Mist Propagation

system design and operation – theory into practice

An enlarged and up-dated version of a paper presented to the IPPS conference, 2003,

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Note.

This paper uses the terms **pH, Alkalinity, Hard water** in specific ways. Please see the appendix.

Introduction

Since G.E.L. Spencer first set out the basic concept of mist propagation in 1936, most professional propagators have had some grasp of the principles involved. However, in our opinion they often manage to turn an essentially simple concept into a technical and commercial headache.

In our experience, mist systems are too often poorly designed and operated. The commonest examples of this are;

inadequate water-pressure, giving poor atomisation of water droplets;
mist-lines and nozzles spaced incorrectly;
nozzles too close to protective structures, thus inhibiting the diffusion of mist across the propagation area;
drips from nozzles and air in pipe work
and poor maintenance routines.

Too dry an atmosphere and too much water in the rooting medium make the management of a mist unit unnecessarily more difficult. The two problems are often linked.

We find that the water-logging of rooting media is the commonest problem. It is normally caused by mist droplets which are too large. Everyone knows that the atmosphere after a shower of rain can be much fresher than before it. In your case, these large droplets knock down mist particles, so that atmospheric humidity is reduced. That in turn results in faster drying of the crop, which leads inevitably to increased frequency of misting cycles. In our experience, excessive misting can almost always be seen to deplete the nutrient reserves of cuttings, and you all know what follows from that.

A true mist system does not require large volumes of water, but correct flow, pressure and diffusion are essential. We look at the colour of a batch of cuttings. If it becomes uneven, and the nozzles are appropriately laid out, then we suspect inadequate diffusion.

The functions of stomata in this context are vital, and not always understood. Both science and practical observation tell us that too humid an atmosphere inhibits growth. We have seen cases where the use of evaporative cooling in the UK has positively depressed growth rates. This is because it inhibits the uptake of CO_2.

Propagators need to keep two essential functions of a mist system firmly in mind. It must ensure that plant material remains turgid and is kept cool enough . When we apply a thin film of water to plant material, it keeps the plants cool by evaporation. While this happens the stomata remain open. They are therefore able – most importantly at this stage – to take in CO_2, and therefore to metabolise.

As temperature rises, we still want to encourage the cutting material to metabolise, so that good quality roots form as rapidly as possible. For this to happen, the stomata must be able to carry on working. If the misting system is inefficient it will apply excessive free water. As that water evaporates, it causes the surrounding atmospheric humidity to increase. That extra humidity will reduce the “vapour pressure gradient” between the inside of the leaf and the air outside it. This makes it increasingly difficult for the stomata to play their part in cooling the foliage by transpiration. As a result, leaf temperatures start to rise, and the plant defends itself by reducing it’s metabolic rate. The uptake of CO_2 is at least reduced, and soon halted. In extreme cases, plants wilt.

Hence our preference, for the present purpose, for the “wet to dry” cycle provided by mist. If it is applied as a thin film, leaching should not be a problem. Therefore, when the temperature gets too hot, you simply open the vents.

Misting controls should be tuneable so as to allow the propagator the opportunity to adjust the extent of ‘Wetting and Drying’ at each end of the misting cycle. Among other things, this is essential for controlling the ratio of air to water in the rooting medium, and therefore plays a major part in managing the quality of callus, cambium and roots.

We pay great attention to the chemical properties of the water used. Welch set out his views and methods robustly in 1970. With the benefit of over 30 years of further practical experience, we now have a much clearer understanding of the practical difference between pH and Alkalinity. We still find that too many growers and teachers do not appreciate that water with high alkalinity can seriously reduce a cutting’s ability to form roots at all, let alone roots of good quality. How many of you have heard that pouring hard water over cuttings is just like pouring cement over your corn flakes? Although the various forms of hardness are only being catered for in specifically appropriate ways in a few particularly difficult situations, the added value on one pot plant nursery of 3 ½ acres was calculated at £860 per week, plus a 25% increase in growth rates. In our experience, nothing pays faster than getting the water quality in a prop. unit right.

The physics of mist

A true mist should hang in the air for long enough to reduce air temperature. Then it should replace the water which has evaporated from leaf surfaces during the period between mist bursts. Burst length should never be increased in order to add water to the rooting medium, or the leaching to which I referred above will occur.

To achieve a true mist, it is essential that water delivered from the orifice of the mist nozzle “shears” into a mixture of droplet sizes which travel far enough, float for long enough, diffuse evenly, and settle gently. The three nozzles in this slide are designed to induce shear at specific pressures. They combine sharp corners, cambers and plane surfaces in fundamentally different ways, to form eddies in which air is inducted to achieve mist.

If the operating pressure is too high, air movements will carry significant quantities of water away from the target area. If it is too low, droplets become heavy enough for anyone with moderately good hearing to hear them landing on a sheet of polyethylene. If the nozzle is not designed to produce an appropriate droplet range for your operating conditions, playing around with the pressures may help a bit, but it will not produce the results which you should expect. The crop will generally develop those dark and light areas to which I have already referred. Would you like to look that stressed?

Water chemistry in relation to mist systems

As a general rule, where high levels of alkalinity are present in water that is used for mist propagation it can have a detrimental affect on a cutting's ability to form roots. Callusing will occur, but rooting will be slow, roots will be fewer, they will be browner at the base and whiter at the tip, and they will become more brittle. In extreme cases, no rooting will occur. *Cupressocyparis X leylandii* cuttings are a good example of this effect.

