebb and flood floors, built in two phases.

The first phase of beds are in units of 250 m^2 with the ground levelled and the stones removed, the soil was then fine-levelled to slope each side at exactly 2% towards four central feed and drain points. A medium weight-butyl liner was then installed and covered in geo-textile. The edges are built up using a special 10 cm × 10 cm polystyrene-block system to give the flood depth — these are pinned in place with scaffold poles. The second phase has 350-m^2 beds with a central drain protected by a metal grid covering.

The first phase beds are much less prone to leakage even though it is much harder to seal the four inlets. To prevent the butyl liners lifting in high winds the irrigation computer is linked to the weather station so that those beds most exposed to the wind can be flooded. To avoid freezing all water pipes are 80 cm deep, and by using compressed air instead of conventional solenoids the valves are kept free of water and are actively drained by the constant air pressure so don't need draining down in winter. This is based on the systems used in fire sprinkler systems in large buildings.

The ebb-and-flood beds use 85% less water than a well designed overhead sprinkler system would for the same area and crops. The construction cost was £15/m^2 and the butyl liner is guaranteed for 15 years, though should last longer, and the geo-textile is being replaced after 10 years.

Water is moved around the system using a high-volume low-pressure pump. The system is operated using two tanks each containing 15,000 L — small enough that in the event of a problem they can be wasted and refilled –– each with a different nutrient solution so that two different liquid-feed regimes can be applied to any of the 107 bed areas. A Brinkman computer monitors and tests all water being applied and it is checked for EC and pH four times in the process of application — if any one of these falls outside the set parameters the system will stop and issue a warning.

The longest stretch for water to travel on the nursery is 25 min and beds are irrigated in groups of five so that as the water drains from the first the last is beginning to fill. It takes 6 min to fill a bed to 6 cm.

Once used the water passes in to a 50-cm-diameter drain pipe into a sump and then through a sieve filter fine enough to remove all weed seeds and is then sent by the computer back to the appropriate feed tank or, if it is rain draining from the bed, into the 2-million-L capacity holding tanks.

Though there is no anti-fungal treatment neither *Phytophthora* nor *Pythium* have been a problem to date.

The system is simple and has low running costs once established. It delivers water and nutrient accurately to a wide range of crops.