Acidification of the propagation water to reduce alkalinity (rather than pH), generally to no more than 60mg/litre as $HCO_{3,}$ will usually control the build up of lime scale on foliage and around the base of the cutting, allowing the plant to use water and nutrients more readily. In addition to quicker and stronger root growth, cutting leaves will form a more glossy or waxy epidermis, which will improve resistance to fungal attack. We think that the improved availability of calcium and nitrogen, which are by-products of dosage with nitric acid, play a significant role in this. Although there are conditions in which the use of sulphuric acid is inevitable, we have always shied away from it for that reason. It must only be deployed with understanding and after trials.

We know propagators who like to adjust dosage rates as they assess the progress of their cuttings. They tend to do so in steps of about 10 p.p.m. (as HCO_3) by reading the crop.

Those species which are difficult to root in harder water also offer a great opportunity for measuring the interest and aptitude of candidates for further professional development. A simple drench with appropriately acidified water can transform the cuttings in question. We have often seen it change peoples' perception of what the profession can be about. Mr. Richard Hammond of HRI, East Malling, has kindly said that he is happy to discuss the results of his trials and subsequent working practices.

Care must be taken not to over - acidify, as this will reduce the buffering capacity of the rooting media. The slide shows how acidic water from a pH - controlled system affected leaves and roots of a crop of Polyanthus. High nitrogen levels have made the leaves strongly convex. Antagonism has depressed uptake of potassium to the point of necrosis. The roots are bright white, flushed with rose pink. The root tips are becoming translucent, hairless and brittle.

High levels of alkalinity will also seriously affect the mechanics of the mist system. Lime scale on mist nozzles always causes an uneven distribution pattern and reduces the nozzle's ability to produce a true mist. Mist nozzles must be maintained. We usually advise regular cleaning by soaking them in diluted citric acid to remove lime deposits. Don't rush this. We have unhappy memories of a very senior propagator who decided that he would clean several hundred jets himself while his nursery manager was on holiday. He used nitric acid, which he diluted, but not enough. Even HCl has caused problems with some materials. Citric acid has always been safer – so far.

Filters should also be cleaned and lines flushed out to remove any loose lime scale that could potentially block nozzles. If you have to do this, close the nozzles off first, and allow about half an hour between treatments. Please also remember that many metal solenoid valves, if handling hard water, will accumulate a deposit of a very hard lime scale akin to Struvite in eddy zones, because local pressure waves cause an instantaneous reaction. If your metal valves tend to stick, you will have to clean them.

Quite often enough, we meet propagators who plan to defy the laws of physics! Sloping side walls and low tunnels are, in our experience, associated with horrendous losses. Are we right in thinking that really accurate misting depends on the diffusion of electrostatically charged particles? If so, how does that tie in with work at Silsoe on sticking water droplets to plant foliage? Perhaps it is worth looking at our comments on stomatal activity again?

The Cambium.

We have never been able to relate the concerns of some researchers about sugar levels in cuttings to our practical experience. So when we read of some contrary results from Wageningen, we were relieved. We have still not seen the papers. For the time being – as for the last several years – we know that fog systems can help to germinate seeds, to wean microprop plants, and to cool the air in a dry climate.

If you want to manipulate the rooting of a cutting in our temperate climate, try to measure what is happening in a mist system. For that we all have, as so many extension officers have pointed out, to learn to “read the plant.” The key to that is appropriate small trials. We need to introduce both students and late-comers to systematic trials methods, so that they can learn rapidly from us, and we also can get on with developing our own skills.

The next frontier for us seems likely to be about direct measurement of activity in the cambium. The pioneering work on the use of thermal imaging by Harold Lewis of the Medical Research Council took about 20 years to become generally adopted. The work on capacitance which FPL patented in 1974 is only now being applied on any scale in productive horticulture. It has been used in South Africa for some years to measure sap flow and stem density in fruit crops. Much smaller sensors are now under development for other applications. It is possible to plot the mass and the density of stems and leaves, with or without reference to water content, as additional components of a climate monitoring programme on a conventional PC based irrigation computer. But will it, we wonder, be as quick as a good grower?

Terminology.

pH

Technically, the pH scale is an inverse logarithmic scale ranging from 1 to 14, indicating hydrogen ion activity. It is commonly used as an indication of acidity or alkalinity, pH 7 generally being considered "neutral" in soils. Advisory officers use it to estimate the probable availability of a range of plant nutrients to a range of plants in soils and other growing media.

In modern professional horticulture, FPL suggest that growers who seek quality should use pH with due regard to the absolute quantities of the nutrients present in the sample, to their synergies and antagonisms, and to the buffering characteristics of the growing medium involved.

Hardness in water.

Technically, hardness is due to salts of calcium and magnesium currently in solution in water. Hardness is usually described as either "permanent," normally in the form of sulphates, hydroxides and chlorides, or "temporary," in the form of carbonates and bicarbonates.

In daily life, hardness in water forms lime scale, and prevents soap from producing lather readily. In horticulture, hard water prevents crop protection chemicals from working, locks up fertilizers and coats plant roots. On cuttings, lime scale inhibits the emergence of roots from callus, rendering them increasingly few, white to translucent, and brittle.

Alkalinity.

We use this term to describe temporary hardness due to carbonates and bicarbonates, which can react with acids in solution to form salts. Classically, temporary hardness was that part of total hardness which can be altered by boiling. It is usually measured as CaCO3 or as HCO3, in units of Mols or p.p.m.

In British commercial horticulture, nitric acid is often used to convert alkalinity into soluble fertilizer. This is not necessarily the best solution, as it always raises the conductivity of the treated irrigation water.

For technical support on the above and related matters, please refer to the reading lists available on www.fpl-irrigation.com